Food and Agriculture Organization of the United Nations

Bringing climate change adaptation into farmer field schools

A global guidance note for facilitators

Bringing climate change adaptation into farmer field schools

A global guidance note for facilitators

Food and Agriculture Organization of the United Nations
Rome, 2021

Required citation:

FAO. 2021. *Bringing climate change adaptation into farmer field schools – A global guidance note for facilitators*. Rome. https://doi.org/10.4060/cb6410en

ISBN 978-92-5-134846-8

Contents

Figures

Tables

Acknowledgements

This guidance note was prepared by Brent M. Simpson and Alma Linda C. Morales-Abubakar. The document draws extensively on material from Simpson (2016, 2018), Simpson and Burpee (2014), and climate change adaptation activities in farmer field school programmes in East Africa, Latin America, Near East and North Africa, West Africa and South and Southeast Asia. Under the supervision of Stefano Mondoví, *Bringing climate change adaptation into farmer field schools: A global guidance note for facilitators* was reviewed by Abram J. Bicksler, Ana Heureux, Anne Sophie Poisot, James Okoth, Jan Willem Ketelaar, Maria Hernandez Lagana, Marjon Fredrix, Sandra Corsi, Suzanne Phillips and Tiko Hema.

Special thanks go to Stephen Sherwood, who provided the case study on Katalysis, and Margaret Mugo, who provided materials for the case study on Malawi's land degradation hotspots baseline assessment. Special thanks also go to all the farmers, FFS master trainers and FFS facilitators who tirelessly work together to identify and try out solutions in field schools that contribute to building the capacity of communities for mitigating risks and adapting to challenges brought about by climate change.

Many thanks also to Pietro Bartoleschi, Elisabetta Cremona and Elisa Lipizzi (studio Pietro Bartoleschi) for their wonderful illustrations and the design of the publication, Zoé Despretz for her excellent support in the management of the entire publication process and to Ruth Duffy for her fast and professional editing.

This document benefited from co-financing from the Global FFS Platform and the Global Environment Facility (GEF) and International Fund for Agricultural Development (IFAD) Resilient Food Systems Programme (RFS Integrated Approach Pilot). The views expressed are those of the authors.

Abbreviations and acronyms

AESA	Agro-Ecosystem Analysis
CBA	Community-Based Adaptation
CBAP	Community-Based Adaptation Planning
FAO	Food and Agriculture Organization of the United Nations
FAQ	frequently asked questions
FFS	farmer field school
FS	Field Study
FToT	Training of Farmer Trainers
GIAHS	Globally Important Agricultural Heritage Systems
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
MEL	Monitoring, Evaluation and Learning
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
PICSA	Participatory Integrated Climate Services for Agriculture
RRI	Regional Rice Initiative
SPS	Silvopastoral Systems
SRI	System of Rice Intensification
ST	Special Topic
TOF	Trees Outside Forests
UN	United Nations

Chemical formulae

CH_4	Methane
CO_2	Carbon dioxide
N_2O	Nitrous oxide

Introduction

Purpose

Climate change and sustainable development are strongly linked. The poor and least developed countries are the most vulnerable, and will be most adversely affected and also the least able to cope with the impacts of climate-related disasters. The United Nations Sustainable Development Goal (SDG) 13 – Climate Action – aims to strengthen every country's adaptive capacity and resilience to climate change-related natural disasters and hazards. It also aims to improve awareness-raising, education and institutional and human capacity on mitigation, impact reduction, early warning and adaptation to climate change (MDG Monitor, 2016). Farmer field schools (FFS) have long been used to enhance critical thinking and informed decision making by local communities through testing innovative solutions to improve production and livelihoods. The FFS process empowers individuals, households and communities with skills they can apply to solving problems in production as well as other broader challenges that confront them such as those brought about by climate change. FFS can make a major contribution towards building rural communities' adaptive capacity for mitigating risks relating to impact of climate change and achieving SDG 13 – Climate Action.

The Food and Agriculture Organization of the United Nations (FAO) developed this guidance note to assist FFS master trainers and facilitators bring about climate change adaptation in FFS. The guide provides key information on how the climate is changing, and how these changes are impacting the agricultural (crops and livestock), aquaculture and agroforestry systems of smallholder farmers. The note provides guidance to FFS practitioners so that they can better work with individual farmers and communities – using a "climate change lens" – in identifying, testing and adapting new practices that respond to changes and variability in local weather. The guide is not intended as a textbook on climate change but is prepared for easy understanding of basic concepts of climate change to support the interpretation of climate information in specific farming contexts and steps that FFS facilitators "must know" in starting FFS programmes that respond to climate change challenges.

The guidance note will add to the repertoire of knowledge of FFS master trainers and facilitators on how to facilitate sessions with communities and farmers to help them:

- understand how local farming systems are exposed and sensitive to specific weather threats;
- identify adaptive solutions, and assess the requirements for utilizing these, to strengthen their resilience to climate change stresses;
- develop context-specific FFS programmes (including field studies and special topics) that respond to the challenges of climate change they have identified;
- engage other farmers and the wider community to work in a planned and coordinated effort in addressing climate change risks.

Ultimately, this guidance note has been prepared to help FFS master trainers and facilitators to design and implement FFS programmes. The guidance note assists master trainers and facilitators in facilitating FFS and working with farmers to find solutions to problems associated with climate change impacts. We cannot prevent these impacts from occurring, but we can assist those most affected in finding innovative solutions to lessen how or delay when these impacts are felt, minimize trade-offs among adaptive options they select and reduce greenhouse gas emissions where possible, while making production systems profitable and sustainable.

Content

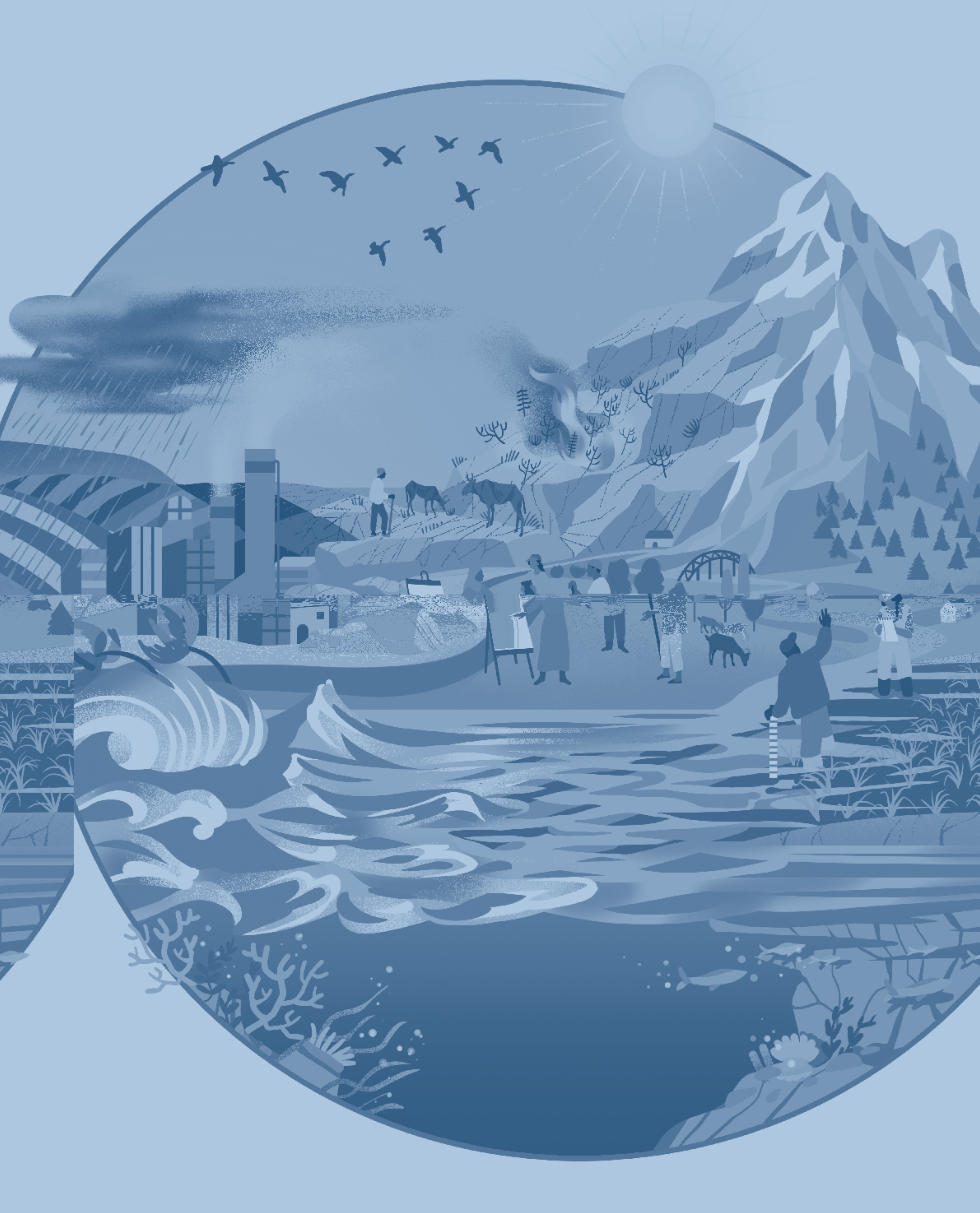
After this introduction, outlining the purpose and content of this guidance note, there are nine brief additional chapters on the "must know" concepts and contents to design and implement an FFS integrating climate change. The guidance note starts with some **frequently asked questions** about climate change. Chapter one introduces some **basic concepts of climate change**. This is followed by a second chapter introducing the **language of climate change** that will help FFS master trainers and facilitators to organize discussions with farmers in identifying and testing adaptive responses to climate change stresses. Chapter three provides background information on the **major climate change processes** and the impact that these processes are having on farming (agriculture, aquaculture and forestry) systems worldwide. Master trainers and facilitators may see some of these impacts in the systems used by farmers that they work with. Chapter four provides an overview of the **steps in integrating climate change adaptation in FFS**. Chapter five presents a series of exercises for conducting a **community baseline vulnerability assessment** of farmers' production systems. These exercises will help master trainers and facilitators to develop and adapt the programme of the FFS in response to local conditions; identifying topics for field studies and special topics – those areas where adaptation efforts are most needed. The sixth chapter introduces some general **adaptation strategies**, and a list of field studies and special topic options in Annex A and B, supported by a list of resources for technical information in Annex C. Case studies on real situations are provided for the field studies and special topics, where these are available, to give FFS master trainers and facilitators an idea of how these really worked with farmers in the FFS setting. FFS master trainers and facilitators may already be familiar with some of the field study and special topic examples but may still find these useful in working with farmers to test responses to climate change stresses – especially using a "climate change lens".

Chapter seven briefly mentions the potential of agriculture (crops and livestock), aquaculture and agroforestry to **reduce greenhouse gases (GHG) and prevent further climate change** from happening. The eighth chapter provides ideas on how to get communities together in an ongoing participatory process of building climate-resilient sustainable agricultural systems through **community-based adaptation plans**. Chapter nine introduces the concept of **the monitoring, evaluation and learning (MEL) process** in FFS integrating climate change adaptation.

Annex A provides additional baseline assessment exercises that may prove useful in a different context. A selection of example adaptation field studies and supportive special topics are presented in Annex B. Annex C contains links to a range of technical background resources on other field study and special topic issues, as well as supportive documentation and videos. References used in preparing this document are included in the Bibliography.

Master trainers and facilitators are encouraged to adapt the ideas in this guide and create exciting learning opportunities for farmers and communities in FFS programmes that address challenges brought about by climate change while increasing productivity, improving livelihoods, and reducing greenhouse gas emissions.

©Stefano Mordovi



Frequently asked questions about climate change

What is the difference between climate change and global warming?

"Climate change" refers to a range of changes happening to the planet's weather system, including global warming. Examples of climate change are rising temperatures, changing rainfall patterns and shift in the timing and length of the growing season, changes in the frequency and severity of storms among many others. These changes are the result of warming caused by human activities that release heat-trapping gases into the atmosphere.

"Global warming" is the long-term warming of the planet. Since the end of the nineteenth century, and especially since the late 1970s, there has been a well-documented steady increase in global temperatures. The average global temperature in 2020 was 1.2 °C warmer than at the end of the nineteenth century.

Source: NASA, 2020a.
https://climate.nasa.gov/faq/12/ whats-the-difference-between-climate-change-and-global-warming

Is the Sun causing global warming?

No. The Sun is not the cause of the warming trend observed BUT it does influence the Earth's climate. Global warming is caused by the accumulation of heat-trapping gases, not by the Sun becoming hotter.

Source: NASA, 2020b.
https://climate.nasa.gov/faq/14/is-the-sun-causing-global-warming

What causes global warming?

Water vapour and certain gases in the atmosphere, like carbon dioxide, occur naturally. Together they help trap the Sun's energy that provides enough warmth for life on Earth as we know it to survive.

Human activities, such as burning of fossil fuels (coal, natural gas and oil) release vast quantities of additional carbon dioxide into the atmosphere. The clearing of forests and agricultural production (e.g. raising livestock) also release carbon dioxide and methane gases. These and other activities cause higher concentrations of greenhouse gases in the atmosphere trapping more heat and leading to an increase in global temperatures.

Source: EESI, 2020a.
https://www.eesi.org/climate-change-FAQ#what-causes-global-warming

What is the greenhouse effect?

Important "greenhouse gases" from the agricultural sector include: carbon dioxide, methane and nitrous oxide. The greenhouse effect is the way in which these "greenhouse gases" trap heat, close to the surface of the Earth like a blanket wrapped around the planet.

Greenhouse gases exist naturally in the atmosphere and make the conditions right for life to survive on Earth. However, human activities have been causing more heat to be trapped in the atmosphere causing temperatures to rise.

Source: NASA, 2020c.
https://climate.nasa.gov/faq/19/what-is-the-greenhouse-effect

Is the ocean continuing to warm?

Yes, the ocean is continuing to warm. The oceans have absorbed approximately 93 percent of the additional heat trapped by GHGs. The year 2020 was the warmest ever measured to date for the global ocean, the last five years the warmest five-year period, the last decade the warmest decade ever recorded.

Source: NASA, 2020d.
https://climate.nasa.gov/faq/53/is-the-ocean-continuing-to-warm

Has Earth continued to warm since 1998?

Yes, while 1998 was exceptionally hot, the earth has continued to warm. As with ocean temperatures, the most recent five years (2016, 2017, 2018, 2019 and 2020) of combined global land and sea temperatures are the warmest five years ever measured, the past decade (2010–2019) the warmest decade ever measured. For the past 44 consecutive years, every year since 1977, the average global temperature has been above the twentieth century average.

Source: NASA, 2020d.
https://climate.nasa.gov/faq/46/has-earth-continued-to-warm-since-1998

Carbon dioxide or CO_2 is produced from many sources and it is the most common GHG resulting from the burning of fossil fuels and biomass in agricultural production.

Methane is a more powerful greenhouse gas than carbon dioxide because it has much higher heat-trapping ability. In agriculture, methane emissions result from livestock's digestive process, manure, flooded rice fields and other agricultural practices.

Nitrous oxide is another important greenhouse gas that absorbs radiation and traps heat in the atmosphere. In agriculture, the use of nitrogen-based synthetic fertilizers for intensive production produces nitrous oxide from agricultural soils. Nitrous oxide is also produced by microbes in soils under natural vegetation and in the oceans.

What is ocean acidification?

When carbon dioxide is released into the atmosphere around 30 percent of it is absorbed by the ocean changing the ocean's chemical composition. Over time the pH value of the water has turned from slightly basic to more neutral. Although it does not become truly acidic, the change is called ocean acidification. The ocean's acidity level has increased about 30 percent. The change affects marine ecosystems.

Source: EESI, 2020b.
https://www.eesi.org/climate-change-FAQ#ocean-acidification

What does global warming have to do with severe weather, like droughts and storms?

The severity and likelihood of extreme events such as storms, floods, droughts and heatwaves increase with an increase in global temperatures. A warming climate results in changes to large-scale rainfall patterns that can led to periodic droughts. A warmer climate also results in more evaporation, and more moisture held in the atmosphere, leading to more frequent and stronger storms.

Source: EESI, 2020c.
https://www.eesi.org/climate-change-FAQ#global-warming-severe-weather

What does global warming have to do with rising sea levels?

Global warming causes sea levels to rise in two ways. First, as water heats up, it expands and causes the ocean to take up more space causing sea levels to rise. Second, glaciers and ice sheets in the Arctic and Antarctic are melting due to hot summers, warm winters and longer melting seasons. Initially, sea level rise was driven by the increase in ocean volume due to warming, recently however, the melting of glaciers and ice sheets in Greenland and the Antarctic has begun to dominate. There is sufficient water in frozen ice for sea levels to rise over 80 m.

Source: EESI, 2020d.
https://www.eesi.org/climate-change-FAQ#rising-sea-levels

Which is a bigger methane source: cow belching or cow flatulence?

The cow's belching, as a result of its digestive process, is a bigger methane source. Roughly 90 percent is expelled through belching. When the cow's digestive system converts sugars into simple molecules so that it can be absorbed, methane is produced as a by-product. Some methane is also released from cow's manure as it decomposes.

Source: NASA, 2020e.
https://climate.nasa.gov/faq/33/which-is-a-bigger-methane-source-cow-belching-or-cow-flatulence

How do paddy fields contribute to global warming?

Wetland rice paddy fields are one of the most important sources of greenhouse gases, contributing about 10 percent of global methane emissions each year. The methane is produced through the decay of organic matter in the absence of oxygen, in continuously flooded fields. Paddy fields also emit nitrous oxide that is produced by microbes in soils that are frequently wetted and dried. The use of nitrogen-based synthetic fertilizers for intensive production also produces nitrous oxide from agricultural soils.

Sources: IPCC, 1996; Sheridan, 2018.
https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch4ref5.pdf
https://phys.org/news/2018-09-nitrous-oxide-emissions-rice-farms.html

What is carbon sequestration?

The process by which carbon dioxide is removed from the atmosphere and stored is called carbon sequestration. Plants and trees, oceans and the soil remove and store carbon dioxide from the atmosphere through biological and physical processes. On land, the most important of these processes is photosynthesis, where plants and trees use carbon dioxide in making new plant material – leaves, stems and roots. When plants die, these materials decompose, with much of the carbon becoming incorporated into the soil where it can remain until the soils are disturbed, such as through ploughing.

Source: Selin, 2011.
https://www.britannica.com/technology/carbon-sequestration

Basics of climate change

1.1 What is climate change?

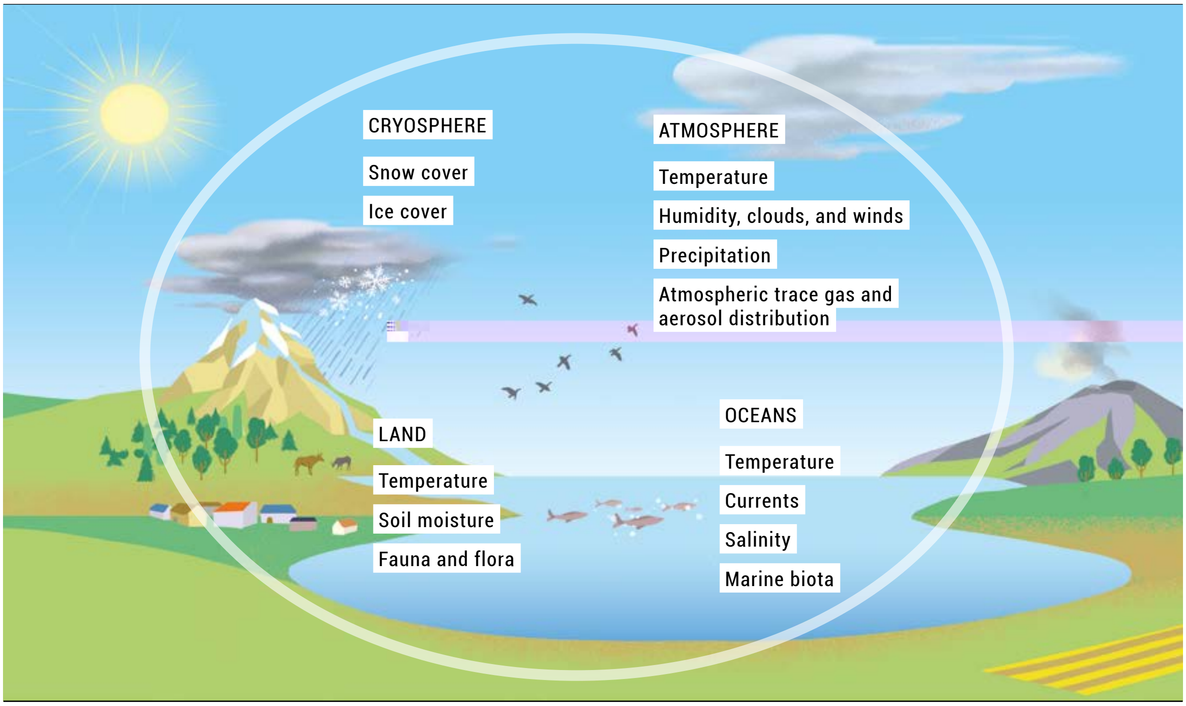
Climate change refers to significant, long-term changes in weather conditions affecting the entire planet.

1.2 What is causing the climate to change?

Human activities – clearing forests and peatlands for timber, fuel and agricultural land; burning fossil fuels (coal, gas, oil); agriculture and industrial processes – in addition to natural internal processes (e.g. respiration and volcano eruptions) – result in vast amounts of carbon dioxide (CO_2) and other important gases being released into the atmosphere. Together, these are commonly referred to as "greenhouse gases." The name comes from their effect in the atmosphere, as shown in the diagram below where they trap the Sun's energy in the Earth's atmosphere, preventing it from escaping back into space, in much the same way that the glass roof of a greenhouse allows sunlight to enter but traps the Sun's heat inside.

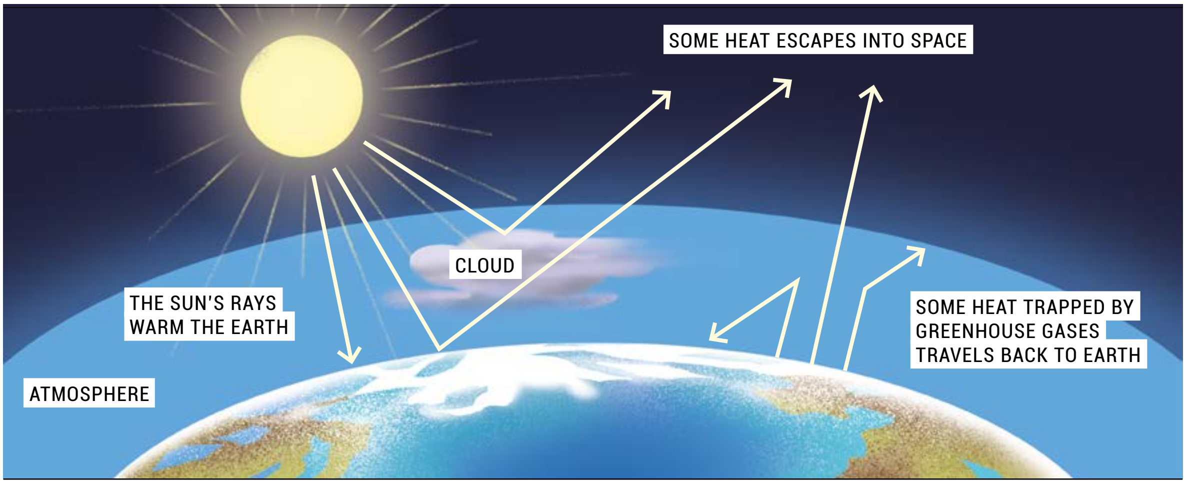
The story of climate change is largely a story of the carbon cycle: the movement of carbon between different forms – in the atmosphere, in the oceans and on land – and back again. Much of the movement and storage of carbon would not be possible without plants. As noted above, the major sources of CO_2 are the burning of fossil fuels (stored carbon from ancient plants) and the clearing of forests for timber, fuel and

Figure 1: The climate system



Source: Adapted from https://www.researchgate.net/publication/242569897_The_Partnership_of_Weather_and_Air_Quality_An_Essay

Figure 2: The greenhouse effect



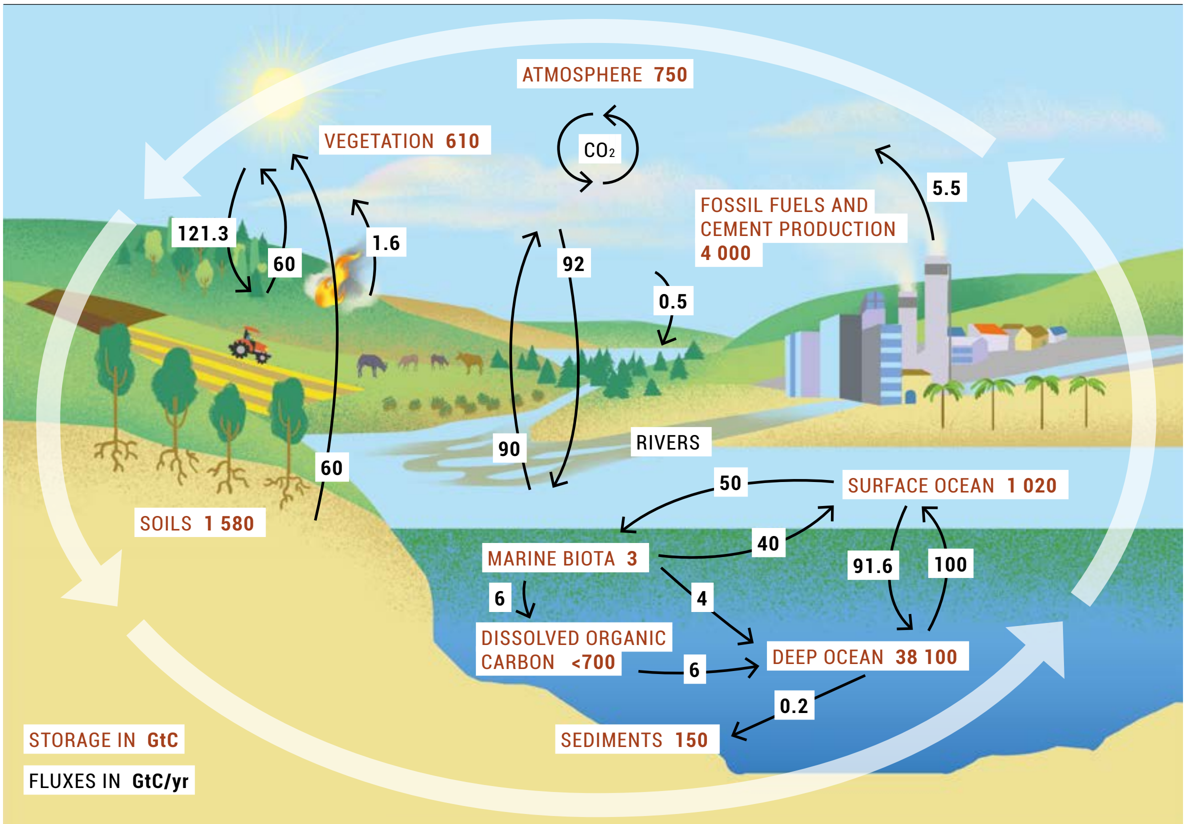
Source: Adapted from https://www.bradford.gov.uk/environment/climate-change/what-is-climate-change-and-how-will-it-affect-the-uk

agricultural land. The second most important greenhouse gas is methane, over half of which is released through irrigated rice production and from livestock digestion and manure. Both directly or indirectly involve plants. As shown in Figure 3 (p.12), though there are many ways of releasing carbon into the atmosphere as a gas, there are two principal ways that carbon is taken out of the atmosphere.

The most important way in which CO_2 is removed from the atmosphere involves the world's oceans and a set of processes through which CO_2 is absorbed at the sea surface. When it moves from the atmosphere to the ocean, CO_2 is chemically dissolved into the sea water. Part of this absorbed CO_2 is directly used by phytoplankton, microscopic organisms that carry out photosynthesis just as land-based plants do; absorbing CO_2 and converting it into plant material. When these organisms die, their bodies sink to the bottom of the ocean, where they can become buried and over millions of years are transformed into oil and gas. Another part of the CO_2 dissolved in sea water combines with calcium and is used by other organisms (clams, coral, crabs, lobsters and oysters) to build their shells. When these creatures die, their shells are deposited on the sea floor, eventually becoming transformed into limestone that can store the carbon for tens of millions of years. Yet another portion of the CO_2 that enters the oceans remains in the sea water, where it may stay for hundreds of years before being re-released into the atmosphere. The other process through which CO_2 is removed from the atmosphere is photosynthesis involving land-based plants – the unique ability of plants to use energy from the Sun to covert CO_2, water and soil nutrients into plant tissue. Together these processes remove roughly half of the CO_2 that we release into the atmosphere each year through the burning of fossil fuels.

Agriculture is a key contributor to the release of carbon dioxide, methane and nitrous oxide. Overall, agricultural activities and the global food system are responsible for roughly one-

Figure 3: The carbon cycle



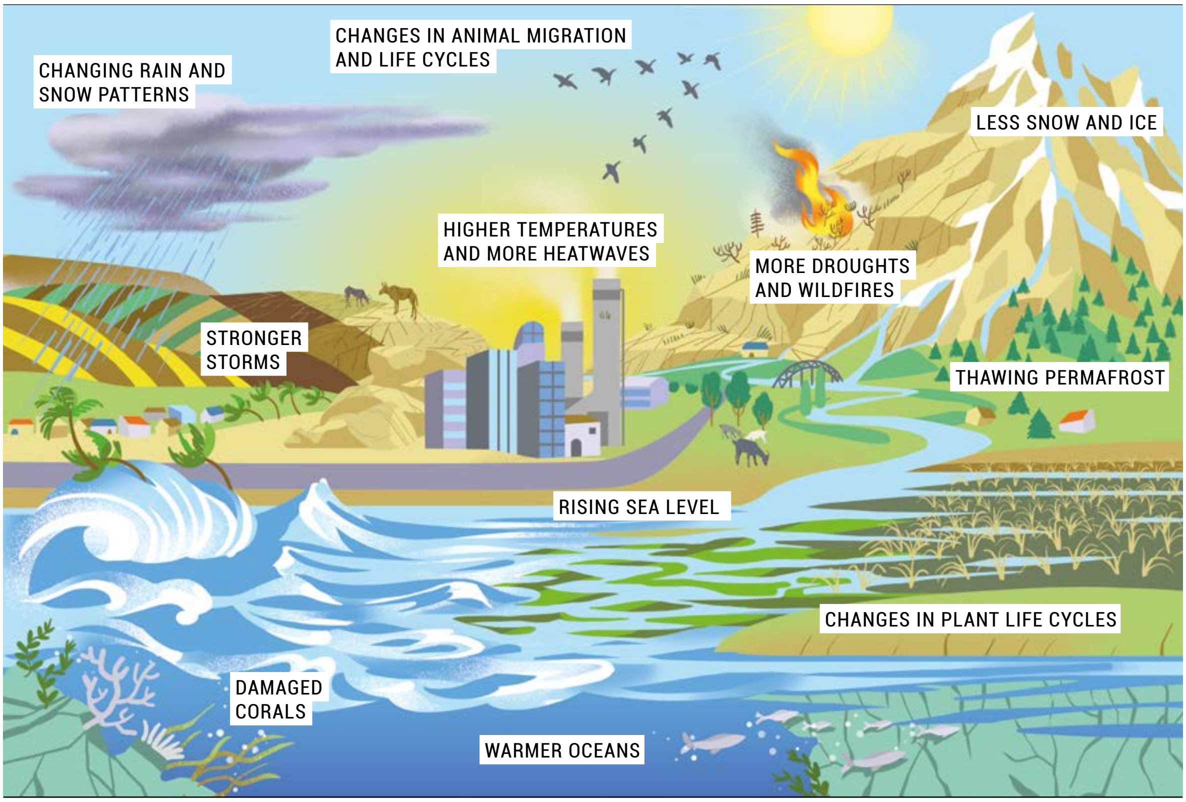
Source: Adapted from NASA Earth Observatory https://www.nasa.gov/centers/langley/news/researchernews/rn_carboncycle.html

third of the total greenhouse gas emissions. In other words, the very act of feeding ourselves is causing much of the climate change problem. As will be discussed in later chapters, agricultural practices can also provide some of the solution by removing CO_2 from the atmosphere.

1.3 How is the climate changing?

Greenhouse gases in the atmosphere, trapping the Sun's energy, are slowly heating the Earth's surface causing changes in the local weather and the global climate. Fortunately, oceans cover 71 percent of the Earth's surface, and they absorb over 90 percent of the additional heat. The oceans are massive, so they warm slowly, thus protecting the planet from experiencing even more rapid rises in average temperatures. Once absorbed, however, this heat is not lost. It simply takes longer for the effects to be felt. Scientists have calculated that it takes about 40 years for all of the additional energy trapped by greenhouse gases, most of it stored in the oceans, to affect air temperatures. This means that the rise in average temperatures that we are now experiencing in the 2020s is due to greenhouse gas emissions that occurred in the 1980s. The increase in temperatures

Figure 4: Global warming consequences



Source: Adapted from https://www.joboneforhumanity.org/global_warming?gclid=EAIaIQobChMItaz2plOI6wIV7dVMAh0-xwCFEAAYASAAEgLmafD_BwE

brings about a variety of consequences such as melting glaciers, rising sea level, more heatwaves and stronger storms (see illustration.) These effects will continue long into the future, and will increase as long as we continue to release more greenhouse gases.

Once released into the atmosphere, the additional CO_2 remains there for a very long time and will continue to hold in the Sun's energy. Scientists generally believe that 50 percent of the additional CO_2 leaves the atmosphere within 30 years of being released, 30 percent will stay in the atmosphere for 100 to 300 years, and 20 percent will linger for over 1 000 years. The combined effect of the length of time that additional CO_2 stays in the atmosphere and the warming of the massive volume of water in the world's oceans means that up to 40 percent of the global warming caused by greenhouse gases already released will continue for thousands of years. In other words, global warming is very serious and is essentially permanent, and requires us all to take urgent actions to reduce the release of more greenhouse gases.

As a result of the changes already set in motion, we will need to learn to live with and continue to adapt to the impacts of climate change during our lifetimes. The additional heat that is being trapped in the atmosphere causes several changes to our climate. These changes are commonly divided between what are called **slow-onset** and **extreme events**.

1.4 Slow-onset climate change

Slow-onset changes to the climate are those that occur gradually. The first and most important slow-onset change in the climate is the **increase in average global temperatures over land and sea surfaces**.

As air temperatures continue to rise, two important things happen. First, evaporation of moisture from soil and bodies of water (oceans, lakes and rivers) increases.

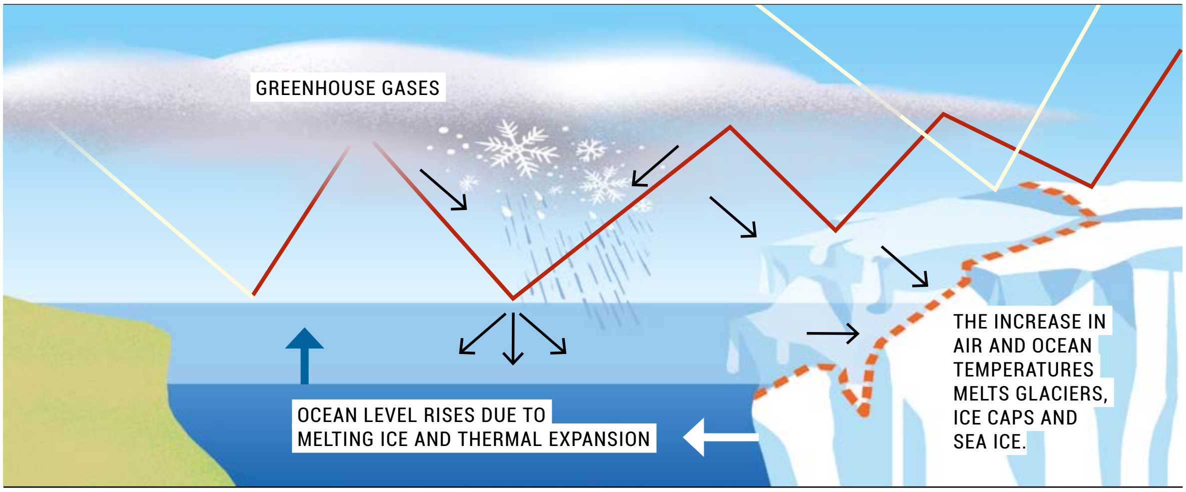
Second, the warmer air becomes the more moisture it can hold compared to cooler air. For each 1 °C of temperature rise, the amount of moisture that can be held in the atmosphere increases by 7 percent. Combined, these two forces – more evaporation and the air's capacity to hold more moisture – lead to increasing amounts of water moving through the global climate system. That means overall more rainfall. The increase in rainfall, however, is not evenly distributed – neither where it falls nor when it falls. It is predicted that those areas that are already dry may become drier, and those with abundant rainfall may get more. FFS master trainers and facilitators might have noticed, when rain does fall, its distribution is beginning to change, with rainy seasons starting earlier or later, and ending earlier or later, with at times more of the rain falling in large storm events and longer dry spells between rainfalls at other times.

Figure 5: A scene after heavy rains

Source: Adapted from https://www.ekshiksha.org.in/chapter/104/water.html

Ocean levels have risen more than 20 cm over the past century, and they are expected to rise

Figure 6: Rising sea levels



Source: Adapted from https://commons.wikimedia.org/wiki/File:Sea-level-rise_scheme.svg much more, and more quickly, in the future as the effects of global warming increase. The increase in air and ocean temperatures is also melting the world's glaciers, ice caps and sea ice. Future sea level rise will increasingly be the result of melting sea and land ice. Rapid melting of sea ice in the Arctic and the collapse of important ice fields in Greenland and the Antarctic have the potential to increase sea levels by an additional half metre by 2050, and potentially several metres by the end of the century. The addition of these huge volumes of water to the world's oceans will result in the gradual inundation of islands and increased flooding of coastal areas. Melting glaciers will also affect the timing and amount of runoff flowing into important river systems on which some countries depend for their water supply.

Figure 7: Floods – a scene after heavy rains

Source: Adapted from https://www.ekshiksha.org.in/chapter/104/water.html

1.5 Extreme events

As the name suggests, extreme events have to do with excesses – too much or too little – in basic weather conditions that occur over short periods of time. Changes in the severity and frequency of extreme events are related to slow-onset changes in the climate. For example, in addition to the slow onset of rising global temperatures, the number of extremely hot days and heatwaves is also increasing, and they are lasting longer and reaching higher temperatures. In parts of Africa, it is predicted that by 2100 average temperatures may be higher than the extreme temperatures of the past, and that heatwaves that once occurred on average every 20 years may occur every two years. As ocean temperatures increase and the air warms, holding more moisture, conditions are ripe for the formation of large cyclones and hurricanes, leading to flooding and damaging winds when the storms hit land. Some of these extreme storms have almost unimaginable power. Take, for example, Hurricane Mitch, which hit Central America in 1998. Over a few days, the storm produced over 1.2 m of rainfall in some areas, causing over 18 000 deaths and USD 6 billion in damages. In 2015, Hurricane Patricia formed over the eastern Pacific, with wind speeds recorded of over 320 km/h, the strongest storm ever measured. Depending on their location, some master trainers and facilitators may already have experienced these extreme storm events. Since the 1970s, the power and duration of these tropical storms have increased, a trend that is expected to continue.

In other areas, increasing temperatures and changes to rainfall patterns over inland areas have led to more dry spells and droughts. Globally, the land area affected by drought has increased by 50 percent since the 1960s. Higher temperatures, more evaporation, and more frequent dry spells and droughts also cause vegetation to dry. As a result, the number of bush and forest fires has also increased. In total, the number of extreme events recorded globally each year is rising, making the world a more chaotic and more challenging environment for agriculture (crops and livestock), aquaculture/fisheries and agroforestry/forestry systems.

1.6 Key ideas

Our knowledge of climate change is growing rapidly as new information becomes available. Nevertheless, many basic facts are well understood. The following are some key things that we know about climate change:

- **Climate change is a natural process driven by Earth system changes and forcings.** However, human activities have created an additional external forcing that has exacerbated the rate of GHG emission and resultant climate change.
- **Climate change has always happened and the impacts are increasing.** Humans have pushed the rate of change to unprecedented levels especially in the context of the vulnerability of humans and other species to climate.
- **Climate change is so long-lasting that it is essentially permanent, in terms of human lifetimes.** The impacts will last well beyond our lifetimes. At least 40 generations will pass before the current effects of climate change will disappear, and that is only if we stop emitting all greenhouse gases now.
- **Climate change includes both changes that are slow in appearing (slow-onset) and changes in the frequency and intensity of rapidly occurring extreme events.** Individually and in combination, these impacts will affect different locations at different times.
- **Multiple changes are occurring at the same time.** Because of the forces behind the various events – rising temperatures and changes to patterns of rainfall – some changes may seem incompatible with one another, such as more frequent floods occurring while the average annual rainfall is declining.

©Stefano Mondovi

The **language** of climate change

This chapter of the guidance note introduces some common concepts regarding climate change. These concepts will be helpful in working with farmers and communities to identify how their agricultural activities are vulnerable to climate change, what can be done to help them reduce causes of climate change and to adapt to new weather patterns.

When working with a community, it is important to help members understand that they can both adapt their practices in response to and anticipation of changes in the climate. In addition it is essential to help prevent further climate change by selecting practices that reduce the release of additional greenhouse gases and remove from the atmosphere some of those already released – this process is called mitigation. A brief description of mitigation actions in agriculture, livestock production and agroforestry is introduced in a later chapter.

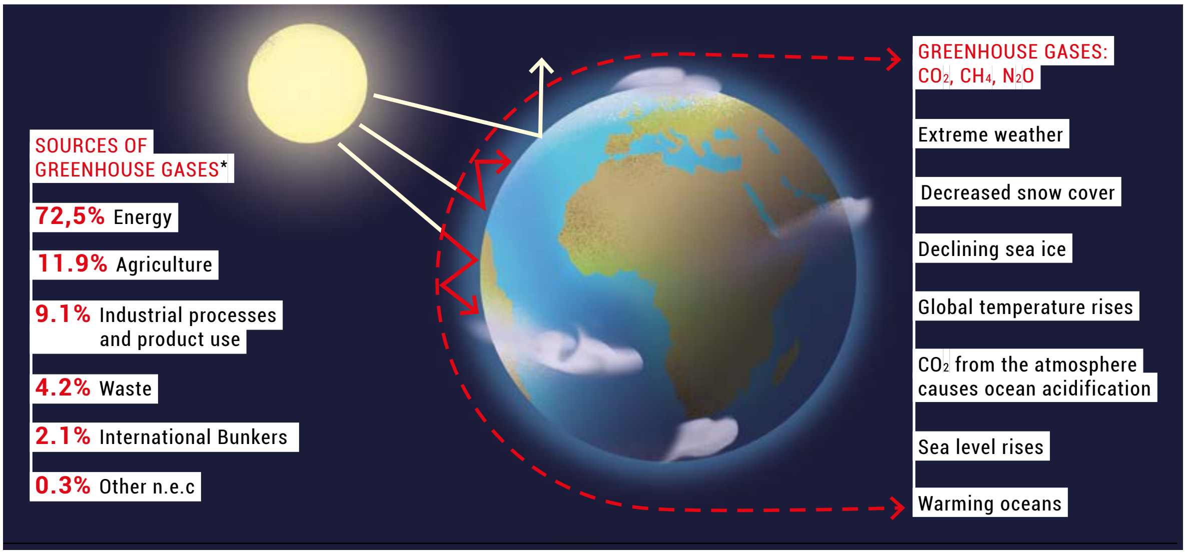
The intent of this guidance note is to assist FFS master trainers and facilitators in working with farmers and communities to reduce the vulnerability of the farming systems to the damaging impacts of climate change through the process of adaptation. To identify the most appropriate adaptive options it is first necessary for the community to understand how vulnerable their current production system is to changes in the weather. **Vulnerability** depends on the level of risk that the community might experience from a particular type of change (its **exposure**), how much that change would influence the system (its **sensitivity**), and the community's ability to adjust the system in response to that change (**adaptive capacity**). One way to think about this process is the following:

Agricultural system vulnerability = (exposure × sensitivity) – adaptive capacity

For example, if a family grows rice in a valley bottom that is starting to have higher floods that submerge their rice plants every three to four years for the first time in memory, the farm's **exposure** to climate change damage is increasing, resulting in yields that in flood years are less than half of past yields. Most rice varieties will die if completely submerged for more than a few days, so they are **sensitive** to deep flooding. When the family adopts a new rice variety that can tolerate being submerged, the family can reduce its sensitivity to the new pattern of flooding by making an **adaptation** to their farming practices.

Exposure to climate change threats refers to the various **direct** and **indirect** effects of changes in temperature and rainfall. For example, drought and high temperatures can directly reduce crop yields or affect animal health. Climate change may also indirectly affect crop yields or livestock productivity by

Figure 8: Climate change



Source: Adapted from https://www.cleanpng.com/png-climate-change-water-resources-environment-meteoro-2340318.
* Data from FAOSTAT, Share of each sector in total emissions with land use, 2017

Key terms for climate change adaptation

Climate change adaption is the process of adjusting to current or expected future changes in the climate.

Climate change stressors include changes to the concentration of carbon dioxide (CO_2), methane (CH_4) and other important gases in the atmosphere (see subchapters 1.2 and 1.3 in the earlier chapter on Basics of Climate Change), the gradual increase in land and sea surface temperatures, and the impact this warming has on rainfall patterns and intensity, sea level rise and changes to the frequency of extreme weather events, such as storms, heatwaves and flooding.

Exposure to climate change stressors is related to geographic location and timing. For example, inland communities in semi-arid regions may be exposed to drought, while coastal communities will have higher exposure to strong storms during the cyclone or hurricane season.

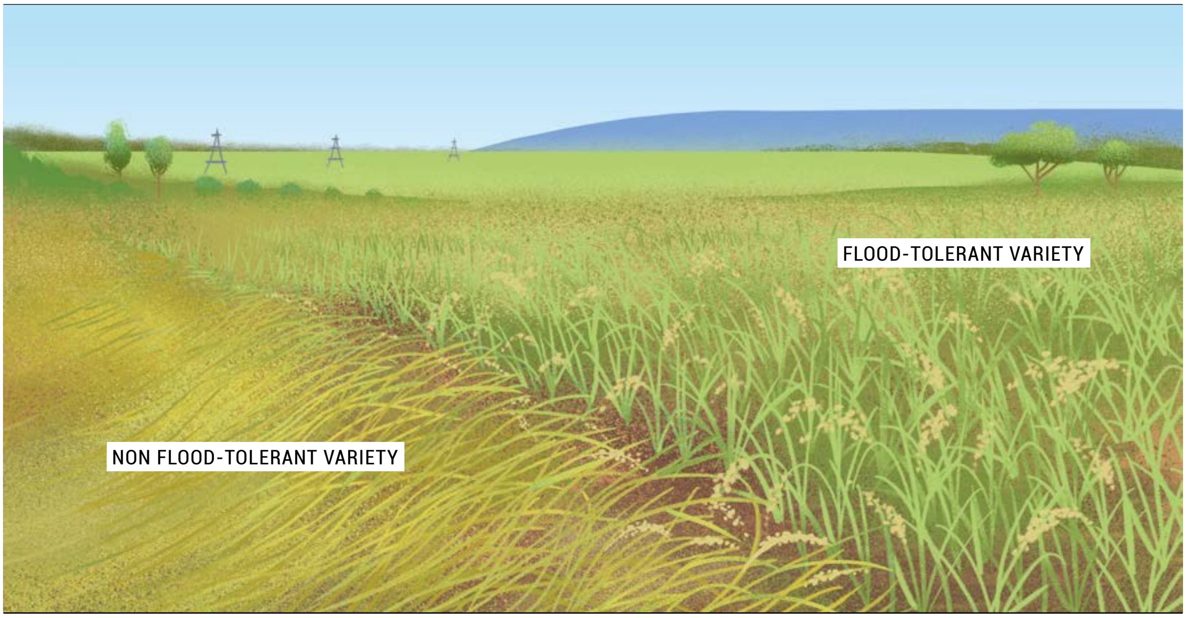
Sensitivity is the degree to which an activity or community is affected by climate-related stresses, when they occur.

Adaptive capacity is the ability of a household or community to adjust to climate change – including weather variability and extremes – to avoid or reduce potential damage, to cope with the consequences and to take advantage of new opportunities.

Vulnerability is the degree to which a farming system is susceptible to or unable to cope with the adverse effects of climate change. Vulnerability depends on the type, severity and speed of climate change and variation to which a system is exposed, its sensitivity and the capacity of those managing the system to adapt.

Source: IPCC, 2007.

Figure 9: Reducing sensitivity by using flood tolerant varieties



From coffee to chocolate

For a decade, a farmer has worked to increase shade on his small Arabica coffee plot, but the shade is no longer enough to reduce the impact of rising temperatures on this cool-weather plant, which prefers temperatures of 16 °C to 24 °C. Now the farmer is gradually replacing his aging coffee plants with cacao, which prefers warmer weather (18 °C to 32 °C). The farmer could not overcome his farm's vulnerability to higher temperatures because of its exposure, caused by its position at a lower elevation, and coffee's sensitivity to higher temperatures. By making a transition to a different cash crop, he is adapting his farming system and learning to live with the effects of climate change.

influencing the types and number of pests and diseases that can injure or kill crops and animals. These concepts, direct and indirect impacts of climate change, as well as **slow-onset** and **extreme weather events**, will be important for working with farmers. Each concept is discussed in more detail in the next chapter of this guide.

Sensitivity to the effects of climate change is the degree to which a farming activity or an entire production system is affected. Take, for example, a 60-year-old farmer who plants maize. She has seen a drying trend in the weather over the past 20 years. Her yields have fallen even though she started planting a variety that is less sensitive to dry weather. She can grow only sorghum now, which is less sensitive to dry spells than maize. Her neighbour had savings and was able to invest in a pond and irrigation equipment and can still

Figure 10: Reducing sensitivity by shifting to other crops

grow maize even in the driest of years. Unlike her neighbour, the 60-year-old farmer faces economic scarcity as well as water scarcity because she lacks the funds for the water storage and basic irrigation equipment that her neighbour has – so her production is lower, her adaptive capacity is less, and her vulnerability is greater. Smallholder farm families producing under rainfed conditions who are experiencing drying trends may be unable to adapt to the impacts of climate change through technical improvements alone.

Adaptive capacity depends on many factors other than technical practices, which are the focus of this guide. In addition to technologies and management practices, adaptation also depends on whether:

- The farmer is aware that patterns of weather – the climate – have changed or are likely to change and that she/he needs to adapt.
- The farm family has enough people to do the work needed to make changes and adopt new farming practices.
- The farm family has the opportunity to access non-farm income (e.g. through employment or social protection) to decrease its sensitivity in case shocks are experienced.
- The farm family has (access to) money and other resources to invest in making changes.
- The farm family or group has ownership or control over key resources (e.g. land, inputs) necessary to make changes.
- The community is willing to work together to make the necessary changes that improve all of their lives at difference scales.
- The community receives government support services, such as extension services, early warning systems and social protection.

- They live in a country that has agricultural policies and strategies in place to increase national climate change resilience.
- Research and extension services support adaptation, especially for rainfed farming.
- Social and economic systems support fair access by women and men to water and land, education and information, financial services and infrastructure.

The activities shared in this guide are meant to give ideas on how to design an FFS programme to help farmers to improve their **mitigation** practices and **adaptive capacities** – reducing the negative impacts of climate change and improving farmers' ability to recover from them more quickly. FFS master trainers and facilitators are encouraged to be creative and adapt or design their own activities based on what will work in their locations.

Climate change is an unending process – it is not a single problem, with a single solution – farmers will need to continually test new responses to new challenges, learning from the experience each time.

It is important to understand, however, that farmers and communities may not be able to overcome all of the vulnerabilities that climate change causes. Farm families must also learn to live with the changes that climate change brings, and to make important decisions about their future. It is important to help farmers understand that climate change is an unending process – it is not a single problem, with a single solution – and that farmers will need to continually test new responses to new challenges, learning from the experience each time.

As weather conditions continue to change, the adaptive practices (e.g. new species, modifications to the production environment or management practices) that respond best to these conditions will also change. In other words, each new practice will provide some relief or offer a limited "**window of opportunity**" in response to the changing weather patterns, but there are always limits. No technology or practice is superior under all conditions. The size of the "window" will be determined by the range of environmental conditions to which the practice responds.

"Climate" and "weather"

These are often used interchangeably, but this is not correct – each refers to conditions and behaviour of the atmosphere over a different period of time. Weather is what is happening, now, today, yesterday, this season or over the past few years – the temperature, cloud cover, humidity, wind direction and speed, and rainfall. Climate refers to average weather conditions over a longer period of time, generally a period of 30 years or more, and how the atmosphere has behaved, on average, over this time period.

©Stefano Mondovi

Determining the best moment to change from one adaptive practice to the next – the **switching point** – will be farmers' most difficult challenge. Depending on the practice, changing too early may put the farmer at a disadvantage with a less productive enterprise or less valuable crop. Waiting too long can result in needless loss. Deciding when to switch is an important, but difficult decision. Because of local conditions, household resources and personal preferences, individual households and communities will likely make adaptive changes at different times. The suggested approach to assessing local climate change impacts, and the field studies/special topics offered in later chapters of this guide, will help farmers identify appropriate moments to switch from one adaptive practice to the next.


©Stefano Mondovi

There are several **pillars of adaptation** to keep in mind when working with farmers. One is **diversification**. The diversification of farm activities provides two types of adaptive benefits. The first is based on the difference in vulnerabilities associated with each activity, or crop. For example, every crop – in fact every variety – has different sensitivities to the same environmental stresses. By simply planting different varieties, different crops, increasing the number and types of agricultural and non-agricultural activities – diversifying their farming system – farmers can greatly reduce their vulnerability to climate change stresses when they do occur. The second type of benefit that comes from diversification are those associated with the direct interactions between crops and other species. For example, the planting of trees within agricultural fields – agroforestry – can reduce the effects of drying winds when crops are already moisture stressed due to low rainfall, as well as providing shade when crops are suffering from heat stress. As will be described in later parts of this guide, these benefits of diversification are found in nearly all agroforestry, intercropping and livestock–crop associations and others activities, such as raising fish.

Climate change **impacts** on agriculture, aquaculture and agroforestry systems

The impacts of climate change discussed in the previous chapters – the slow onset of rising global temperatures and related changes to rainfall amounts and distribution, and the increased frequency and severity of extreme events – are affecting the basic environmental conditions on which every living thing on the planet depends. Every species – tree, plant, animal, fish – prospers under certain environmental conditions, can tolerate others and will perish beyond some limit. Agricultural species are no different. Some of the impacts – temperature and rainfall – directly affect plant and animal growth, health and reproduction. Other impacts are indirect in their influence, leading to changes in the populations and distribution of pests, pollinators and the outbreak of diseases, as well as changes in the productivity, nutritional content and distribution of crop and forage species.

In general, crops and animals are most sensitive to weather-related stresses when they are very young, during their reproductive period (flowering, laying), and when grain or fruit is forming, or livestock are lactating. For example, if, after germination, young seedlings experience a gap in rainfall for a week or more in hot environments, many will likely perish, even though most adult plants, having well-established root systems, will be able to survive. Some tree, crop, fish and animal species are more tolerant – or less susceptible – than others to certain types of stresses. There are, however, no super species that are unaffected by all of the weather stresses.

Chapters 3.1 and 3.2 present some of the important direct and indirect general effects that changes in the weather are having on production systems.

Variability and change

Both weather patterns and longer-term climate conditions are variable, and both can change. Variability in weather is what we are used to – the natural difference between what normally happens (the average) and what actually happens. Some areas, particularly those in dry environments, have more variable weather conditions than others. Variation can be observed over different periods of time – between days, months or years. For example, the difference between the temperature today and the average temperature on this date over the past 30 years; the amount of rainfall received this month, and the amount of rainfall received on average during this month; when the rains begin, how long they last and the amount of rainfall received this season versus long-term average seasonal conditions.

Change is what we must become used to, the trend in average conditions over time in one direction or another – rising temperatures, increasing or decreasing rainfall, earlier or later start of the rains, shorter or longer rainy seasons, more or less total rainfall received. There will always be variability with changing conditions. With climate change, the amount of variability itself will increase in many locations.

3.1 Direct effects

Rising average temperatures

Higher air and water temperatures have many direct impacts on tree, crop, fish and animal species. As the oceans have warmed, the stocks of most marine species have begun to move towards the North and South Poles at a rate of 30–50 km per year in search of cooler water. In coastal areas and river systems, harmful algae blooms that produce toxins can occur more frequently as water temperatures rise. The toxins can stress or kill fish and other species using the water source for drinking. More abundant plant life in waterbodies, and warmer water itself, reduce oxygen levels needed by fish to thrive and survive. Warmer waters also increase fish vulnerability to parasites and diseases.

On land one of the most important general impacts of rising average temperature on plants is that they mature more quickly. The faster plants mature, the less time they spend in each stage of their development, including the reproduction stage. A shorter flowering period can result in less successful fertilization and lower yields. All plants have limits to the temperatures that they can tolerate (high and low). Once these limits are passed, yields of specific varieties and crops begin to decline, and ultimately the crops will no longer be able to be grown. Similarly, under higher temperatures livestock and poultry can become heat-stressed, resulting in reduced feed intake, lower reproduction, slower growth, less milk production or fewer, smaller eggs, and changes in meat quality.

Increasing night-time temperatures

The increase in average temperatures is due mainly to the more rapid increase in temperatures at night. Higher night-time temperatures affect crop species in many ways. One of the most important is through increasing plant respiration (plants breathe,

Figure 11: Impacts of climate change

Source: Adapted from https://thefinancialexpress.com.bd/views/impacts-of-climate-change-on-mental-health-of-farmers-1511707679 just as we do). Plant respiration occurs day and night, and as temperatures rise, plants' use of stored energy also rises. At night, after the sun has set and plants are no longer storing energy (through photosynthesis), high temperatures lead to the consumption of larger amounts of plants' energy created during the day. In rice, for example, the increase of night-time temperatures from 27 °C to 32 °C increases respiration by 40 percent. Energy used in respiration is not available for producing grain, so crop yields decrease.

Higher night-time temperatures can also reduce the milk production of dairy cows resulting from the inability of cattle to cool themselves at night from the heat accumulated during the daytime.

Heatwaves

Livestock are vulnerable to extreme events such as heatwaves. Reduced milk production (worse when a heatwave occurs during peak of lactation), illness and death are some of the risks to dairy cows. Exceptionally high temperatures can be damaging to crops in the reproductive stage. For example, when cereal crops like rice and maize are flowering, the pollen will become sterile when temperatures rise above 35 °C and 40 °C respectively, even for a few hours.

Just like on land, marine heatwaves can occur in the oceans. These events can cause damage and death to coral reefs – coral bleaching. Coral reefs are among the most biologically rich environments on earth, providing a habitat for many important fish species and serve as nurseries for the young and food supply of many others. Fish species cannot effectively cool themselves and as water temperatures rise this makes them vulnerable to climate change stresses. As water temperatures increase to the maximum that each species can tolerate, fish grow more slowly, become more vulnerable to disease and parasites, and have less success reproducing. Fish that cannot migrate to new environments with more suitable conditions will die out once temperatures go beyond their critical thresholds.

General changes to rainfall

Rainfall that occurs out of season – too early or too late, when crops are not being grown – or rain that falls in quantities greater than the soil can absorb, and is therefore lost to runoff or evaporation, is not useful for agriculture. Thus, even if the overall amount of annual rainfall remains nearly the same under climate change, changes to when and how the rainfall occurs may reduce the portion that is actually available to crops. In some areas, rainfall is becoming more variable and thus less dependable, resulting in more "false starts" to the rainy season, crop failure after germination and the need to replant. The amount and type of forage that is available for livestock may be reduced and water systems that support aquaculture and wild fish populations may also be affected by an overall reduction in rainfall.

Changing seasonality and monsoon patterns

Changes to overall rainfall patterns are changing the very nature of rainy seasons – when the rains begin, how long they last and the total amount that an area receives. A shortened rainy season – because of a later start or an earlier end or both – reduces the

time that crops have to complete their growth cycle. Indirectly, changes in rainfall patterns can affect the abundance, distribution and transmission of animal pathogens by creating the environmental conditions favoured by pathogens and disease vectors (those species, such as biting flies and ticks, that transmit disease between animals).

Dry spells and droughts

Moisture stress caused by dry spells and drought slows down and can halt tree growth, and cause injury and death to trees and other plants if conditions continue for too long. Indirectly, moisture stress makes both plants and animals more susceptible to insect pests and disease, and creates conditions where the chances of wildfires increase significantly. Livestock need to increase water consumption under high temperatures to replenish the moisture they lose from breathing and sweating. Animals will die if there is an absolute shortage of water. Drought can also bring about fish kills in reservoirs, natural waterbodies and streams if the water flow is reduced below critical levels.

Floods and periods of inundation

Serious flood events can be devastating, literally washing soil, crops and livestock from hillsides and level plains, bursting the banks of fish ponds, and drowning animals trapped in cages or structures. In less severe cases, flooding that results in standing water that

Figure 12: Crops drowned in standing water from floods

lasts for several days will drown most crops by filling the air spaces in the soil that crop roots need to breathe (waterlogging). Some locations in the landscape are more vulnerable to damage from floods and inundation than others, and these locations may change as rainfall patterns change.

High winds

The impact of high winds along coastal areas from hurricanes, cyclones and typhoons, and those associated with severe storm events inland can be devastating for crops and trees. Cereal and horticultural crops in particular are susceptible to being knocked down, especially when they are heavy with mature or nearly mature grain or fruit.

Interactions between direct effects

Important interactions can occur between changes in weather conditions that directly affect crop and animal species. For example, in the effort to cool themselves, crops naturally lose more moisture through their leaves as the temperature increases. This can magnify the stress on plants if at the same time they are already suffering from a lack of soil moisture due to inadequate rainfall. Higher temperatures, which occur when crops are already moisture-stressed, can have nearly double the damaging effects in certain crops than if heat stress occurs by itself. The combination of heat and moisture stress is particularly damaging during crop reproduction (flowering). The effect of both heat and dry spells on crops can be further intensified by strong winds that increase the rate of moisture evaporation from soil. Livestock are more vulnerable to the effects of rising temperatures when air humidity levels are also high. The combination of high temperatures and a shortage of water can be fatal to livestock.

3.2 Indirect effects

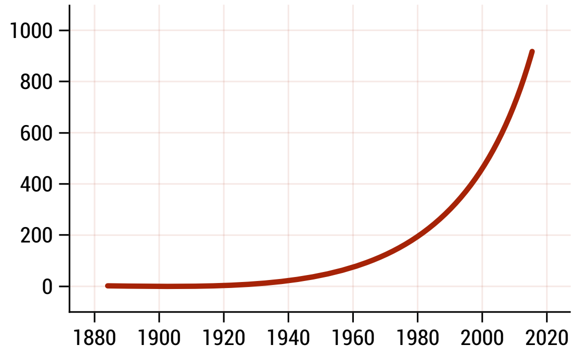
Pollinators

Over 80 percent of all flowering plants are pollinated by another species. These species, known as pollinators, are essential in assisting crop reproduction that globally produces 35 percent of the food we eat. Birds, bats and small animals contribute, but the most important are insects – bees, wasps, flies, beetles, ants, moths and butterflies. Climate change impacts that directly affect these species will be devastating for crops that require pollinators for their reproduction. It is believed that in the tropics most pollinators are nearing the upper limit of their temperature tolerance, so the effect of rising temperatures will be most severe here. Furthermore, in the face of climate change, keeping up pollination ecosystem services will be affected by farmers' habitat management practices that could conserve and augment important pollinators.

Insect pests and their natural enemies

Worldwide, crop insect pests are thought to reduce yields by 10 percent to 16 percent. As temperature and rainfall conditions change, the locations where various pests are found and their populations will also change. Incursions

Figure 13: Insect response programmes by year – new pests increasing



Source: Data from https://www.ippc.int/static/media/files/publication/en/2019/11/Day2_4.0_Keynote_PFA_WEH_2019-11-08.pdf

and spread of new invasive crop pests and diseases happen more frequently as a result of the combined reality of global transport and trade and changing weather conditions due to climate change. In cold-weather climates, milder winters and temperatures that rise earlier in the spring will also allow more pests to survive and to appear earlier in the year. Higher temperatures may allow some pests to reproduce more frequently, thus increasing the potential intensity (more pests per season) of crop damage. The same changes that affect pests also affect other species – their natural enemies – that feed on pests (pest-predators) or lay their eggs on pests (parasitoids). Across different ecologies, the diversity of insects, number of individuals and total weight, have declined by up to three-quarters. Given the speed and severity of these declines, there may be situations where important pest predators are no longer able to cope with changes to the climate while pests are less affected. This could lead to a decline in predator populations and rising populations of pests.

Diseases

Some crop and livestock diseases are spread by insects. Others are spread through the environment by wind, water or infected soil, and still others by physical contact – animal to animal or contact with infected tools or clothing. Those diseases that are spread by insects or environmental conditions are most likely to be affected by changing weather conditions. In some locations, changes in climate conditions can lead to the sudden appearance of diseases that were not present in the past and increasing outbreaks and severity of diseases that had been present but not devastating. This is most easily seen in mountainous areas. As temperatures rise, pests and diseases can move higher up the slopes into areas that were previously too cold for them. In places where diseases are already present, local infection rates may explode in years when conditions are right. Heavy rainfall, for example, that leads to increased local humidity or flooding of pasture areas can create conditions in which populations of certain types of crop disease organisms (mould and fungi) and livestock pests (gastrointestinal parasites) can soar. In general, crops and animals that are already stressed by other changes in environmental conditions – heat, drought and poor nutrition – are more vulnerable to disease infections and parasites.

Temperature is a key factor in determining whether an infection in fish species (e.g. koi herpesvirus) will result in disease and death or immunity and recovery. It is highly likely that fish may be affected severely by climate change.

Weeds

As with insect pests, weed species' populations and where they are found may change. Globally, weeds are believed to reduce potential crop yields by as much as 36 percent. Relying primarily on wind, water, birds and animals, weed seeds are constantly being moved to new locations. Often the conditions in areas where these seeds land are not suitable and weed species do not become established. As temperature and moisture conditions change, however, weeds can quickly move into new locations. Weeds have not been bred to put their energy into producing edible grain or fruits – instead, they use their energy to establish themselves quickly and develop extensive root systems that ensure their survival. As a result, once established, weeds are generally more resistant to weather stress than agricultural crops. Weed seeds can also survive in the soil for decades and longer. Even after severe weather events, such as droughts, they will return as soon as there is sufficient moisture.

Environmental effect

Changes in temperature, rainfall, soil fertility and rising carbon dioxide levels will also change the diversity and nutritional quality of plant species found in grazing areas. The types of plants that will be favoured may be less nutritious feed for livestock and thus affect their health and productivity. Similar changes are happening in the ocean, coastal environments and freshwater systems, where entire food chains are being disrupted through rising temperatures, reduced mixing of water layers, sea level rise submerging habitat and changes to river flow that allow more saltwater to enter estuaries.

Interactions of indirect and direct stresses

Although direct effects of climate change on crop and livestock species can already have significant impacts, a combination of these with indirect effects can place even more stress on animals and plants. For example, when some crops, such as potatoes, are under moisture stress (a direct effect), damage from insect pests, e.g. green leafhoppers (an indirect effect) can soar. The weakened plants become more attractive to pests, leading to more pest damage.

Management responses can create new vulnerabilities

Sometimes human management responses to direct and indirect effects of climate change can create new vulnerabilities and if inappropriate responses are selected can result in maladaptation, the increase in farmers' vulnerability. For example, in areas experiencing a decline in rainfall, farmers can take steps to capture more of the rain that does fall. Some of the available technologies are very effective. Depending on the soil types and crop sensitivities to waterlogging, the capture of more rainfall, especially that from large storm events (also increasingly common), can create localized inundation conditions that decrease growth in waterlogging-sensitive crops. The movement of livestock herds to new locations in search of water and better pasture can expose animals to new pest and disease pressures. Efforts to retain river water in reservoirs and dams in response to reduced rainfall can affect stream flow and survival of wild fish populations downstream. Some species have adapted their reproduction cycle to match seasonal flooding. Disruption of that cycle can greatly reduce their populations.

3.3 **Key ideas**

- **Every species has unique tolerances as well as limits** to the range of conditions that it can withstand.
- **Increasing temperatures and changes to rainfall patterns and amounts** are directly affecting all crop, fish, forest and animal production systems and even the entire food value chain.
- **Climate change can also indirectly affect these same systems and species** through changing pressures from diseases, weeds and insect pest populations. These indirect impacts are sometimes less noticeable than direct impacts and may be more difficult to connect to changing weather patterns.
- **Climate change stresses can also act in combination with greatly increased effects**. The potential combination of effects – heat and moisture stresses (direct–direct), moisture stress and vulnerability to insect pest damage (direct–indirect), increased pest populations and pest-transmitted disease (indirect–indirect) – makes the identification of appropriate management responses and rapid action especially important and challenging.
- **Some management responses can create new risks**. It is important to thoroughly think through the potential consequences of various management options before taking action.

Steps in **bringing** climate change **adaptation** into farmer field schools

Quality farmer field schools go through a preparatory stage, implementation stage and post-FFS/follow-up stage. The *Farmer field school guidance document: Planning for quality programmes* (FAO, 2016) provides detailed steps and guidance on how to design FFS programmes. More information about designing and implementing FFS programmes is available in many manuals such as the guide for FFS on discovery-based learning in land and water management (FAO, 2017a).

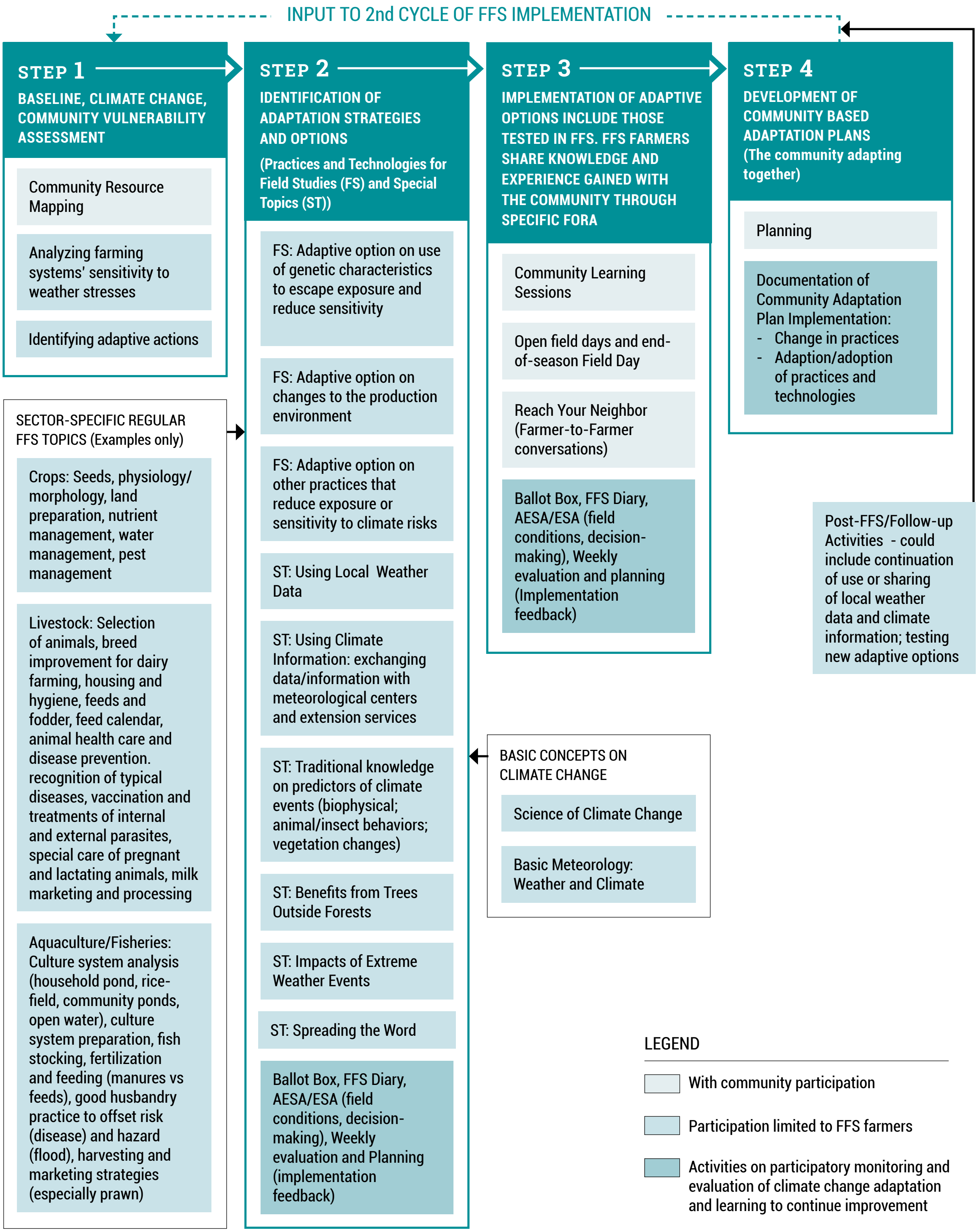
In an FFS that brings climate change adaptation into the curriculum, the contents and some activities during the preparatory, implementation and post-FFS/follow-up stages will be expanded and/or adjusted to integrate aspects on climate change. The diagram below proposes how climate change adaptation can be integrated in existing FFS programmes. Activities detailing each step will be provided in the remaining chapters of this guidance note. The technical content of the FFS curricula – whether agriculture, aquaculture or agroforestry – reflected on the chart may not be exhaustive and may be different from what exists in the countries. The proposed steps consider that the most ideal approach to enhance resilience to climate change is to involve various stakeholders in the community in identifying and implementing adaptation and, to some extent, mitigation strategies.

Bringing climate change adaptation into an FFS (whether agricultural crops or livestock, aquaculture or agroforestry) begins when master trainers and facilitators first introduce the FFS programme to the community. It will be important to introduce the concept of integrating climate change in the FFS curriculum during the initial dialogue with the community leaders and members. It is during this dialogue that the role of each stakeholder is defined and responsibilities (e.g. active participation in activities) are clarified and agreed on. When the FFS programme is accepted by the local leaders and the community, the next steps in preparing for setting up and implementation of activities will be facilitated.

Climate change variables influence the duration of the FFS, the space/area to be covered and the number of people to be involved – i.e. in some activities maybe the entire community or maybe also more communities!

During the preparatory stage, master trainers and facilitators carry out the Baseline Climate Change Community Vulnerability Assessment (**Step 1; see Chapter 5**) with community leaders and members. The Community resource mapping exercise (see Exercise 1) will be done together with other members of the community to identify the locations where important farming system activities are carried out, and the weather risks the various activities are exposed to. The results of the discussions during the mapping exercise could include the identification of strategies and options that farmers/community may have already been implementing and could be included in the community-based adaptation plan for possible immediate application by more farmers. (See p. 38 for the Malawi Case Study on use of hotspots baseline assessment for designing FFS.)

Figure 14: Steps in bringing climate change adaptation into farmer field schools



Source: Authors' own elaboration

CASE STUDY

Malawi's land degradation hotspots baseline assessment for catchment management interventions in FFS integrating climate change adaptation

An innovative participatory approach geared to strengthen baseline assessment based on the Intergovernmental Panel on Climate Change (IPCC) definition of vulnerability is being employed by the farmer field school (FFS) programme in Malawi for the purpose of developing climate change catchment-specific FFS adaptation and mitigation interventions for hotspots. The implementation plan of the participatory approach is based on three components namely: 1) location-based hotspot profiling and mapping, 2) catchment-based zoning and planning for site-specific interventions, and 3) development of community-based catchment adaptation and management plans.

A hotspot is a location considered under severe threat due to natural and human-induced activities, which result in loss of productivity of part of or the entire catchment or watershed. Within a catchment, several locations could be termed as hotspots exhibiting climate-related vulnerability/variability issues and indicators of critical degradation like presence of gullies, flooding, deforestation, riverbank cultivation, soil erosion, and extensive mining. In the innovative participatory approach, the land degradation hotspots in the targeted communities are profiled and mapped and micro-catchments delineated within a Geographic Information System (GIS) environment for purposes of zoning and planning for appropriate site-specific catchment interventions. While hotspots are location-specific, they do not conform to administrative

Figure 15:
Extensive gulley erosion

Figure 16:
Physical degradation from brick making

demarcations and therefore a catchment-based approach is needed to avert the degradation and achieve sustainable agricultural production and productivity.

The process of land degradation hotspot baseline assessment is carried out in addition to resource mapping. Results from both assessments form the basis for establishing farmer field schools, identifying study topics/activities to focus on, identifying community-wide climate adaptation and mitigation short- and long-term strategies, defining group by-laws etc. During the baseline assessment, a strong component of transformative knowledge transfer is employed through the use of time series satellite imagery. High-resolution imagery is reviewed to enable the community to appreciate levels of degradation that has taken place over the years. Geotagged photos of each hotspot location are captured for progressive monitoring. Consequently, using imagery, remote monitoring of site-specific interventions undertaken is captured for change detection analysis.

Figure 17:
FFS Field Day in Malawi

At catchment level, a community adaptation plan (CAP) is generated, incorporating various adaptation and mitigation strategies. Each FFS group established in the catchment selects from the CAP the strategies suitable for their location, and designs site-specific interventions to implement the strategies through a group adaptation plan (GAP) for their location (hotspot at micro-catchment level). The rationale for developing the CAP at the onset of the FFS is to ensure that there is sufficient time for the community-wide adaptation and mitigation strategies that go beyond the FFS learning cycle, such as natural tree regeneration in conservation belts, protection of riverbanks and other water sources, and safeguarding of landraces with important food or nutrition attributes. Most ongoing FFS initiatives are within the framework of projects that often do not exceed five years.

At the end of, or during the learning cycle, the community re-evaluates the CAP based on lessons emerging from the various FFS groups in the given catchment. These experiences are shared at the joint field days and graduation events as well as during joint monitoring/supervisory visits by stakeholders. Additionally, the same process of remote monitoring using satellite imagery is done in subsequent years to enable the community to see the progress of improvements in their landscape as a result of their actions after the FFS.

Source: FAO Representation in Malawi.

The other baseline assessment exercises will be carried out by FFS farmers only and the outputs will be used to identify adaptation strategies and options to be tested in field studies and special topics (**Step 2; see Chapter 6** and **Chapter 7**).

Adaptive options will be tested in field studies and farmers select special topics to include in the curriculum (**Step 3; see Chapter 6** and **Chapter 7**). Regardless of the field studies that are chosen, it is strongly recommended to **include the collection of weather information as part of the FFS activities** (see Special Topic 1, in Annex C). Climate change is about changes in the weather patterns. Being able to record and compare what happens with the weather, and how the different treatments in the field studies respond to specific weather stresses, will be essential for assessing whether the different practices offer farmers adaptive solutions, or not.

©FAO/Ami Vitale

Information gained from FFS activities, including progress of field studies, will be shared with the community in a more systematic approach. FFS participants are encouraged to prepare a plan on how they can help to spread the benefits of the new technologies and practices that prove useful in their field studies (see Special Topic 6, in Annex C). The purpose of sharing FFS experiences is to expose and support community members in gaining benefits from the activities being carried out in the FFS.

In some cases, at the end of the FFS cycle, the community may choose to develop an adaptation plan (**Step 4; see Chapter 8**) taking lessons learned from FFS farmers (i.e. results of field studies and special topics) in addition to strategies and options community members have already been implementing and found effective.

A participatory monitoring and evaluation approach can be used to support dynamic information sharing between stakeholders (e.g. communities, project team etc.). The process seeks to answer whether the FFS is implemented according to plan, of high quality and considered useful by the community as well as to assess changes that result from participation in the FFS. Monitoring, evaluation and learning – carried out throughout the FFS cycle – allows all stakeholders to reflect on what needs to be modified or strengthened in the FFS programme as to achieve target impacts or design a follow-up programme (see Chapter 9 for more details).

Community Baseline Climate Change **Vulnerability Assessment**

From this chapter onwards, details on the steps in bringing climate change adaptation into FFS will be presented. This chapter provides details on Step 1: Baseline Climate Change Vulnerability Assessment.

In designing an FFS programme, master trainers and facilitators work closely with communities and support them in examining the local/field-level context in which the programme is being designed, including the problems to be addressed, among other considerations. Preparatory activities are carried out prior to designing the FFS programme, working with local communities to design, conduct and interpret a baseline survey and/or context analysis on both biophysical and socio-economic conditions in the target FFS area.[1] The Community Baseline Climate Change Vulnerability Assessment in this guide will strengthen existing FFS baseline surveys with aspects on climate change and related risks and a stronger community participation in view of the development of local adaptation plans as part of the programme.

To start working with communities and farmers to assess the vulnerabilities of their agricultural systems to changes in weather patterns it is possible to begin the discussion in different ways. The options include: identification of the major vulnerabilities of the household livelihood systems; use of a landscape approach, identifying locations where specific types of events are most common or severe; discussion of farmers' observations of changes in weather patterns and the impacts on the crops they grow; or another point of entry (e.g. livestock) depending on their farming system.

The Community Baseline Climate Change Vulnerability Assessment should lead to the design of field studies for the FFS and **initial** community adaptation plans. There are two suggested ways to carry out the assessment. This chapter introduces a simplified option for facilitating the vulnerability assessment. The second option, a detailed and in-depth process for assessing climate change impacts is presented in **Annex A**. Depending on the context and objectives of the FFS programme, and other considerations, FFS master trainers and facilitators may find that one approach, or the other, will work better. They may also find that organizing these exercises differently will help the field school to run more smoothly. The exercises that follow may use examples from a specific production system, e.g. agriculture (crop and livestock), aquaculture or agroforestry. Do not be afraid to experiment in making adjustments to suit local requirements!

As described in the previous chapter of this guide, climate change and its direct and indirect impacts on production systems is not one thing but many related changes and types of stresses. Exactly what, when, where and how farm families will feel these changes – individually, one after another and in combination – is unknown. To work with communities and farm families to reduce their vulnerability to the various climate change

[1] More details about designing an FFS programme are available in the *Farmer field school guidance document* (FAO, 2016).

risks, FFS master trainers and facilitators will need to identify with them:

- How local weather patterns are changing.
- How exposed their different activities are to specific climate change risks.
- How sensitive various species or activities are to the risks identified.
- What adaptive responses can be made or improved to avoid climate change risks and reduce their impacts.

As a general rule in answering these questions, always look for and compare multiple sources of information – for example, using farmers' observations to locally validate data analysed by the national or local meteorological service or information from vulnerability studies. Bringing in local leadership, representatives of organizations and the meteorological service during the planning stage of the field school stresses the importance of the participation of the entire community in addressing climate change risks and their impacts in a concerted effort. The exercises that follow in this chapter are designed to raise awareness of the larger community and introduce and gradually guide farmers through a process of collecting evidence, identifying and assessing the impacts that changes to weather conditions are having on their production systems.

Remember. Involve the community from the start. Climate change affects **everyone**!

Details are important!

For example, you may learn from the meteorological service that the total amount of annual rainfall has not changed much in the past 20 years. But you need to go deeper to learn, for example, whether more of the rain that does fall now comes outside of the traditional growing season or falls in large storm events, lost as runoff, with longer gaps between storms. Rain falling outside of the growing season – too late or too early – and rainfall lost as runoff in large storms is not available to growing crops.

5.1 Overall process

To help organize the various types of information needed to assess local climate change impacts, begin with mapping the physical location of the village, important natural resources and areas where farmers' major activities take place. The map should also indicate the type and locations where important weather-related damage occurs most often. The mapping exercise should include wide representation from within the community – young, old, women, men, individuals involved or specialized in different agricultural activities. Following the mapping exercise, this guide presents several additional exercises designed to help FFS members further assess the vulnerability (the exposure and sensitivity) of their main production activities to climate change. Together, these exercises will help master trainers and facilitators guide farmers through the steps of identifying when damaging weather events tend to occur, which farming system (crops, livestock, fish or trees) are most sensitive and when and where activities are most at risk. Once identified, potential adaptive responses can be proposed for testing during the field studies that reduce or eliminate major problems.

5.2 Preparing for the field: collecting valuable weather information

Before beginning to work with farmers, it will be important for master trainers and facilitators to collect and review all the information that can be found on climate change. Information that will be particularly important includes, how the weather patterns have been changing, how they are anticipated to change further, and how these changes impact – or may impact – the various production activities. Potential sources of weather-related information include the national meteorological agency, the national agricultural research service, the national climate change focal point, university researchers or specialized research units, studies and donor-funded projects. However, in facilitating an assessment of the local effects of climate change on farming systems, rather than information on annual averages, better still are details on changes to specific weather features that tell whether the weather risks affecting crops, livestock or aquaculture and agroforestry production etc. are occurring more often.

In livestock production, for example, information on the increase in temperature will be useful. However, details on changes to specific weather features would be more important, such as the frequency of heatwaves that result in less successful livestock reproduction. For aquaculture production, information on temperature changes in both water and air will be useful. However, specific information on change in the timing of hot and extremely high-temperature days affecting surface temperature of water would be more important. For crop production, specific information such as the start of the rainy season or frequency of drought events that have important impacts on local crop production systems would be more important than general information on average annual rainfall (see Table 1).

Information on weather features will help to better understand what changes are occurring in local weather patterns and to identify the risks that may affect farming activities.

The exercises that follow are progressive and build on key messages from earlier exercises, offering a simple approach to carefully analysing the stresses that farmers are experiencing from changes in weather patterns and identifying the impact these changes are having on their production systems that require adaptive action. The objective, completed in **Exercise 5** (in Chapter 6), will be to establish field studies and special topics for the FFS.

The examples used in the exercises are all on crop production systems only to illustrate how the outputs of the earlier exercise feed into the subsequent exercises.

The exercises may be adjusted to suit the requirements of other farming systems.

Heatwaves are the combination of duration and intensity of air temperature.

Table 1. Climate change risks for crops and rainfed cropping systems

Temperature		Rainfall	
Measurement	Insight	Measurement	Insight
Change in average annual temperature	Are temperatures increasing?	Change in average annual rainfall	Is rainfall increasing or decreasing?
Change in average monthly high temperature	Are days getting hotter during the cropping season and, if so, how quickly?	Change in average monthly rainfall	Is there a shift in when rainfall is occurring during the year?
Change in average monthly low temperature	Are nights warming and, if so, how quickly?	Change in timing of start of rainy season	Are rains starting sooner or later?
Change in number of days above crop's high temperature threshold	Is more of the growing season above critical temperatures affecting crop yields?	Change in number of dry spells at the start of the rainy season	Are "false starts" to the growing season increasing?
Change in number of days above crop's low temperature threshold	Are hot nights becoming more common?	Change in timing of end of rainy season	Are rains ending earlier?
Change in number of extremely high temperature days	Are hot days or heatwaves becoming more frequent?	Change in length of rainy season	Is the growing season getting longer or shorter?
Change in timing of hot and extremely high temperature days	Are hot days and heatwaves occurring during periods when crops are most sensitive?	Change in amount of rainfall within rainy season	Is the amount of rainfall available during the rainy season changing?
Change in timing of high temperature nights	Are hot nights occurring during periods when crops are most sensitive?	Change in number of days between rainfalls	Are dry spells becoming more frequent and/or longer?
Change in number of high temperature nights	Are night-time temperatures rising faster than daytime temperatures?	Number of large rainfall events above soil infiltration threshold	Is more rainfall being lost to runoff?

EXERCISE 1

Community resource mapping

Background:

The participation of the different community organizations (local government, local meteorological office, women's association, youth association etc.) and community members from the early stage of establishing the field school is essential in raising awareness on the issue of climate change and its impacts on local production systems.

FFS master trainers and facilitators should request local leaders to call a community meeting, scheduled at a time that is convenient for the villagers. Ideally, the meeting should be open to everyone in the community. However, to ensure more active participation in discussions, the various community organizations may assign representatives to attend so the size of the group will be more manageable. Stress that the contribution of the community during the mapping exercise is important as inputs will be used to design the FFS content and select field studies. The field studies could identify and test options to address impacts of climate change on the community.

Climate conditions will differ depending on the landscape, altitude and livelihood conditions. Climate change adaptation practices and technologies will vary depending on these conditions.

Learning objective:

Identify the locations where important farming system activities are carried out, and the weather risks the various activities are exposed to.

Materials/preparation:

Four pieces of flip chart paper and markers ready to support four groups.

Timing:

Before the start of the field school.

Time:

2 hours.

Steps:

Prior to the session, prepare a matrix in the format below to enter information emerging from discussions following the mapping exercise.

Explain that the exercise seeks to identify the locations where important farming system activities are carried out, and the weather risks the various activities are exposed to, specifically indicating what, when and where. This information will be used later in discussions with the community on what they can do – individually and together – to reduce risks and threats.

Using the main road as the point of reference, divide the village into quadrants. Divide participants into four groups. Assign one group each to a quadrant. On their assigned quadrant, the group should map the village using the following information:

- Agricultural land using variation production criteria, such as crops, soil types (moisture-holding soils versus soils that have more sand and are free draining), soil fertility and water supply.
- Location of agriculture (crop and livestock) areas in relation to water sources (wells, canals, lakes, ponds, rivers), fields in low-lying areas versus those in the uplands, fields that are on slopes versus those on flat ground, fields near the community that may be managed differently than bush fields located farther away.
- Aquaculture production areas (e.g. fishponds) and criteria such as source of feed and water supply.
- Livestock production areas and criteria such as source of feed (e.g. grazing lands including native pastures, croplands producing forages such as rice straw or vegetables), shelter and water supply/ water points.
- Non-agricultural and non-residential land using utilization criteria (e.g. forest, watershed, reservoirs).
- Degraded/impacted areas in the village.

When all groups have completed the task, put the quadrants together to form the village map for everyone to see. Ask participants to validate or add information on the outputs of the other groups.

Lead discussions on the questions below and note the answers in the matrix (see Table 2) that was prepared before the session.

Make sure to keep the map. It is intended to serve as a source of baseline information for use in exercises in this chapter and later in the season (see especially, Special Topic 4 on Impact of extreme weather threats).

Table 2: Weather-related production problems and how they affect livelihoods

Weather-related production problem	How it affects livelihoods	Where does the problem have its greatest impact?	When during the year does the problem occur most often?
Example: Long dry spells during the growing season	Reduces crop yields, lowers income	Upland fields south of the village	July and early August

Discussion questions:

- On what areas (e.g. low-lying areas, slopes, flat ground) are crops grown? What crops? Since when have farmers been growing these crops in these locations?
- Where are livestock and aquaculture/ fish raised? What species? Since when have farmers been raising livestock and aquaculture/fish in these locations?

- Where are the grazing lands located? The watersheds? The forested areas? Where are the water points?
- Are there areas that were used differently ten years ago? What are the reasons, if any, for changes in the use of the areas?
- What causes degradation of the areas identified on the map?
- Where are the most vulnerable sites in the community? What makes these sites vulnerable? To what degree are the farming systems susceptible to or unable to cope with the adverse effects of climate change? What will happen if farmers/the community do not take any action?
- What climate-related threats to production have farmers reported because of the field or production area's location/position in the landscape? Are the threats more severe, or do they occur most often in particular locations or types of fields? Have these threats been changing in recent years?

Optimum balance

Areas with two rainy seasons, perhaps known locally as long and short seasons, will be more complicated to represent than areas that have only a single rainy season. Always seek a balance between completeness and simplicity, so that calendars do not become too complicated and unreadable. In areas with two rainy seasons you may need to record the information about the different seasons on two separate calendars.

EXERCISE 2

How is the weather changing?

Background:

It is important to identify the weather events that farmers have observed which threaten their farming activities. Farmers can indicate when these weather events most commonly occur within the production season calendar. For example, farmers growing beans may be able to easily recall specific events such as flooding caused by heavy early rains or damaging dry spells that occurred while their crops were very young and sensitive to these types of stresses. In dryland areas, farmers growing sorghum and millet may have noticed rainy seasons that ended sooner, causing lower yields due to moisture stress during the crop's grain-filling stage. The intent is to have farmers think back over the past five to ten years and indicate at what point in the production season specific types of weather threats most often occur in their area. Individual threats may occur at more than one time during the season.

Learning objective:

Develop a calendar that identifies when, within the farming season, important weather stresses most commonly occur and how these might be changing.

Materials/preparation:

Paper/flip chart and markers.

Timing:

Before the start of the field school.

Time:

1 – 1.5 hours.

Steps:

To create the weather threat calendar, start a brainstorming session with farmers to identify weather threats that occur during the production season that harm one or more of the products they produce. On a flip chart or piece of paper, have farmers make columns for the months of the year or local ways of dividing up the production season. Create a new row for each type of weather threat that is identified. Keep adding new threats until the list is complete. For each weather threat, have farmers indicate when the threat most commonly occurs during the season, as shown in **Figure 18**. Remember, threats may occur at more than one time during the season.

Figure 18: Farmers' observation of weather threat calendar

Weather risk	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heatwave												
Dry spell												
Flood												

Farmers' observation

(If smaller groups were formed, bring them back together at this point and allow each group to present and explain their calendars. After the presentations, it is useful to build a single calendar containing all the weather threats identified by the different groups.)

Once you have indicated on the calendar the weather threats that farmers have observed, you can add information that you have gained from other sources, such as researchers, the meteorological service or climate change studies. Add this additional information to the calendar using different colours or symbols for each different source of information as in the example in **Figure 19**. It is good to discuss with farmers any difference between their observations and those from other sources, and to come to agreement on the best way to represent recent weather patterns.

Depending on the type of information that you have access to, you may be able to further modify the weather threat calendar to include anticipated, future weather conditions as in the example in **Figure 20**. Including this additional information will allow you to use the weather threat calendar to discuss with farmers what has occurred in the past, up until the present, and also what is anticipated to occur in the future. Comparing and discussing the two situations – the past and the future – will be helpful in understanding climate change trends and what challenges may be coming. Looking only at what happened in the past may lead to mistakes in anticipating what conditions will be like in the coming decades.

Figure 19: Farmer–research observation of weather threat calendar

Weather risk	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Heatwave							X	X	X															
Dry spell									X	X	X													
Flood															X	X	X							

Farmers' observation   X Research observation

Figure 20: Farmer–research–future weather threat calendar

Weather risk	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Heatwave							X	X	X	X														
Dry spell									X	X	X	X												
Flood															X	X	X							

Farmers' observation   X Research observation   X Future threats

Discussion questions:

- What are the main threats identified? Have these threats been changing in recent years? More or less common? More or less severe?
- Which weather threats are most common? Most severe?
- Are the threats more severe, or do they occur most often in particular locations or types of fields?
- Is more information on weather patterns needed? Where can we find more information? Is there information that we can collect ourselves that will help us to monitor future changes to the weather?

Details, details, details

In creating this calendar, it will be very important to be as specific as possible. For example, if farmers first identify "lack of rain" as a major weather threat, keep questioning them until you have a clear definition of what "lack of rain" means. Is it a year when little rain falls, although the rain that does come is evenly distributed? Or is it a year when the rains start late, the rains end early, or there are one or more dry spells in the middle of the season? How long does a dry spell need to be before it becomes a problem? One week, two weeks? It is important to be as specific as possible because the most effective adaptive practice may vary depending on the details of the threat.

EXERCISE 3

When are local farming systems (e.g. crops, livestock, aquaculture, agroforestry) most sensitive to weather stresses?

Background:

The same weather stresses can have very different impacts on a local system's productivity – their sensitivity – depending on when they occur, at what stage of the production cycle. You will also want to pay particular attention to possible combined effects (e.g. high temperatures occurring at the same time that crops are under moisture stress) as the impacts from combined weather stresses are generally much greater.

Learning objective:

Develop a timeline for each local farming system, indicating those stages of development or phases in the production cycle when these are most sensitive to different weather stresses.

Materials/preparation:

Paper/flip chart and markers, priority species identified in **the Community resource mapping (Exercise 1)** and the **Weather threat calendar** developed in **Exercise 2**.

Timing:

Before the start of the field school.

Time:

1 – 1.5 hours.

Steps:

Introduce the topic and lead a general brainstorming session with the entire group on farmers' production systems. Ask participants to refer to the map created in Exercise 1 showing the physical location of production-related activities around the village and ask them toand ask them to identify: What production systems are there in the different locations on the map? To what degree are the farming systems susceptible to or unable to cope with the adverse effects of climate change?

As farmers name the local systems, make a list of the species/varieties that farmers mention.

To identify how **sensitive** the specific farming activities are to various weather stresses, you will want to create a development timeline for each, showing each stage of growth or production cycle. For crops, starting with seeding and crop germination (the use of drawings is helpful, see **Figure 21** on p. 53). You will need to develop a separate development timeline for each of the farming activities (e.g. crops, livestock, aquaculture, tree resources) that have been listed at the start of the exercise as these are the main products most exposed to specific weather threats.

Organize farmers in a single group for this exercise. Farmers should lead this exercise, dividing the stages of the production cycle for each activity in the way that makes sense to them. They can even draw the stages of development (see **Figure 21**) or the production cycle! Make sure, however, that the development timelines include the critical stages of development or production cycle.

For crops, this should include germination, plant reproduction (flowering), yield formation and harvest, as these are times when all plants are most sensitive to weather stresses. The timelines should indicate how long the farming system is in each development stage or phase of the production cycle, typically counted in the number of days (or weeks). Try to make the boxes indicating the different stages proportional to the length of that stage – longer boxes for long stages, narrower boxes for short stages (see **Figure 21**). Use a separate piece of paper for each farming activity timeline.

After farmers have created the development timelines, review each of the timelines and add any important information that you may have learned from researchers or other partners related to important stages of development where the product/s are particularly vulnerable to specific weather stresses.

Make another column to the left of the timeline to create rows for each type of weather threat that the activity is most sensitive to. Review the map recreated in Exercise 1, **Community resource mapping**, to make sure all of the weather threats identified as affecting each activity are listed. You can also supplement the list of weather threats as a brainstorming exercise with farmers, adding a new row for each type of weather threat.

Beneath the picture of each stage of development/production cycle, indicate those stages where each identified weather threat is most harmful (or the activity is most at risk), as shown in the bottom part of

Figure 21: Stages of plant growth and vulnerabilities to weather threats

	Germination/Emergence Early vegetative growth 25-30 days	Vegetative maturation 25-40 days	Flowering 15-20 days	Early grain filling/Grain maturation/ Harvest 45-60 days
Frost				
Heat				
Drought	XXXXXX	X XXXXXXX	XXX	
Flood	XXX			

X Farmers' observation   Research observation: Most severe   Least severe

Figure 21. Threats may appear in more than one stage of development. It is best to guide farmers through this exercise first, then add any additional information that you might have collected from researchers or other sources, using a different colour marker or symbol. When you have finished, you will have created an accurate diagram of the stages of development/production cycle showing when each farming system is most **sensitive** to each specific weather threat.

Now, overlay the individual stages of crop development and the **Weather threat calendar** (**Figure 18** on p. 49 and **Figure 21**). You are looking for any stages of crop development where the crop is particularly sensitive to a weather stress, and when that weather stress has been observed to commonly occur.

The list of the specific weather stresses and the critical stage of development/production cycle to which the activity is most sensitive and exposed is very important as it identifies areas of greatest **vulnerability** within farmers' production systems. These are areas where adaptive responses may be most needed. The list can be used in identifying adaptive practices to test in the field studies and special topics of the FFS.

Figure 22: Linking crop sensitivity and weather

	Germination/Emergence Early vegetative growth 25-30 days	Vegetative maturation 25-40 days	Flowering 15-20 days	Early grain filling/Grain maturation/ Harvest 45-60 days
Frost				
Heat				
Drought	XXXXXX	X XXXXXXX	XXX	
Flood	XXX			

Weather risk	April		May		June		July		August		September		October	
Heatwave	X	X	X	X										
Dry spell			X	X	X	X								
Flood														

Discussion questions:

- For each farming system covered in the exercise: How do the different weather threats affect the activity? What are some of the signs that farmers notice? At which stages are the main activity/ies most sensitive and exposed to weather threats? What happens exactly when these weather threats occur (e.g. slower growth, reduced production, death)?
- Are the threats that occur in the most sensitive stages of the crop or animal development becoming more or less common? What have you learned from other sources about future weather conditions? Will the threats become more or less common?
- Which crops or species are more sensitive to weather threats? Which ones are less sensitive? Are there locations where the farming systems are more exposed to weather threats? How have these weather threats affected your decisions on which products to engage in?
- Are risks to weather threats higher in farming systems that produce only one product (monoculture) or in diversified systems? Why or why not?
- Is it possible to anticipate what weather threats will happen in the future and which crops or species will be affected? Why or why not?

Pay particular attention to the estimated future climate changes. These estimations may also help you to identify potential threats – those that are not currently a problem but may become problems in the future. **The ability to anticipate increasing or future problems is key to successful climate change adaptation.**

EXERCISE 4

What adaptations have farmers already made?

Background:

Farmers are constantly adjusting and making changes to their farming systems in response to various pressures and opportunities. In this exercise, farmers will list those changes that they may have made in their farming practices in response to the key areas of **vulnerability** identified in **Exercise 3** and evaluate how effective these changes have been in responding to the important weather stresses that have been identified.

Learning objective:

Develop a list of the adaptive changes farmers have already made in their production systems in response to the observed weather stresses, and how effective these changes have been as an adaptive practice.

Materials/preparation:

Paper/flip chart and markers, figures produced in **Exercise 3**.

Timing:

Before the start of the field school.

Time:

1 – 1.5 hours.

Steps:

Before the session, prepare a matrix following the format in Table 3.

Start discussions by reviewing the list of system sensitivities to observed weather threats developed by the group in **Exercise 3**. Go through each product one at a time and brainstorm with the whole group to see if any of the participants have made adaptive changes to their production system in response to the observed sensitivities–threats.

Note down the farming activity and product at the top of the matrix. Fill in the matrix beginning with the action taken and indicate which specific weather stress it responds to.

Table 3: Farming activity and product

Action taken	Weather stress	What worked	What did not work	What changes or adjustments could be made to make it work	Test or not test (Y/N) – based on feasibility, difficulty, priorities

Next, ask the person (or individuals) who implemented the change to determine how effective the change was; what worked, what did not work, what changes or adjustments might be necessary and could be tried out. The list could be the basis for selecting topics for the field studies in Chapter 6 on adaptation options.

Discussion questions:

- What are the main changes that farmers have made? At the field level? At the community level? What are the results so far?
- What are other ideas of changes that can be made? Think about changes you can make in the production system and actions that might be taken at the landscape level.
- For the ideas listed above, which are feasible? Which will be difficult to do (technically difficult, expensive, labour demanding)? What are the priorities?

The next exercise, **Exercise 5**, in Chapter 6 on adaptation options is designed to help you in selecting and designing the FFS field studies and special topics.

5.3 Key ideas for reflection

- **Timing is everything**. Individually and in combination, when specific weather events occur makes all the difference. Production systems (e.g. crops, livestock, aquaculture, agroforestry) have different sensitivities to weather stresses at different stages of their development/production cycle. For crops, dry spells of a week or more can be fatal for seeds that have recently germinated, whereas plants that are already well established will generally survive. The combination of two or more stresses at the same time generally has much greater impact than one alone. For example, many crops can tolerate periods of high temperatures unless they are under moisture stress at the same time. Then high temperatures can have very severe impacts, especially if these stresses occur during critical times such as flowering.
- **Change is different from variability.** Farmers need to understand that what is happening to their farming systems under climate change is different from the stresses of weather variability that they have experienced in the past – where coping until conditions returned to normal was the best strategy. Under climate change, weather conditions are increasingly moving away from the way they were in the past and will not return to former levels. In response, farmers will need to begin changing their


©K. Pratt

farming practices – doing things differently, and doing different things – in order to adapt to the new conditions.

- **Climate change is a process without end, so adaptation will be continuous.** Each new adaptation will offer a window of opportunity where it provides benefits until conditions pass a point where another adaptation action is required. There are limits, however, to the adaptive options available for any activity. At some point, activities, even certain fields, may simply need to be abandoned.

- **Determining the best moment to switch between adaptive practices (the switching point) will be farmers' most difficult challenge.** Depending on the practice, such as switching between crops, changing too early may put the farmer at a disadvantage with a less productive or less valuable crop. Waiting too long can result in needless loss and depletion of resources. Because of local conditions and household resources, households and communities will most likely make adaptive changes at different times.

©Agrorural_MINAGRI

- **Work at the scale that the climate change threat needs to be addressed** – plot, hillside, watershed. The response to some risks is best taken at the field level by individual farm families, such as the decision to change varieties. Other risks require group actions, such as farmers up and down the hillside each protecting his/her own plot to reduce soil erosion and prevent landslides brought on by heavy storm events. Matching the adaptive response with the scale of the climate change threat will be an important principle in working with farmers.

Some challenges to integrating climate change adaptation in farmer field schools

As you begin to prepare for and carry out your FFS activities, it will be good to consider some of the challenges listed below:

- Some features of climate change are difficult to observe, such as irregular, long-term trends, changes to night-time temperature that occur when most people are sleeping, the impacts of increasing CO_2 gas concentrations.
- Some impacts of changing weather patterns are not known (have not occurred before in farmers' experience), or are the result of multiple factors, such as low yields occurring in a year when crops suffered from a combination of deficient soil nitrogen, high temperatures during flowering and moisture stress during grain filling. "Unpacking" the impacts of weather stresses can be difficult. The impact of changing weather stresses is less well known for pests, weeds and diseases.
- Limitations to human memory can make the recall of detailed information, such as the calendar date or the age of certain crops at the time when an important weather event occurred, unreliable beyond three to five years.
- Changes to season-to-season weather are not constant; weather may not cooperate with planned field study activities designed to test specific adaptive actions (e.g. the benefits of conserving soil moisture in a season with sufficient and regular rainfall).
- The optimal timing for making a change ("switching point") is difficult to determine and highly dependent on the local context, household needs and personal preferences of the decision maker.

Adaptation options
to test in FFS field studies and special topics

This chapter provides details about Step 2: Identification of Adaptation Strategies and Options and Step 3: Implementation of Adaptive Options Tested in FFS.

6.1 Getting ready for the field

After working with the community (**Exercise 1**) and the FFS farmers in **Exercises 2, 3 and 4** to assess how specific features of the weather may be changing, how these changes affect their farming systems (e.g. crops, livestock, aquaculture) and how farmers may have started trying to adapt, the FFS group is now ready to begin the next steps of selecting and testing potential adaptive options. The **adaptation options** selected for testing in FFS field studies can be included in the **community adaptation plan** if the results are promising, i.e. that the options can reduce the impacts of climate change on farmers and the community, reduce greenhouse gas emissions where possible, while making agricultural production profitable and sustainable.

FFS master trainers and facilitators are very knowledgeable in the process of designing field studies and special topics with farmers, having been trained in training of trainers (ToT) and from their experience in implementing FFS programmes.[2] However, for integrating climate change adaptation in FFS some further explanation is provided below that should be considered in the selection of the subject of the field study or special topic.

To help guide the process of selecting adaptive options for testing, you may find it useful to think in more detail about the sources of **risk exposure** and **sensitivity** to weather threats. These concepts were introduced earlier in this guide (see Chapter 2). The weather risks that farmers' various activities are exposed to are the result of **location** and **timing** – flooding risks are most common in lowland areas during the rainy season; dry spells have the greatest impact in upland fields with sandy soils – for crops, especially when they occur just after seeds have germinated and during the reproductive period. Adaptive practices that reduce or eliminate exposure to specific weather risks often involve changing **where** and **when** production – in this case, agriculture – activities are carried out. For example, shifting where certain crops are planted to avoid waterlogged field conditions from increasingly frequent large rainstorms, or switching to a quicker maturing variety to avoid yield damage when there is a trend of increasingly unreliable rains at the end of the growing season. Or for example, shifting the location of the shelter of livestock to avoid mortality brought about by flooding in low-lying areas, or changing the work schedule of draft animals to early in the morning or late in the afternoon to reduce heat stress during dry spells. Regardless as to when and where the farming system (crops, livestock, aquaculture, and agroforestry) activities take place, all have varying sensitivities to what occurs in that location, in a particular season.

[2] Detailed information on how to design field studies and special topics is available in various FFS guides such as *Facilitating scientific method as follow-up for FFS graduates* (Van Den Berg, 2001).

When we talk about **sensitivity**, we are concerned with **what** happens in a particular place at a specific time – how farming systems or species or management practices respond to specific weather threats when they do occur. For example, the difference in the amount of topsoil lost during storms with heavy rainfall on plots where farmers use anti-erosion barriers and practise conservation agriculture (no soil disturbance, residue maintenance) compared with topsoil losses from plots where farmers use conventional tillage, with bare soils and furrows running up and down the slope. The unprotected plot is much more sensitive to soil loss from large rainstorms. In some cases, farmers can adopt practices that entirely remove sensitivity to major weather threats, such as when a farmer invests in irrigation equipment for a particular field. The farmer may plant the same crops in that field, but the field is now different – crops grown in that field are no longer sensitive to the effects of dry spells. Or for example, when a farmer in a coastal area shifts to raising shrimps instead of trying to continue growing rice to address the problem of increased salinity due to rising sea levels. The farmer still uses the same plot of land, but the plot is now different – it is a shrimp pond – as shrimps are not sensitive to the effects of salinity. The practices that farmers use can have a significant effect on how sensitive various production activities are to different weather threats. By carefully examining the results of assessment of the weather conditions that threaten various production systems and locations and when (covered in Exercise 2 and Exercise 3), the FFS group is now ready to identify the adaptive options for changing the farming system's exposure or the sensitivity to those threats and setting the FFS programme of field studies and supportive special topics.

It is also important to know that for each weather threat identified there may be several options for reducing or removing exposure or sensitivity (see Escape, reduce, remove box). Some options may reduce or completely remove exposure to a threat. Other options may reduce or remove sensitivity to the same

Escape, reduce, remove

In adapting to observed or anticipated impacts of climate change, the way in which various production practices function can take different forms. With regards to exposure, the vulnerability to weather threats relates to when and where farming systems are established or varieties are grown, and some changes will allow farmers to escape from being exposed to specific threats. In other words, the threat is still present, but by changing the timing or location of an activity, farmers are able to avoid some or all of the exposure. Other practices allow farmers to reduce the impacts of certain weather threats. In this case, the adaptive practice can either reduce the exposure to a particular weather threat, or reduce the sensitivity when it occurs, but cannot entirely avoid or eliminate the threat. Lastly are those practices that completely remove the sensitivity, usually by replacing an activity with another that is not affected. The weather threat is still there, but the negative effects are no longer felt.

weather threat. In some cases, making a single change may be sufficient, in other cases a combination of practices that reinforce each other in addressing the same weather stress may be most effective, even required. You will need to evaluate these different alternatives with farmers to choose those that best fit their situation, interests and resources while improving productivity and reducing negative impacts of the production system (e.g. crops) on the rest of the landscape (e.g. forests, pastoral communities).

Type of adaptation

The adaptive options available to farmers to respond to weather threats can be placed into three general categories:

Genetic

Using biodiversity – the genetic characteristics of different varieties or species – to escape exposure or reduce sensitivity to certain changes to the climate. Examples include planting earlier maturing varieties to avoid hot spells during the reproductive period, planting heat-tolerant varieties that are less sensitive to higher temperatures when they do occur, or switching to different tree species that better tolerate or even prefer warmer conditions.

Environmental

Making changes to the productive environment – how it looks and more importantly how it functions – to eliminate or reduce the impact of climate change-related risks. One example is building terraces or planting barriers of vetiver grass that protect the topsoil on vulnerable hillsides from erosion caused by increasingly heavy rainfall. In locations that are becoming drier, examples include introducing rainwater harvesting techniques to capture more of the rainfall that does come, building up soil organic matter to hold more of the moisture that is captured, and using mulch to reduce the loss of moisture held in the soil through evaporation.

Other practices

Making decisions – other than changes in the type of crops used or alterations in the production environment – that reduce exposure or sensitivity to climate risks. Examples include growing crops in new locations to avoid drought-prone sandy soils, or changing how seeds are planted to respond to the increasingly uncertain start of the rainy season. Crops can also be planted in different combinations so that plants are healthier and better able to withstand moderate weather stresses. There are even things that can be done to seeds before planting so that they germinate faster and are more resistant to certain types of threats early in the growing season.

Some adaptations can be implemented by individual farmers at the field level. For others, larger group and community action may be required. The FFS can contribute to discussions and planning for actions at these different scales as part of the learning cycle.

EXERCISE 5

Designing the FFS field studies

Background:

It is recommended that FFS master trainers and facilitators go through the options matrices below (Table 4 and 5) and read up on technical resource materials listed in **Annex C**. This will equip you with information on additional adaptive practices for testing in response to the weather stresses identified by FFS participants in Exercise 2 and Exercise 3.

Note again that the examples used in the exercises are all on crop production systems only to illustrate how the outputs of the earlier exercise feed into the subsequent exercises. The exercises may be adjusted to suit the requirements of other farming systems.

Learning objective:

Select potential adaptive options to test in the field studies considering "environmental" options, "genetic" options and "other practices" that work by changing the "exposure" or a species' "sensitivity" to a weather threat.

Materials/preparation:

Paper/flip chart and markers. The map created in **Exercise 1** and lists created in **Exercises 2, 3 and 4**.

Timing:

Before the start of the field school.

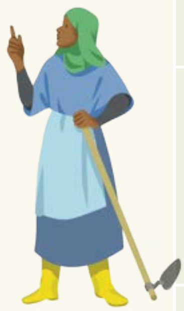
Time:

Half-day to full-day.

Steps:

- Start with an icebreaker on "Exposure" and "Sensitivity". Designate one area of the session place as "Exposure" and one area as "Sensitivity". Explain to farmers that you will describe some situations – one at a time. After you describe one situation, they should think about whether it is an "exposure" or a "sensitivity" and run to the designated area. After everyone has decided on a place, ask a few farmers why they think the situation is an "exposure" or why it is a "sensitivity". Clarify misconceptions so that farmers understand the differences. Possible examples:
  - Soil loss from large rainstorms from plots where farmers use conventional tillage with bare soils and furrows running up and down the slope compared with topsoil lost on plots where farmers use anti-erosion barriers and practise conservation agriculture – no soil disturbance, residue maintenance (Answer: Sensitivity)
  - Flooding in lowland areas during the rainy season (Answer: Exposure)

Vulnerability depends on the level of risk that the community might experience from a particular type of change (its **exposure**), how much that change would influence the system (its **sensitivity**), and the community's ability to adjust the system in response to that change (**adaptive capacity**).



- Rice plants dying because of increased salinity (Answer: Sensitivity)
- Dry spells in upland fields (Answer: Exposure)

- After the icebreaker, remind the farmers about the discussions during the Community resource mapping exercise. Display the matrix from Exercise 1 (Table 4) where you wrote down notes on discussions during the mapping exercise. Call attention to the fact that climate change affects the whole community and needs the action of various stakeholders. Explain also that the adaptive options that will be tried out in the field studies and show good results could later be used by other members of the community as part of an adaptation plan.

Table 4: Weather-related production problems and how they affect livelihoods

Weather-related production problem	How it affects livelihoods	Where does this problem have its greatest impact?	When during the year does this problem occur most often?
Example: Long dry spells during the growing season	Reduces crop yields, lowers income	Upland fields south of the village	July and early August

- Review with participants the results of Exercise 2 and Exercise 3 and select the most important farming activity (either crop, livestock, aquaculture, agroforestry), and the weather threats that you want to discuss first and focus on for the FFS. The activity selected should be of common interest to all the farmers of the FFS. Review the matrix created in Exercise 4 (Table 5) to stimulate farmers to reflect again on the options highlighted previously in the vulnerability assessment and to begin to think about possible additional options to be tested.

Table 5: Farming activity, product and weather threat (Example: Crop production, rice, dry spell during reproductive stage)

Action taken	Weather stress	What worked	What did not work	What changes or adjustments could make it work	Test or not test (Y/N) – based on feasibility, difficulty, priorities
Change to other rice varieties	Dry spell during reproductive stage	Fewer unfilled grains	Low yield	Try drought-tolerant rice varieties	Yes, this can be tested
Change to other crop (e.g. watermelon) with lower water requirement	Dry spell during reproductive stage	Watermelon survived	Soil type not suitable for watermelon	Try other crop species that require less water	Yes, this can be tested

Hint: If farmers are interested, it is recommended that you invest the time to discuss all of the different species–risk combinations identified in the earlier exercises. By going through the steps of identifying potential adaptive options, farmers will gain insights into how they might address these threats on their own, whether or not the products and adaptive responses are selected for testing in the field studies.

- Ask farmers to identify additional ways of responding to the selected weather threat (e.g. dry spell). After the farmers have exhausted their ideas, introduce ideas such as those summarized in the adaptive options matrices in Tables 8-11 and what you may have learned from the technical resource materials listed in **Annex C**.
- As you review the table (see example in Table 6), introduce and discuss with farmers the difference between the types of adaptation responses – i.e. actions they have taken (are they examples of **genetic, environment, other practices** described in the text box above) and whether the response allows farmers to change the **exposure** of their activity to a particular weather threat, or reduce **sensitivity** to that threat (see Chapter 2). The important point is to identify all the different possible adaptive options and to understand how they function so that you can lead a critical review of each option as described in the discussion questions that follow.

Table 6: Farming activity, weather threat and type of adaptation response (Example: Crop production, rice)

Action taken	Weather stress	What worked	What did not work	What changes or adjustments could make it work/type of adaptation response	Test or not test (Y/N) – based on feasibility, difficulty, priorities
Change to other rice varieties	Dry spell during reproductive stage	Fewer unfilled grains	Low yield	Try drought-tolerant rice varieties/**genetic**	Yes, this can be tested
Change to other crop (e.g. watermelon) with lower water requirement	Dry spell during reproductive stage	Watermelon survived	Soil type not suitable for watermelon	Try other crop species that require less water/**other practices**	Yes, this can be tested
Planting beans on rice bunds	Dry spell during reproductive stage	Fewer unfilled rice grains	Low yield from rice crop, but good yields from beans on the bunds	Try again to compare between seasons and viability of beans as alternate source of food and income/ **other practices**	Yes, this can be tested
Not yet tried, idea from facilitator	Dry spell during reproductive stage	Not yet tried	Not yet tried	Water harvesting practice (pit method)/ **environmental**	No, this may be expensive

- Once you have completed each table, listing all of the options for responding to a specific threat for a particular farming activity (crop, livestock, aquaculture, agroforestry etc.), **critically review the advantages and disadvantages of each option. Identify any resources that farmers might need in order to make use of the option. Also discuss the timelines (faster or slower results) that the options will need and how sustainable the options might be in the shorter or longer term (see Discussion questions).**
- From the previous matrix, take the options that have been identified to be tested and work through the next table to spell out details for possible field studies.

Table 7: Farming activity, weather threat and selected adaptive actions (Example: Crop production, rice, dry spell during reproductive stage)

Option to be tested	What to observe (examples only)	How to observe	When to observe
Try other rice varieties	Number of panicles Number of grains/panicle Insect pests and diseases Weeds Soil condition Inputs Yield % filled grains Weight of 100 grains	Observe samples (number depending on plot size) per treatment Use records, calculate costs Crop cuts	Weekly When inputs are made Harvest
Try other crop species (e.g. watermelon, turnip, sweet potato) that require less water	Length of stems/vines, colour of leaves etc. Insect pests and diseases Weeds Soil condition Inputs Yield	Observe samples (number depending on plot size) per treatment Use records, calculate costs Crop cuts	Weekly When inputs are made Harvest

Discussion questions:

For each of the adaptive options that are identified, guide farmers through a thorough assessment, discussing such things as:

- Does the option serve **multiple functions**? Does it respond to more than one weather threat, or product, or does it serve to protect an entire farming system where several different products are raised/grown together?
- Are there any **technical requirements** associated with using the option, such as a reliable source of seed for new varieties or crops, specialized equipment or other inputs?

- Are there any **social requirements** for using the option, such as mobilizing group labour, agreeing on collective management of a resource, or recognizing individual ownership of trees planted or protective barriers that they might need to construct?
- Are there other **enabling conditions** or **support services** that are required, such as access to sources of credit or additional training?
- Are there **markets** for the products?
- Are there any potential **trade-offs** associated with the adaptive option? For example, the same crop residues cannot be used for more than one purpose – they cannot be left in the field as mulch to protect the soil and conserve soil moisture, collected to make compost, fed to livestock or used as cooking fuel.
- What are the **impacts** on family labour, household income, food security, relationships within the community and with neighbouring communities?

*Hint: In addition to your discussions with farmers **you may also want to contact other knowledgeable partners, particularly those related to research**. They can help in many ways. They can suggest other possible options. They might be able to help you to identify ways of meeting specific resource needs or overcoming particular constraints.*

After you have finished discussing each of the options, guide farmers through a process of **selecting which options they want to experiment with in the FFS field studies** based on earlier discussions on the advantages and disadvantages, resources needed, timelines and sustainability of each option. Keep the number of field studies to a manageable level, i.e. a maximum of three field studies. Farmers can always test additional options on their own fields, and you should encourage them to do so!

After the FFS farmers have selected the field studies, a meeting with the community should be scheduled to inform the local leaders and members about adaptive options that will be studied in the FFS.

Throughout the season, FFS farmers will share information about the progress of their field studies and learning from the FFS with the community. Promising adaptation options resulting from the field studies may be incorporated in the community adaptation plan that will be developed later in the FFS cycle.

NOTE: When climate change adaptation is integrated into the FFS curriculum, there are more things that need to be done before the start of the production season. You will need to begin your activities several weeks, even a month or more earlier than you normally would to give you time to complete **exercises 1-5**, and to carry out other operations, such as purchasing and setting up weather data collection instruments, and other essential activities so that you are prepared to start your field studies when the production cycle/ growing season begins.

IMPORTANT! After the FFS farmers have selected the field studies, a meeting with the community should be scheduled to inform the members about adaptive options that will be studied in the FFS.

6.2 Common weather threats and adaptive option matrices

The key idea behind many of the adaptive options is to **help farmers use natural resources** – e.g. the characteristics of various farming systems (crops, livestock, aquaculture and forestry) and other biological and physical processes **– to assist them in making adaptive changes to the observed and anticipated weather conditions**. Locally available materials and the use of natural resources are generally less expensive, and can be more effective, than other alternatives. Management practices relying on natural resources also often produce multiple benefits. Farmers can use each of the different practices alone, or practices can be combined. Using a combination of practices – **environmental, genetic, other** – can produce even greater effects. Some of the practices are complementary. In other words, they help to achieve the same outcome, and if used together the combined effect is much greater than what can be achieved by using one practice alone. Other practices involve trade-offs, farmers can use one practice, but if they do so they will not be able to use another. By identifying and discussing the use of different options and combinations you will provide farmers with flexibility in selecting those practices, or combinations, that they can adopt on their own farm, using the resources that they have access to, and that respond to the weather threats that they are experiencing.

Tables 8-11 give ideas on the different types of adaptive practices for agriculture (crops and livestock), aquaculture/fisheries and agroforestry/forestry systems that respond to various weather threats discussed earlier. The practices, consistent with the climate-smart agriculture approach, address sustainable increase of productivity and incomes, adaptation to and building resilience to climate change and, where possible, reducing or mitigating greenhouse gas emissions. FFS master trainers and facilitators may review these option matrices with farmers for more ideas on possible adaptive options.

Table 8. Common weather threats and adaptive option matrix for crops

	Adaptive options		
Weather-related threats	**Environmental**	**Genetic**	**Other practices**
Lower average rainfall	Adopt water harvesting practices (rock lines, hedges, contour ridges, bunds/demi-lunes, infiltration trenches, zai holes etc.) Adopt moisture conservation practices (mulch, manure/green manure, cover crops etc.)	Less water demanding crops/ varieties	Planting density Planting location System of rice intensification
Late/uncertain start to rainy season	Adopt water harvesting practices Adopt moisture conservation practices	Grow rapid maturing varieties Grow crops with shorter maturation periods	Use dry seeding Use seed soaking Use seed coating (with P)
Dry spells during reproduction period/grain filling	Adopt water harvesting practices Adopt moisture conservation practices	Grow drought-tolerant crops/ varieties Grow indeterminate crops/ varieties	Change planting location Adopt intercropping (double-up legumes) Use seed coating (with P)
Earlier ending of rains	Adopt water harvesting practices Adopt moisture conservation practices	Grow shorter season crops/ varieties Grow photoperiod-sensitive crops/ varieties	Adjust cropping seasons
Shorter growing season	Adopt water harvesting practices Adopt moisture conservation practices	Grow shorter season crops/ varieties	
Longer growing season		Grow longer season crops/ varieties	Practise relay cropping Practise sequential cropping Practise ratoon culture
Large storms/flooding	Apply mulch Use vetiver hedges	Grow flood-tolerant crops/ varieties	
Strong and/or drying winds	Practise agroforestry	Grow dwarf varieties	Adopt intercropping
Rising average temperatures	Practise agroforestry Apply mulch	Grow heat-tolerant crops/ varieties	Adopt intercropping
High temperatures during reproduction	Practise agroforestry Apply mulch	Grow heat-tolerant crops/ varieties	Adopt intercropping
Changing weed pressures	Apply mulch		Adopt intercropping (push–pull) Grow cover crops Practise rotation
Changing pest and disease pressures	Adopt habitat management and ecosystem engineering approaches for conservation and augmentation of natural enemies	Grow resistant varieties	Adopt intercropping (push–pull) Practise rotation Apply hot water treatment Use seed soaking Apply biopesticides (e.g. neem)
Declining pollinator populations	Use engineered habitat	Grow self-pollinating crops	Grow pollinator plants

Photo: ©Stefano Mondovi/Benin

Note: More information about the practices listed are found in the resources listed in Annex C or are described as one of the example field studies in Annex B.

Table 9. Common weather threats and adaptive option matrix for livestock

	Key weather-related threats and effects on livestock production	Adaptive options		
		Environmental	Genetic	Other management practices
Increased temperature	Lower yield in milk, meat and eggs, primarily due to heat stress and lower feed intake and feed conversion efficiency	Adopt integrated crop–livestock production system	Include heat-resilient ruminants in livestock assets	Make appropriate adjustments in herd and feed management Adapt feed management options, using of climate-resilient fodder crops
	Effects on health, longevity, production and reproductive capacity of livestock and poultry assets	Adopt agroforestry practices: feed crops, trees as shade for animals		Adopt multi-nutritional block for feeding fattening sheep or cattle Feed cattle with urea-treated straw
	Gradual loss of biodiversity, i.e. cattle having the highest number of extinct breeds	Improve pastures with introduction of pasture species (usually grasses in combination with legumes)	Diversify livestock assets/ species Diversify livestock assets/ species, introduce breed upgrading	Manage manure, including harnessing animal waste as fertilizer for forage and feed crop production and use in inland fisheries
Shifts in rainfall distribution	Low rainfall pattern: reduced water supply for animal drinking and cultivation of feed crops	Adopt water harvesting practices (e.g. rainwater catchment) Raise animals in locations with water abundance	Diversify livestock assets/ species	Raise animals in livestock systems that demand less water Protect water sources for animal watering
	Increased vulnerability of livestock assets to disease epidemic		Practise animal husbandry; introduce breed upgrading	
Increased frequency and intensity of extreme weather events	Drought, heatwave and floods: effects (e.g. water scarcity) on fodder crops, animal health, and overall livestock and poultry production	Reduce stock densities to provide sufficient space for animal movement Adopt agroforestry practices – feed crops, trees as shade for animals Introduce pasture conservation belts	Diversify livestock assets/ species to minimize risk or loss due to extreme weather events Practise over-sowing with improved grasses	Carry out studies on inherent genetic capabilities of different breeds and identify those that can better adapt to hostile climate conditions.
	Susceptibility to changing pest and disease patterns		Upgrade livestock assets to more pest-resistant breeds	Carry out biological control of livestock pests

Photo: ©Solomon Nega

Note: More information about the practices listed are found in the other resources listed in Annex C or are described as one of the example field studies in Annex B.

Source: FAO, 2017b (adapted).

Table 10. Common weather threats and adaptive option matrix for aquaculture and fisheries

Photo: ©Austin Stankus

	Key weather-related threats and effects on fisheries and aquaculture	Adaptive options		
		Environmental	**Genetic**	**Other management practices**
Changes in seawater temperature and circulation patterns	Affects overall production ecology in both marine and freshwater systems, leading to changes in species composition (e.g. advent of more invasive species), lower yield and production, changes in distribution and seasonality, emergence of diseases and other disruptions, coral bleaching and calcification Increasing coastal acidification weakens coastal habitats' capacity to support marine life resulting in restraints on raising yield and productivity	Practise mariculture, i.e. seaweed farming	Diversify and use heat-tolerant species	Adapt fish culture practices Improve feed conversion efficiency for inland fisheries and aquaculture settings Adopt ecosystem approach to management of capture fisheries and aquaculture
	Specific to aquaculture, changes in sea surface temperature increase stock vulnerability to diseases and parasites, presence of more harmful algal blooms that release toxins in the water resulting in fish kills	Consider transferring cage units to cooler areas	Promote salt-tolerant fish species for aquaculture in waterlogged areas and ponds Use species tolerant of changes in temperature and chemical content of coastal waters	Protect against pond floating, mechanize boats, adopt fishing technology, develop pond aquaculture
	Rising sea level, as compounded by melting of ice over land, specifically affects habitats Coastline erosion, wetland flooding, soil contamination with salt affect habitats	Carry out coastal rehabilitation, mangrove management restoration and dune rehabilitation with community focus/ participation		Adopt integrated fish farming (e.g. with livestock, crops) Diversify sources of livelihood of farmers/fishermen Practise other appropriate culture methods
	Specific to aquaculture, rise in sea level increases severe flooding and results in loss of areas available for aquaculture, causes salt intrusion into groundwater and loss of areas for mangroves as protection from waves/surges and as nursery resource for aquaculture seeds	Improve physical defences in flood-prone areas alongside integrated coastal management Improve farm siting and design	For coastal/saline area, use short cycle and fast growing saline-tolerant fish species	Adopt early warning system and improve education
Frequency, severity of extreme events	Coastal flooding and storm surge affect production cycles in both marine and freshwater environments, threatening food security and livelihoods	Where water availability is an issue, set small seasonal ponds for coastal and saline areas when available freshwater can still be used for fish	Select more resilient species Adopt short-cycle species in flood-prone areas	Take out insurance options to minimize production (escape of stock) and economic loss due to extreme weather events Use indigenous stocks to minimize biodiversity impacts
	Droughts lead to reduced natural spawning, limited water volume, reduced water quality in addition to salinity changes	Use water reservoir to address water shortage during drought		Improve efficacy of water usage, improve water sharing

Note: More information about the practices listed are found in the other resources listed in Annex C or are described as one of the example field studies in Annex B.

Source: FAO, 2017b (adapted).

Table 11. Common weather threats and adaptive option matrix for forestry and agroforestry

	Key weather-related threats and effects on forests	Adaptive options		
		Environmental	Genetic	Other management practices
Frequency and intensity of forest wildfires	Fire affects forest ecosystem, disturbing wildlife habitat, accelerating nutrient cycling and mortality of individual trees	Adopt afforestation/ reforestation in areas with reduced tree populations, mainly due to forest fires	Promote or plant heat-tolerant trees	Adopt better forest management system to improve and sustain forest productivity and health and minimize risks associated with forest fires, deforestation and degradation
Outbreaks of pests and diseases	Environmental stresses like winter injury, drought, salt damage, wood-boring insects, vascular wilt diseases, and herbicide injury can result in diebacks in trees Soil compaction, excavation damaging roots, vole damage to roots and root disease can result in dieback of branches	Adopt agroforestry activities Prevent further forest degradation and manage timber production for carbon stocks to remain constant or increase over time, thereby restoring degraded forests	Use species that can adapt better to changing conditions	Apply forest pest management Implement forest conservation and protection measures Monitor changing conditions and promptly set in place appropriate modifications
Frequency and severity of extreme weather events	Damage from extreme events, i.e. severe drought, typhoons and high winds, can be further aggravated by changes in temperature and precipitation regimes, changes in water availability and increased damage from wildfires and outbreaks of pests and diseases Loss of species and impacts on forest biodiversity	Promote sustainable forest management Adopt agroforestry activities, especially in most vulnerable and/ or most affected forests and forest communities	Increase the population of heat-resistant or drought-tolerant species in planted forests Maintain genetic variation in tree populations and promote natural regeneration, when possible Match species and varieties to current and projected site and climatic conditions	Adopt other forest management options to reduce vulnerability of both forests and forest communities or address lower yield expectations Diversify sources of livelihood including other products and income-generating activities for forest-dependent poor communities Adjust harvesting schedules (e.g. hunting seasons, cutting cycles and non-wood forest product collection)

Photo: ©FAO/ I. de Borhegyi

Note: More information about the practices listed are found in the other resources listed in Annex C or are described as one of the example field studies in Annex B.

Source: FAO, 2017b (adapted).

6.3 List of example field studies

Based on recommendations from resource persons with extensive experience on climate change adaptation, suggestions from field practitioners and references on climate-smart practices, below is a list of a few season-long **field studies** that could be tried out in the FFS – in addition to topics identified by farmers in the baseline vulnerability assessment (exercises 1–5). FFS master trainers and facilitators may already be familiar with some of the field studies. The purpose of including them in this guide is to reinforce the key idea behind many adaptive options which is – to **help farmers use natural forces** – e.g. the characteristics of various species (crops, livestock, aquaculture and tree resources) and other biological and physical processes in making adaptations to the observed and anticipated weather threats.

The field studies listed here are intended to serve as examples and cover only a few possible situations and may need to be adjusted to suit location-specific conditions. The full write-up of the field studies is contained in **Annex B**. Other adaptation practices may be accessed from references in the list of Technical Background Resources in **Annex D.** Where available, case studies on FFS experiences documenting the results of the application of the adaptation options through field studies are provided.

Taking note, keeping records

As part of your preparations for all of the field studies, you will need to set up and start using your field study logbook (or FFS diary). This is essential. Start by having one of the participants make a drawing of each plot, noting the position of each treatment. Be sure to include a point of reference, or landmark, on the drawing to help orientate the picture, such as a road or large tree. In case the plot sign is lost or damaged, having an additional drawing in your logbook will ensure that you can continue to monitor the field study through the entire season.

You will want to keep accurate, complete records for the duration of the field study. For every field study you will want to record all of the management practices that are used, including the date, description of what was done, materials used and how long it took to complete the task. You will use this information in calculating the benefit–costs of each adaptive option. (FFS master trainers and facilitators are familiar with and have carried out this exercise in FFS they have previously conducted and in ToT courses.) Include also any other observations, such as damage to the field study, e.g. pest or disease problems. It will be essential that you record any important weather events that occur. The purpose of these field studies is to test new practices for their adaptiveness to specific weather stresses – heat, lack of moisture, shorter/longer season etc. Having a complete and accurate record of everything that happened during the season will be important in reviewing and interpreting the results at the end of the field study (see Special Topic on Using Local Weather Data).

Table 12: List of example field studies

	Farming system/adaptive option	Title	Objective
1	Livestock, environment change	Impact of sensitivity to heat stress resulting from livestock housing	Observe and compare the influence of housing on milk production
2	Aquaculture, environment change	Impact of heat stress on growth yields of fish	Observe and compare the impact of heat stress on growth and yields of fish
3	Crops, environment change	Moisture stress during the growing season	Observe and compare the benefits of using different quantities of mulch, and different types of mulch, as a way of reducing the effects of dry spells during the cropping season
4	Livestock, genetic resources	Adaptive varieties – comparison of yields of different grass fodder varieties	Identify varieties that tolerate or better respond to changing weather patterns and stresses
5	Crops, genetic resources	Adaptive varieties – temperature and moisture stress tolerant, and early maturing varieties	Identify new varieties that tolerate or better respond to changing weather patterns and stresses
6	Aquatic biodiversity-fish and crops, other management practices	Comparison of yields and benefits from rice-only and integrated rice–fish aquatic biodiversity production systems	Observe and compare yields and benefits from rice-only and integrated rice–fish aquatic biodiversity production systems, as a way of reducing the effects of climate variability Case study: Save and Grow practices utilizing integrated rice–fish aquatic biodiversity increases gross income by 210–550%, Viet Nam
7	Crops, other management practices	Responding to an increasingly uncertain start to the growing season with a) seed priming/seed soaking; and b) dry seeding	a) Test the effectiveness of seed soaking to help crops to quickly establish themselves in response to a delay in the start of the growing season b) Determine the best planting depth for dry seeding in response to growing uncertainty regards the start of the rainy season
8	Livestock and forestry, other management practices	Effect of silvopastoral systems on yields, income and resilience to climate change	Observe and compare the benefits of using silvopastoral practices on milk production and income, and promote practices that contribute to resilience to climate change Case study: Developing climate-smart cattle ranch in the central region of Nicaragua
9	Forestry, other management practices	Comparison of benefits between traditional forest enterprise and farm forestry enterprise	Evaluate the effect of social forestry practices and enterprises (e.g. tree nurseries, intercropping and income-generating activities, fodder banks, woodlots, fruit orchards, food cropping with improved techniques) on increasing productivity and income, and promote practices that contribute to resilience to climate change Case Study: The Intensified Social Forestry Project (ISFP) in Kenya

Note: The fifth field study in the list ("Adaptive varieties – temperature and moisture stress tolerant, and early maturing varieties") corresponds to the example in Exercise 5 (Table 6) addressing the problem of dry spell during the reproductive stage and the adaptive option selected falls under the genetic category. This illustrates how the assessment exercises lead to the identification of adaptive options to test in field studies.

6.4 List of example special topics

This chapter presents a list of examples of **new special topics** designed especially for this guidance note on bringing climate change adaptation into FFS. Other special topics may be familiar and possibly used in FFS in the past – but are being revisited here with a “climate change lens”.

Since there will most likely be other topics covered in the FFS, each with their own content for the curriculum, no attempt is made to include additional material in this guide. However, plan to include certain special topics, such as some of those included here. Other special topics can also be selected based on farmers' requests or in response to a problem that arose in the field that needs to be addressed in one of the FFS sessions.

Regardless of the field studies included in the FFS, it is strongly recommended to **include the special topic on Collection of Weather Information as part of the FFS activities.** Climate change is about changes in the weather patterns. Being able to record and compare what happens with the weather, and how the different treatments in the field studies respond to specific weather stresses, will be essential for assessing whether the different practices offer farmers adaptive solutions, or not. Building the capacity to record and assess changes in local weather patterns will be an important resource for farmers long after the FFS is completed as climate change will continue and impacts of climate change become more severe.

Where available, case studies have been included to provide examples of how special topics have been introduced or are being used in FFS. The full write-up of the special topics is contained in **Annex C**.

Table 13: List of example special topics

	Title	Objective
1	Using current local weather data	
1a	Using a rain gauge	Correctly set up a rain gauge and collect and record rainfall data
1b	Using a max./min. thermometer	Correctly set up a max. /min. thermometer and collecting and record temperature data
1c	Taking rainfall and temperature measurements	Correctly take measurements and record rain gauge and thermometer data
	Case study: Science field shops in Indonesia	
2	Using forecast weather data	Make decisions and design adaptive strategies based on a forecast of expected climate conditions
	Case study: Science field shops in Indonesia: Disseminating seasonal climate scenarios	
	Case study: How "Katalysis" helped FFS graduates in the Andes to mitigate climate change	
3	Benefits from Trees Outside Forests	Familiarize participants with agroforestry ecosystems, and in particular the services and functions provided by trees included within farming systems
4	Impact of extreme weather threats	Observe the differences in exposure and sensitivity of farming systems, based on their location and timing, to extreme weather events that occur during the FFS
5	Traditional knowledge on predictors of climate events	Discuss examples of traditional weather predictions and explore how traditional and scientific weather forecasting can be integrated and the benefits from combining these systems
6	Spreading the word and adapting together	Prepare a community learning plan to expose and support community members in gaining benefits from the activities carried out in the FFS
7	Testing seed germination	Test the quality of seeds being used in the field study and the skills for determining the percentage of farmers' seeds that may germinate and how to make adjustments
8	Mulching and mulches	
8a	Maximize cover to reduce run-off and erosion	Demonstrate soil erosion occurring from large rainfall events and the crucial role of soil cover in reducing soil losses
8b	Maximize soil cover to reduce soil moisture losses	Appreciate the importance of crop residues and mulch in decreasing soil water losses through evaporation
8c	Benefits of soil structure promoted by the use of mulch	Help farmers see the difference between healthy soils – where the soil particles are held together (i.e. soil has structure) indicating the presence of many air spaces which can hold water – and unhealthy soils – those soils that have lost their structure, with little holding the soil particles together, and few places where water can be stored

Mitigation response to and **action** in climate change

Earlier in this guide (Chapter 3, **Basics of Climate Change**), agriculture was identified as a key contributor to climate change through the release of carbon dioxide, methane and nitrous oxide into the atmosphere. It was noted that agricultural activities and the global food system are responsible for roughly one-third of the total greenhouse gas emissions causing the climate to change. On the other hand, by undertaking mitigation actions – reducing emissions and promoting sequestration (see Key terms box) – farmers have the possibility of making important contributions to the reduction of GHGs in the atmosphere. Such actions are important. Farmers and communities can do many things to reduce their vulnerability to climate change.

Key terms for climate change mitigation

Mitigation is any human action undertaken to reduce the release, or removal, of greenhouse gases from the atmosphere. In the agricultural sector the major gases are carbon dioxide, methane and nitrous oxide. The release of all three gases can be reduced by changing practices or technologies, but only CO_2 can be removed from the atmosphere once it is released.

Emissions refer to the release of greenhouse gases into the atmosphere. Depending on the particular greenhouse gas, they are either created and emitted from a source through a biological or industrial process (e.g. methane emissions from rice production or the manufacture of chemical fertilizer), or the greenhouse gases are emitted through the transformation of a stock, from a solid to a gas, such as the release of carbon stored in trees through clearing and burning of forests, or methane released from the melting of permafrost, frozen deposits in the Arctic, from enteric fermentation, from rice paddy cultivation.

Sequestration is the process of removing CO_2 from the atmosphere and its storage in another reservoir, such as the tissues of plants and ultimately the soil. Sequestration also occurs when CO_2 is absorbed into the ocean, and through new human-made technologies that are being developed to help remove CO_2 from the atmosphere.

CASE STUDY

SRI-LMB Project farmers try out practices that reduce methane emission

In 2013, the Asian Institute of Technology (AIT) partnered with FAO and national IPM programmes to implement the training component of the EU-funded project titled "Sustaining and Enhancing the Momentum for Innovation and Learning around the System of Rice Intensification (SRI) in the Lower Mekong River Basin". The project – with a strong research focus – sought to stimulate local innovation using SRI practices and FFS approaches involving smallholder farmers in rainfed areas of four LMB countries (Cambodia, the Lao People's Democratic Republic, Thailand and Viet Nam) to contribute to enhanced resilience and sustainable production in the context of climate change adaptation. The project engaged farmers in learning about SRI techniques that required the use of less water, seed, manure and labour and experimenting with location-specific technologies to increase yields and benefits as well as explore better market opportunities.

The project brought together more than 15 000 farmers (> 50 percent women) from four countries in learning activities using FFS approaches and farmer-led field studies. All together, the farmers' groups carried out a total of 1 500 experiments/field studies over four years (2014–17). These field studies explored individual SRI practices in detail (planting distance, intermittent irrigation etc.) as well as the application of combinations of SRI practices.

Combined results of the project at regional level showed that SRI practices helped to improve farmers' livelihoods and the environment through:

- increased average rice yield by 52 percent, and net economic returns by 70 percent;
- increased labour productivity by 64 percent, water productivity by 59 percent, and fertilizer use efficiency by 75 percent;
- decreased total energy input for farming operations by 34 percent, along with significant reductions in per-hectare net emission of greenhouse gases, respectively by 14 percent with irrigated rice production, and by 17 percent in rainfed cropping brought about by practices such as the use of intermittent irrigation, use of manure, reduced urea fertilization and chemical substances (e.g. pesticides).

The calculation of the reduction in greenhouse gas emission was carried out by researchers and was not an activity of the farmers. However, it would be useful for farmers to be able to use simple GHG accounting steps and use the information and knowledge to emphasize how each individual can contribute to reducing GHG emissions by using more efficient production practices such as those used under the System of Rice Intensification.

Sources: AIT, 2019. Ketelaar *et al.*, 2020.

The primary focus of this guide is on bringing climate change adaptation learning opportunities into the FFS curriculum. However, there are limits to the conditions to which farmers can adapt. If actions are not taken to reduce the release of more GHGs into the atmosphere, farmers in many locations will reach the limits of their adaptive capacity. That is why all must work together to help prevent the release and remove GHGs from the atmosphere. Fortunately, many adaptive practices also produce mitigation benefits, and mitigation actions in agriculture also serve to help farmers adapt to climate change.

Mitigation actions can be placed into two general categories, actions that **reduce** greenhouse gas emissions, or all types, and those that **remove** CO_2 already in the atmosphere through sequestration. In agriculture, examples of mitigation practices in response to common sources of greenhouse gas emissions are sequestering carbon in agricultural soils, sequestering carbon in agroforestry systems and forestry management, reducing methane emissions from enteric fermentation through better feed quality, reducing methane emissions from paddy rice paddy cultivation, reducing nitrous oxide emissions through improved fertilizer usage. More detailed information about these actions are available in the list of technical references (Annex D).

Individually or collectively farmers and communities can carry out action to mitigate climate change!

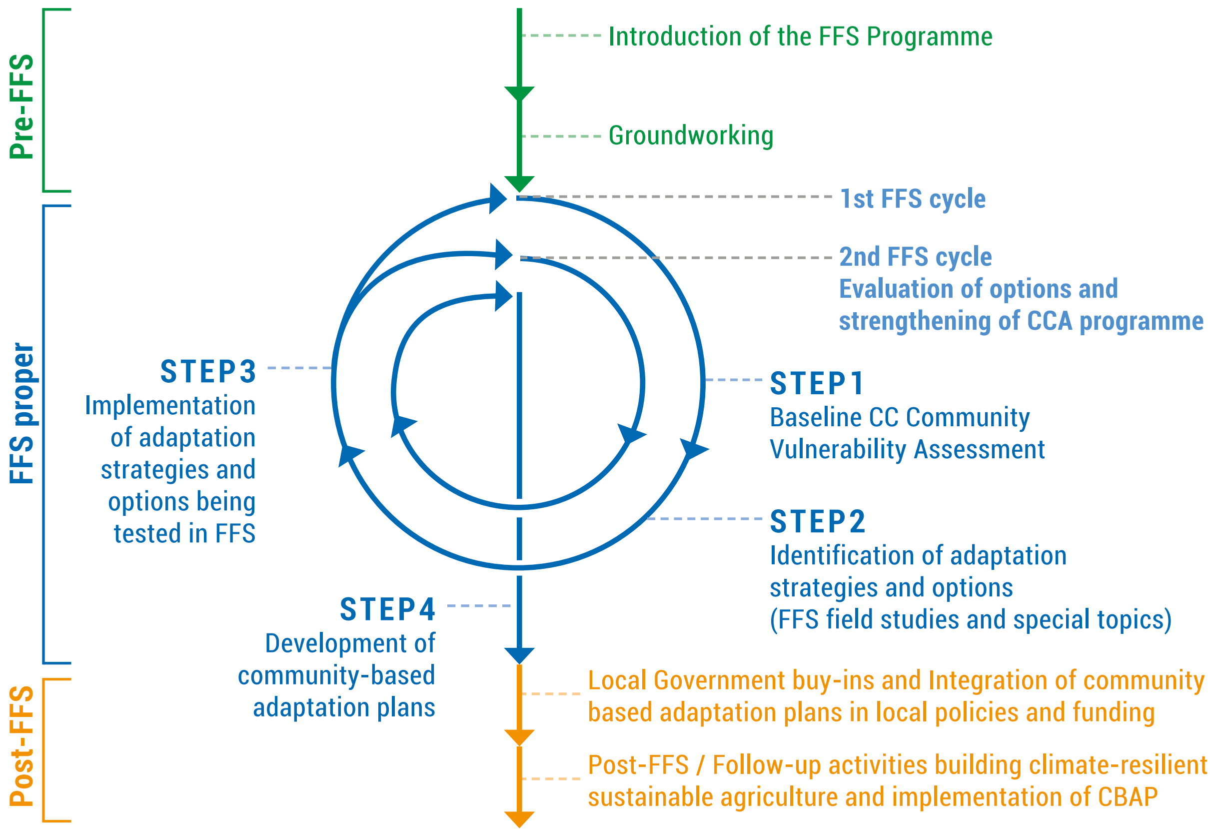
©Stefano Mondovi/Burundi

Community-based adaptation plans: the community adapting together

This chapter provides details about Step 4: Development of Community-Based Adaptation Plans.

The response to some climate change risks is best taken at field level by individual farm families, e.g. the decision to change varieties. Other risks require group action such as farmers up and down the hillside each protecting his/her own plot to reduce soil erosion and prevent landslides brought on by heavy storm events. Community-Based Adaptation Planning (CBAP) in an FFS programme supports integration action of climate change adaptation at larger scales (see **Step 4** in Figure 14, p. 37). Participation of the community in Community-Based Adaptation Planning gives them ownership of the process and its results. They identify their priorities and make plans to address climate change-related threats and risks to the community and own the responsibility of making their plans succeed. In effect, this is the purpose of CBAP and for this reason, starting from **Step 1** (see Chapter 5, p. 39), community members – especially the most vulnerable farmers – and other stakeholders are already engaged in the process. Figure 23 summarizes the community-based adaptation planning process that can be applied to FFS integrating climate change adaptation.

Figure 23: Community-Based Adaptation Planning Process (and the Community Climate Change Adaptation Programme)



Source: Authors' own elaboration

8.1 Developing the community-based adaptation plan

After identifying vulnerabilities of their farming systems to changes in weather (**Step 1 Baseline Assessment**) and **successful** actions that the community has been taking on their own (if any) to address the climate change threats, the successful strategies/options could be directly included in the CBAP (**Step 4**). The Malawi case study (see p. 25), for example, demonstrates how the results of a baseline assessment are used for group action plans for possible immediate application by communities. On the other hand, FFS farmers – using additional exercises – will identify adaptation strategies and options (**Step 2**) to test in their field studies and special topics (**Step 3**). As farmers in the FFS begin to understand climate change better, and as they share what they learn with the rest of the community, they are increasingly in a position to create locally appropriate plans that respond to their local needs. Understanding climate information and how to manage risks despite the uncertainty of what the climate will be in the future will prepare them for making timely and informed decisions when the need arises (King, 2014). At the end of the initial FFS cycle, successful adaptive strategies/options

Figure 24: Map of the Kayokwe Watershed (Muyebe and Murama Hills) in 2019

(tested in the FFS) could be integrated into the CBAP (**Step 4**), enriching the list of options earlier identified and applied by other farmers in the community.

In Burundi, community members assessed their current situation and drew their vision for their communities by the end of the project. The results of the exercises were used as the basis for the formulation of their community action plan for a watershed management through FFS.

In view of the maps in Figure 25, the 2024 vision of Muyebe and Murama hills was formulated by the communities as follows:

> By 2024, the Kayokwe Watershed will be climate-resilient through the protection of the banks of Kayokwe River, establishment of anti-erosion measures and vegetation as well as the improvement of agricultural productivity.

To achieve the 2024 vision, the community prepared the action plan presented in table 14.

Figure 25: Map of the Kayokwe Watershed (Muyebe and Murama Hills) - 2024 vision

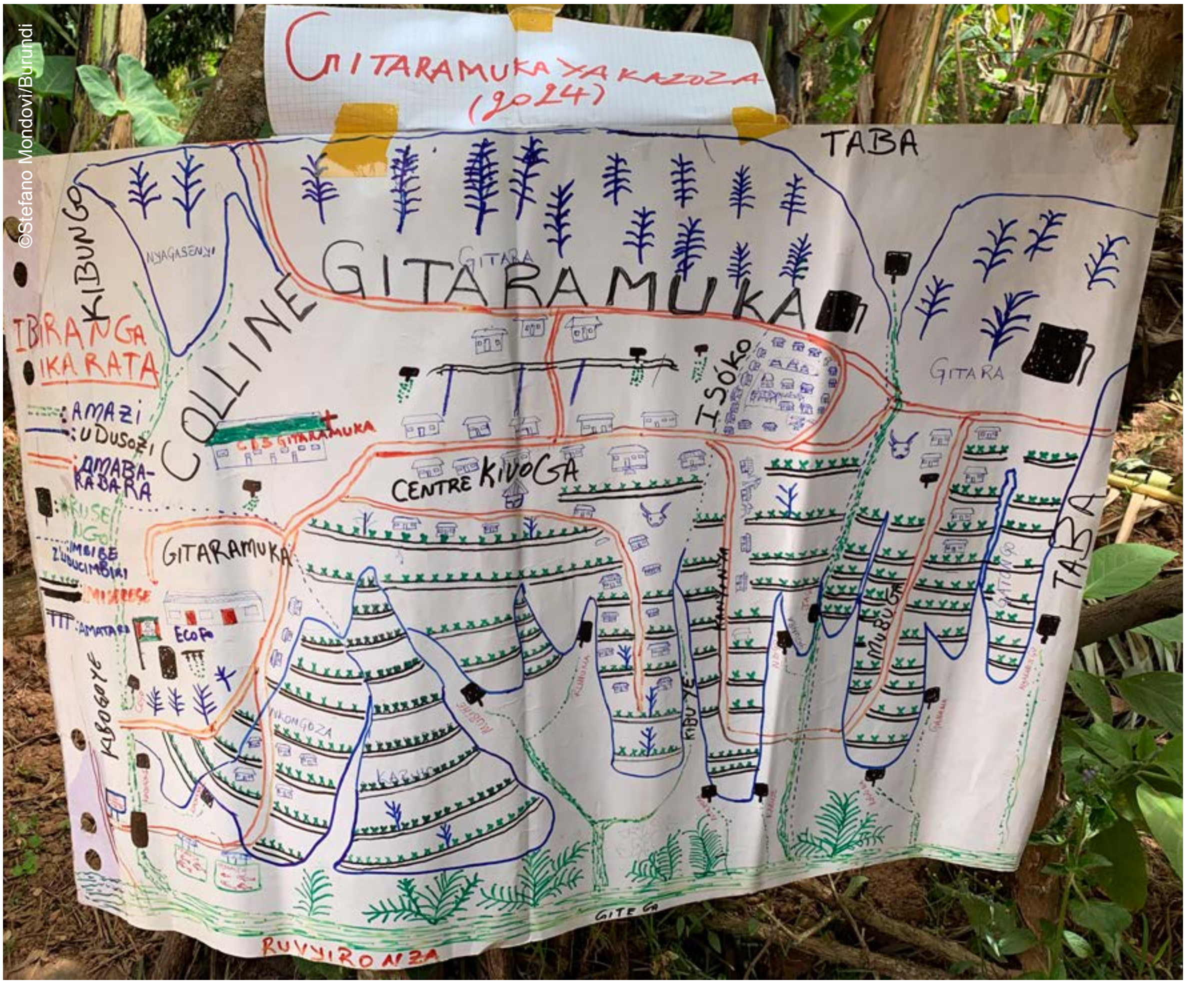


Table 14: Community action plan for the Kayokwe Watershed (Burundi)

Activities	Responsible	Location	Time frame
Reforest 500 ha of degraded areas	FFS members, Ministry of the Environment, Agriculture and Livestock (MINEAGRIE) technical service, project team	Murama: Nyarusange at the base of Bahuuzu hill Muyebe: base of Mushonji hill	December 2019 to mid-February 2022
Plant 650 000 forest trees, agroforestry and fruit trees at a rate of 65 000 plants per year	Community management, MINEAGRIE technical service, project team	Murama: base of Gitwa hill Muyebe: base of Mushonji hill	December 2019 to mid-February 2022
Protect 100 km of banks of the Kayokwe River with bamboo	Community management, MINEAGRIE technical service, project team	Banks of the Kayokwe River in Murama and Muyebe	June 2020 to December 2021
Establish 1 500 nitrogen-fixing trees	December 2019 to mid-February 2022	On all the base of Murama and Muyebe hills	January 2020 to December 2022
Multiply improved seeds and 15 indigenous tree species	Community management, MINEAGRIE technical service, project team	Murama: base of Gitwa and Ndeberi hills for indigenous species Muyebe: base of Mushonji hill	January 2020 to December 2022
Experiment with and scale up the resilience fund approach	FFS leaders, project team	On all bases of Muyebe and Murama hills	February 2020 to December 2022
Connect agricultural producers to potential markets for the supply chain of agricultural products	MINEAGRIE technical service, project team	On all bases of Muyebe and Murama hills	January 2020 to December 2022
Structure the FFS into cooperatives	FFS members, community management, MINEAGRIE technical service, project team	On all bases of Muyebe and Murama hills	February 2020 to December 2022
Organize inter-community experience exchange visits on good SLM practices	Community management, community, MINEAGRIE technical service, project team	In provinces of Karusi and Mutyinga as well as in communes of Nyurange and Gishubi in province of Gitega	August 2020 and August 2021

NOTE: The Community-Based Adaptation Plan is only one aspect of a bigger picture – the community climate change adaptation programme. The other aspects, described below, are based on the Figure 23.

8.2 Using evaluation results to enhance the CBAP and generate local policy support

Climate change is not the problem of one community alone and climate change adaptation is not something that a community can address alone. Action towards adaptation must be taken at all levels starting from individual households to community level to several communities working together. However, an enabling environment, e.g. local government policy and financial support, is crucial to turn plans contained in the CBAP into concrete action. Results of evaluation of viable options tested in FFS can be used to strengthen/enhance the CBAP and at the same time can be used to convince the local government of the importance of supporting farmer/community-led climate change adaptation initiatives. When more than one FFS is operating in the same area (for example three or four FFS in the same watershed), collaboration among them to set up collective actions, if needed, can be very useful for the implementation of a CBAP.

8.3 Local government investing in productive assets

Adaptation strategies go beyond the FFS. Local government buy-ins and integration of the CBAP in local government action programmes is necessary. This will create the conditions for CBAP to continue evolving and communities to continue exploring adaptation strategies/options and adapting to climate change beyond the initial FFS cycle. The community can hold dialogues with the local government about the need for investment in productive assets as well as location-specific investments in income-generating activities and production insurance. (For example, a community-wide water catchment-based management approach which can provide guidance on rangeland/landscape restoration, flood control and investment on productive assets.)

8.4 Evolving from an FFS programme to a community climate change adaptation programme

Climate change adaptation is a continuous process and does not end after a season or with the FFS duration. Continuous review and evaluation of adaptive options will feed into evolving community-based adaptation plans. With an enabling environment, the initial FFS learning experience could lead to a community climate change adaptation programme building climate-resilient sustainable farming systems that support increasing productivity and improving livelihoods, and where possible, reducing greenhouse gas emissions.

In community-based adaptation planning, participation is key and communities are at the core of the planning process – an empowering learning process that should build adaptive capacity, and develop concrete but flexible plans to reduce the community's vulnerability to climate change over time.

Monitoring, evaluation and **learning** (MEL)

Monitoring, evaluation and learning – carried out throughout the FFS cycle – allows all stakeholders to reflect on what needs to be modified or strengthened in the FFS programme as to achieve target impacts or design a follow-up programme

Monitoring and evaluation are important tools for FFS master trainers, facilitators and programme managers in helping to implement good quality learning opportunities for farmers through consistency and planned content and well-planned FFS. A participatory monitoring and evaluation approach can be used to support dynamic information sharing between stakeholders (communities, project team etc.). The process seeks to answer whether the FFS is implemented according to plan, of high quality and considered useful by the community as well as to assess changes that result from participation in the FFS. Monitoring, evaluation and learning (MEL) allows all stakeholders to reflect on and learn from successes and weaknesses and identify what needs to be modified or strengthened in the FFS programme in order to achieve target impacts or design a follow-up/future programme.

Master trainers and facilitators have probably already been carrying out participatory monitoring and evaluation efforts in support of a continuous learning process in their FFS programme. An existing FFS programme would normally have established protocols and methods for MEL in place. However, if the programme is bringing climate change adaptation into the FFS, adjustments will have to be made to ensure that the MEL framework will include the new target impacts, indicators and updated tools to collect information.

Existing tools – such as those listed in Table 15 – can continue to be used while the FFS master trainer or facilitator ensures that climate change-related content is incorporated. Hence, for example, the FFS Diary would include details about field studies on adaptation options being tested in the FFS. The ballot box test would include questions to assess pre- and post-training knowledge about climate change adaptation. Agro-ecosystem analysis would include questions about the climate as it influences ongoing FFS field study plots. The weekly evaluation and planning session at the end of each session should also consider climate-related issues.

Table 15: Examples of MEL tools in FFS

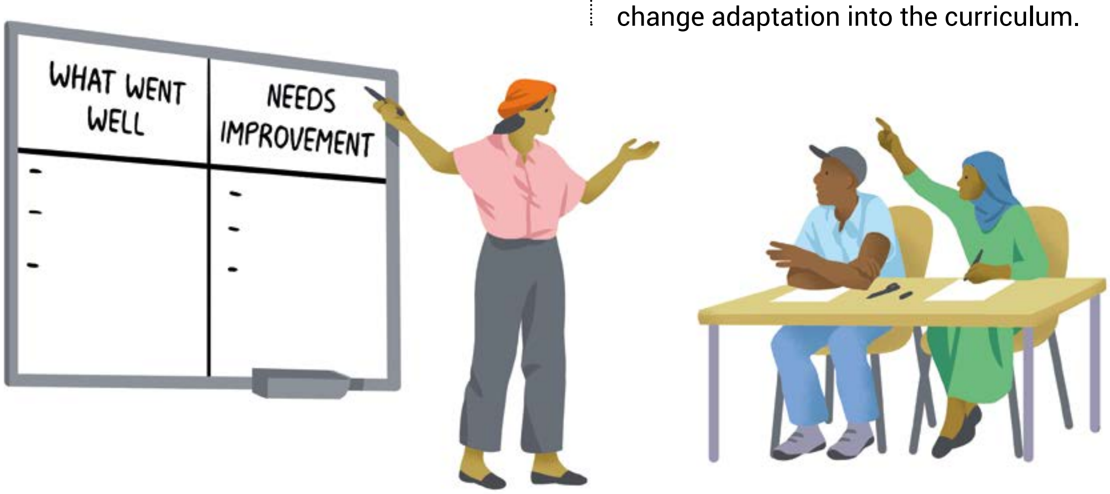
Tool	FFS Diary	Ballot box test	AESA/ESA	Weekly evaluation and planning
What to assess	Implementation of activities Attendance Results of field studies	Pre and post-training knowledge	Field conditions Decision-making	Implementation feedback

Regular reviews of data collected through monitoring and process evaluation become learning opportunities to enhance or modify FFS activities to improve quality. Regular review of data can alert programme management on quality issues that may need immediate attention, e.g. weak analysis of field study observations in agro-ecosystem analysis, and the need to upgrade skills of FFS facilitators through refresher training to improve the curricula. Adequate mechanisms need to be in place to identify and address problems in the FFS in a timely manner.

In addition to periodic process evaluation (e.g. evaluation of weekly FFS sessions), there are outcome evaluation tools that give indications of results of FFS activities. Collecting and comparing information on the situation before and after the FFS programme (e.g. pre- and post-ballot box test) provides a useful evaluation of progress towards target impacts. However, monitoring data of the implementation process can provide information about the quality of the FFS programme.

MEL is a collective process that highlights the role that communities play in assessing their own progress towards the changes that they wish to achieve. Farmers should be directly involved in monitoring the quality of their FFS through attendance rates, participation levels, experience sharing with non-FFS participants etc. Feedback from communities will provide information on whether or not the FFS activities respond to local expectations and are relevant to them. This is especially important for FFS programmes that integrate climate change adaptation and where members of a community develop and implement community-based adaptation plans together.

The chapter on Monitoring, Evaluation and Continuous Learning (MEL), in the *Farmer field school guidance document: Planning for quality programmes* (FAO, 2016) provides key concepts and detailed guidance on how to design and implement MEL. *A guidance note on Monitoring, Evaluation and Learning (MEL) in farmer field school programmes: A framework and toolkit* is also being developed by the Global FFS Platform that FFS master trainers and facilitators can use as a reference to support MEL in FFS and integrate climate change adaptation into the curriculum.



Bibliography

Asian Institute of Technology (AIT). 2019. Final report: Sustaining and enhancing the momentum for innovation and learning around the System of Rice Intensification (SRI) in the Lower Mekong Basin.

Archer, D. & Rahmstorf, S. 2010. *The climate crisis: An introductory guide to climate change*. Cambridge, UK, Cambridge University Press.

Archer, D., Eby, M., Brovkin, V., Ridgwell, A., Cao, L., Mikolajewicz, U., Caldeira, K. *et al.* 2009. Atmospheric lifetime of fossil fuel carbon dioxide. *Annual Review of Earth and Planetary Sciences*, 37: 117–134.

Bernabucci, U. 2019. Climate change: impact on livestock and how can we adapt. Animal Frontiers, 9(1): 3–5.

Beye, A.M. & Wopereis, M.C.S. 2014. Cultivating knowledge on seed system and seed strategies: Case of the rice crop. *Net Journal of Agricultural Science*, 2(1): 11–29.

Campbell, B.M., Thornton, P., Zougmore, R., Asten, P. & Lipper, L. 2014. Sustainable intensification: What is its role in climate smart agriculture? *Current Opinion in Environmental Sustainability*. 8: 39–43.

CARE. 2015. *Adaptation planning with communities: Practitioner Brief 1.* Kenya, CARE International. (also available at https://careclimatechange.org/wp-content/uploads/2014/08/CBA_Planning_Brief.pdf).

Casas, N.M. 2017. *Crop weather and climate vulnerability profiles: A collection of crop temperature and water requirement profiles to help reduce the exposure of smallholder farmers to weather and climate-related shocks*. Dublin, Concern Worldwide.

Cook, J., Nuccitelli, D., Green, S.A., Richardson, M., Winkler, B. & Painting, R. 2013. Quantifying the consensus on anthropogenic global warming in the scientific literature. *Environmental Research Letters,* 8(2): 1–7.

Dazé, A., Percy, F. & Ward, N. 2015. *Adaptation planning with communities: Practitioner Brief 1.* Kenya, CARE International. (also available at https://careclimatechange.org/wp-content/uploads/2014/08/CBA_Planning_Brief.pdf).

Del Rio, A. & Simpson, B.M. 2014. *Fifteen crop phenological profiles for climate change adaptation*. United States Agency for International Development, African and Latin American Resilience to Climate Change Project. Washington, DC, TetraTech.

Dubois, K.M., Chen, A., Kanamaru, H. & Seeberg-Elverfeldt, C. 2012. *Incorporating climate change considerations into agricultural investment programmes: A guidance document.* Rome, FAO. (also available at http://www.fao.org/3/i2778e/i2778e.pdf).

Environmental and Energy Study Institute (EESI). 2020a. Global warming/Frequently asked questions. In: *EESI* [online]. Washington, DC. [Cited 17 August 2020].

Environmental and Energy Study Institute (EESI). 2020b. Global warming/Frequently asked questions. In: *EESI* [online]. Washington, DC. [Cited 17 August 2020].

Environmental and Energy Study Institute (EESI). 2020c. Global warming/Frequently asked questions. In: *EESI* [online]. Washington, DC. [Cited 17 August 2020].

Environmental and Energy Study Institute (EESI). 2020d. Global warming/Frequently asked questions. In: *EESI* [online]. Washington, DC. [Cited 17 August 2020].

FAO. 2019a. *Silvopastoral systems and their contribution to improved resource use and sustainable development goals: Evidence from Latin America.* Rome. (also available at http://www.fao.org/3/ca2792en/ca2792en.pdf).

FAO, 2019b. *Soil health for paddy rice: A manual for farmer field school facilitators.* Rome. (also available at http://www.fao.org/3/ca8167en/ca8167en.pdf).

FAO. 2017a. *Discovery-based learning in land and water management: A practical guide for farmer field schools*. Rome. (also available at http://www.fao.org/3/i6897e/i6897e.pdf).

FAO. 2017b. *Climate-smart agriculture sourcebook. Second edition* [online]. Rome, FAO. [Cited 10 May 2021]. http://www.fao.org/climate-smart-agriculture-sourcebook/en/

FAO. 2016. *Farmer field school guidance document: Planning for quality programmes.* Rome. (also available at http://www.fao.org/3/a-i5296e.pdf).

FAO. 2016a. *Climate change and food security: Risks and responses.* Rome. (also available at http://www.fao.org/3/i5188e/i5188e.pdf).

FAO. 2016b. *Save and Grow practices utilizing integrated rice-fish-aquatic biodiversity increases gross income by 210%-550%, Vietnam.* Regional Rice Initiative. Bangkok, FAO. (also available at https://icerd.vn/stories-from-the-field/).

FAO. 2012. A case of agricultural heritage systems. In: *Agroecology Knowledge Hub* [online]. Rome. [Cited 17 May 2021]. (also available at http://www.fao.org/agroecology/database/detail/en/c/442979/).

FAO, JICA & KFS. 2011. *Farmer field school implementation guide. Farm forestry and livelihood development.* Rome, FAO. (also available at http://www.fao.org/3/i2561e/i2561e00.htm).

FAO. 2011. *Save and Grow: A policy makers guide to the sustainable intensification of smallholder crop production.* Rome, FAO. (also available at http://www.fao.org/3/i2215e/i2215e01.pdf).

FAO, JICA & KFS. 2007. *Kenya Intensified Social Forestry Project in Semi-arid Areas Impact Assessment Report*. Rome, FAO. (also available at http://www.ipcinfo.org/fileadmin/user_upload/fsn/docs/Mathe_KEN-ISFP-Complete.pdf).

Farooq, M., Wahid, A. & Siddique, K.H.M. 2012. Micronutrient application through seed treatments – A review. *Journal of Soil Science and Plant Nutrition*, 12(1): 125–142.

Forister, M.L., Pelton, E.M. & Black, S.H. 2019. Declines in insect abundance and diversity: We know enough to act now. *Conservation Science and Practice*, 1(8).

Haggblade, S. & Tembo, G. 2003. *Conservation farming in Zambia*. EPTD Discussion Papers No. 108. Washington, DC, International Food Policy Research Institute.

Hansen, J., Sato, M. & Ruedy, R. 2012. Perception of climate change. *Proceedings of the National Academy of Sciences*, New York, Trinnovim Limited Liability Company. (also available at https://www.researchgate.net/publication/230623997_Perception_of_Climate_Change).

Harris, D. 2004. The Status of 'on-farm' seed priming and related work funded by DFID Plant Sciences Research Programme. Paper prepared for the Plant Sciences Research Programme "Highlights and Impact of Seed Priming".

Hatfield, J.L & Prueger, J.H. 2015. Temperature extremes: Effects on plant growth and development. *Weather and Climate Extremes,* 10(A): 4–10.

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 2009. *Fertilizer microdosing: Boosting production in unproductive lands.* Patancheru, India.

Inman, M. 2008. Carbon is forever. *Nature Climate Change*, 2: 156–158.

Intergovernmental Panel on Climate Change (IPCC). 1996. *Methane emissions from rice cultivation: Flooded rice fields. Guidelines for national greenhouse gas inventories: Reference manual.* PLACE. (also available at https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch4ref5.pdf).

IPCC. 2013. Summary for policymakers. Technical summary and frequently asked questions. *In* T.F. Stocker, D. Qin, G-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P.M. Midgley, eds. *Climate change 2013: The physical science basis.* Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, Cambridge University Press.

IPCC. 2014. *Climate change 2014*: *Synthesis report.* Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland, IPCC.

IPCC. 2012. Summary for policymakers. In C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, & M.D. Mastrandrea *et al*., eds. *Managing the risks of extreme events and disasters to advance climate change adaptation*, pp. 1–19. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, Cambridge University Press.

IPCC. 2007. *Climate change 2007*: *Impacts, adaptation and vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, Cambridge University Press.

Ketelaar, J.W., Morales-Abubakar, A.L., Phasouysaingam, A., Chanthavong, V., Ngo, D.T., Rojas, M.F., Mishra, A. & Sprang, P. 2020. Save and Grow: sustainable intensification of crop production and innovative market linkages for building resilient rural economies in the Greater Mekong Subregion. *In* U.S. Nagothu, ed*. The bioeconomy approach: Constraints and opportunities for sustainable development*, pp. 107–129. New York, Routledge.

King, S. 2014. *Community-Based Adaptation in practice: A global overview of CARE International's practice of Community-Based Adaptation (CBA) to climate change.* London, CARE International.

Lal, R. 1974. Soil erosion and shifting agriculture. In: *Shifting cultivation and soil conservation in Africa*. FAO Soils Bulletin No. 24. Rome, FAO.

Liniger, H.P., Mekdashi Studer, R., Hauert, C. & Gurtner, M. 2011. *Sustainable land management in practice: Guidelines and best practices for sub-Saharan Africa*. Rome, FAO and Bern, WOCAT. 243 pp. (also available at http://www.fao.org/3/a-i1861e.pdf).

Lobell, D. 2011. *Climate change and agricultural adaptation.* Global Food Policy and Food Security Symposium Series. Center on Food Security and the Environment. Stanford, California, USA, Stanford University.

Luo, Q. 2011. Temperature thresholds and crop production: A review. *Climatic Change*, 109(3): 583–598.

Marshall, E.J.P., Brown, V.K., Boatman, N.D., Lutman, P.J.W., Squire, G.R. & War, L.K. 2003. The role of weeds in supporting biological diversity within crop fields. *Weed Research*, 43: 77–89.

MDGMonitor. 2016. SDG 13 – Fight Climate Change and Its Effects. *MDGMonitor* [online]. New York. [Cited 8 November 2020]. https://www.mdgmonitor.org/sdg13-fight-climate-change-and-its-effects/

Mohammed, A.R. & Tarpley, L. 2011. Effects of high night temperature on crop physiology and productivity: Plant growth regulators provide a management option. *In* S. Casalegno, ed. *Global warming impacts – Case studies on the economy, human health and on urban and natural environments*, pp. 153–172. Rijeka, Croatia, InTech.

Muchane, M.N., Sileshi, G.W., Gripenberg, S., Jonsson, M., Pumariño L. & Edmundo Barrio, B. 2020. Agroforestry boosts soil health in the humid and sub-humid tropics: A meta-analysis. *Agriculture, Ecosystems and Environment* 295: 1–12. Rome, FAO. (also available at https://www.sciencedirect.com/science/article/abs/pii/S0167880920300840).

National Aeronautics and Space Administration (NASA). 2020a. Vital signs of the planet. In: *NASA: Global climate change.* [online]. Pasadena, USA.[Cited 17 August 2020].

NASA. 2020b. Vital signs of the planet. In: *NASA: Global climate change.* [online]. Pasadena, USA. [Cited 17 August 2020].

NASA. 2020c. Vital signs of the planet. In: *NASA: Global climate change.* [online]. Pasadena, USA. [Cited 17 August 2020].

NASA. 2020d. Vital signs of the planet. In: *NASA: Global climate change.* [online]. Pasadena, USA. [Cited 17 August 2020].

NASA. 2020e. Vital signs of the planet. In: *NASA: Global climate change.* [online]. Pasadena, USA. [Cited 17 August 2020].

Nawaz, J., Hussain, M., Jabbar, A., Nadeem, G.A., Sajid, M., Subtain, M.U. & Shabbir, I. 2013. Seed priming a technique. *International Journal of Agriculture and Crop Sciences*, 6(20): 1373–1381.

Ngo, D.T., Nagothu, U.S., Morales-Abubakar, A.L., Ketelaar, J.W. & Tesfai, M. 2018. Innovative practices in potato production for food and nutrition security. *In* U.S. Nagothu, ed. *Agriculture development and sustainable intensification-technology and policy challenges in the face of climate change*, pp. 111–135. London, Earthscan.

Oregon State University. 2020. *Forage information system.* Oregon, USA. (also available at https://forages.oregonstate.edu/nfgc/eo/onlineforagecurriculum/instructormaterials/availabletopics/grasses/utilization).

Pauly, D. & Cheung, W. 2017. Is climate change shrinking our fish? *Environmental Science Journal for Teens* [online]. USA. [Cited 8 November 2020]. https://sciencejournalforkids.org/articles/is-climate-change-shrinking-our-fish/

Rader, R., Cunningham, S.A., Howlett, B.G. & Inouye, D.W. 2019. Non-bee insects as visitors and pollinators of crops: Biology, ecology, and management. *Annual Review Entomology*, 65: 391–407.

Radke, J.K. & Burrows, W.C. 1970. Soybean plant response to temporary field windbreaks. *Agronomy Journal*, 62: 273–278.

Roose, E. 1994. *Introduction à la gestion conservatoire de l'eau, de la biomasse et de la fertilité des sols (GCES)*. Bulletin pédologique de la FAO 70. Rome, FAO. (also available at http://www.fao.org/3/t1765f/t1765f00.htm).

Rusinamhodzi, L., Corbeels, M., Nyamangara, J. & Giller, K.E. 2012. Maize-grain legume intercropping is an attractive option for ecological intensification that reduces climatic risk for smallholder farmers in central Mozambique. *Field Crop Research*, 136: 12–22.

Sahrawat, K.L., Jones, M.P. & Diatta, S. 1997. Extractable phosphorus and rice yield in an Ultisol of the humid forest zone in West Africa. *Communications in Soil Science and Plant Analysis*, 28: 711–716.

Sánchez-Bayo, F. & Wyckhuys, K.A.G. 2019. Worldwide Decline of the Entomofauna: A review of its drivers. *Biological Conservation*, 232: 8–27.

Seibold, S., Gossner, M.M., Simons, N.K., Blüthgen, N., Müller, J., Ambarli, D. & Ammer, C. *et al*. 2019. Arthropod decline in grasslands and forests is associated with landscape-level drivers. *Nature*, 574: 671–674.

Selin, N.E. 2011. Carbon sequestration. In: *Britannica* [online]. [Cited 17 August 2020].

Sheridan, K. 2018. Greenhouse gases from rice paddies may be 2x higher than thought. In: *PhysOrg* [online]. [Cited 17 August 2020]. https://phys.org/news/2018-09-nitrous-oxide-emissions-rice-farms.html

Sherwood, S.G. & Bentley, J. 2009. *Katalysis: Helping Andean farmers adapt to climate change*. Participatory Learning and Action. Community-based Adaptation to Climate Change. Nottingham, Russell Press.

Simpson, B.M. 2016. *Preparing smallholder farm families to adapt to climate change: Pocket Guide 1; Extension practice for agricultural adaptation*. Baltimore, USA, Catholic Relief Services.

Simpson, B.M. 2018. Preparing smallholder farm families to adapt to climate change: Pocket Guide 2; Managing crop resources. Baltimore, USA, Catholic Relief Services.

Simpson, B.M. & Burpee, G. 2014. Adaptation under the "New Normal" of climate change: The future of agricultural extension and advisory services. MEAS Discussion Paper 3. Urbana-Champaign, Illinois, University of Illinois.

Skidmore, E.L. & Hagen, L.J. 1970. Evaporation in sheltered areas as influenced by windbreak porosity. *Agricultural Meteorology*, 7: 363–374.

Steduto, P., Theodore, C.H., Fereres, E. & Raes, D. 2012. *Crop yield response to water*. Irrigation and Drainage Paper 66. Rome, FAO. (also available at http://www.fao.org/3/i2800e/i2800e.pdf).

The Conversation. 2020. Severe heatwaves show the need to adapt livestock management for climate. *The Conversation* [online]. Australia. [Cited 8 November 2020]. https://theconversation.com/severe-heatwaves-show-the-need-to-adapt-livestock-management-for-climate-73447

The Washington Post. 2018. With warmer water, fish need more oxygen than their gills can supply. Climate. In: *Bangor Daily News*, 23 April 2018 [online]. [Cited 17 May 2021]. https://bangordailynews.com/2018/04/23/outdoors/with-warmer-water-fish-need-more-oxygen-than-their-gills-can-supply/

Van Den Berg, H. 2001. *Facilitating scientific method as follow-up for FFS graduates*. FAO Programme for Community IPM in Asia. Peradeniya, FAO. (also available at http://www.fao.org/3/ca8266en/ca8266en.pdf).

Weston, L.A. 1996. Utilization of allelopathy for weed management in agroecosystems. *Agronomy Journal*, 88: 860–866.

World Bank. 2015. *Agricultural risk management in the face of climate change*. Agriculture Global Practice Discussion Paper 09. Washington, DC.

World Neighbours. 2000. *Reasons for resiliency: Toward a sustainable recovery after Hurricane Mitch*. Oklahoma City, USA, World Neighbours.

World Fish Center. 2007. *Policy Brief: The threat to fisheries and aquaculture from climate change*. Malaysia.

World Resources Institute. 2019. Course 5: Reducing greenhouse gas emissions from agricultural production. In *World Resources Report: Creating a sustainable food future*, pp. 311–390. Washington, DC. (also available athttps://research.wri.org/wrr-food/course/reduce-greenhouse-gas-emissions-agricultural-production-synthesis).

Young, A. 1997. *Agroforestry for soil management. Second edition*. Wallingford, UK, CAB International.

Winarto, Y.T., Walker, S., Ariefiansyah, R., Prihandiani, A.F., Tadiuddin, M. & Nugroho, Z.C. 2018. *Institutionalizing science field shops: Developing response farming to climate change.* Rome, GACSA. (also available at http://www.fao.org/3/I8454EN/i8454en.pdf).

Zhu, J. J. 2008. Wind shelterbelts. *Encyclopaedia of Ecology*, 3803–3812.

Annexes

Annex A.
Community baseline climate change vulnerability assessment: Option 2

The community baseline climate change vulnerability assessment should lead to the design of field studies for the FFS and initial community adaptation plans. **Chapter 5** in the main body of this guide includes a more concise and simplified option for the vulnerability assessment based on adaptations that farmers have tried. This section uses a detailed and in-depth process based on climate change impacts. FFS master trainers and facilitators have the option to select which approach to use based on the requirements of their FFS programme.

©FAO/Luis Tato

EXERCISE A-1

What crops are grown in the community?

Background:

Preparing this and the following calendars will be time-consuming, but they are critical to deciding what to do next. It is a good idea to start with the crops that are most important to household food and nutrition security and income generation. Remember, however, that what is most important is not the same for everyone. The farming activities of men and women, as well as farmers with different types of farming systems (or farmers that are better off or poorer) are not the same.

Who Knows What

Farmers' knowledge of crops and activities will be most detailed for the management practices that they perform at various points in the cropping season. Determining who does what and when they do it will be an important step. In addition to gender considerations, if the communities where you work also include important differences in household resources (land, labour, money) that are linked to different farming systems, or include families that are primarily herders or fisherfolk in additional to agriculturalists, it is a good idea to organize separate groups so that everyone has a chance to express her/his views on the farming activities that they know best.

Learning objective:

Produce a calendar of the major crops grown in the community, by whom, how, where and at what time of the year.

Materials/preparation:

Have enough paper/flip chart and markers ready to support 4–5 groups.

Timing:

Before the start of the field school.

Time:

1–1.5 hours.

Steps:

Introduce the topic and lead a general brainstorming session with the entire group on farmers' cropping systems. Questions that may be helpful to ask include:

- Are all the fields used by farmers the same, or are there different types of fields (fields near the village, fields farther away; upland fields, those in valley bottoms; rainfed fields, irrigated fields etc.)?
- Do farmers grow the same crops in all the different types of fields, or do they plant certain crops only in specific locations? Are there common rotations used by farmers in different locations?
- Do all farmers have access to or manage the same types of field, or are there differences? Fields, or crops managed by men vs women? Older established farmers vs younger farmers? Farmers engaged in cash crop production vs food crops etc.?

Following this initial group discussion, and depending on the answers farmers give to the brainstorming questions, you may find it useful to have participants break into 4–5 smaller groups. Groups can be formed in many ways. For example, if only some farmers have access to lowland fields, or specialize in the production of an important cash crop, you may want to divide the field school participants into smaller groups placing individuals that have more knowledge of particular types of fields or crops together. Alternatively, smaller groups can be formed that are completely mixed, with men and women farmers, those of various ages and farmers that are better off or poorer. Each group can then select, or be given, a priority crop for which they will develop a calendar. Having several, smaller groups will allow more people to actively participate in preparing the cropping calendar.

Regardless as to whether you maintain one large group, or divide into several smaller groups, you will need to be alert so that certain individuals or those representing any particular type of farming system do not dominate the discussions. If this begins to happen, use your good facilitation skills and thank the individual(s) for their contributions and ensure that others also have the opportunity to speak. It will be important to ensure that everyone gets to participate and that all of the major cropping activities are identified.

To begin creating the calendar of the cropping season you will want to explain the cropping calendar matrix (see **Figure A-1**). To construct the matrix, start by making columns for the months of the year, or based on local divisions of the agricultural season. This can be done by you, if working with a single large group, or by the farmers themselves if they are working in smaller groups. If working with smaller groups, it will be important that participants first come to an agreement on how they will divide up the agricultural season so that each group uses the same approach for organizing their calendars. Next, create a new row for each major crop that is identified. Indicate the period when the crop is being cultivated, beginning with planting and ending with harvest for each crop as shown in Figure A-1.

If you create separate groups, each with their own calendar, you will need to bring the groups back together and allow each group to present their calendars and discuss with the other participants the discussion questions.

Figure A-1: Cropping calendar

Key crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cotton (irrigated)												
Vegetable (irrigated)												
Maize (rainfed)												
Beans (rainfed)												
Rice (irrigated)												

After all the groups have presented it is useful to create a single cropping season calendar that combines the input from all the groups. Individuals may have specialized knowledge about certain crops or activities, but they are also part of communities, and it is important to strengthen these community relations. Some adaptation measures will require community efforts. It will be easier to carry out these group actions later if the identification of problems and potential solutions was also part of a group effort.

Discussion questions:

- What are the main crops grown? What are the practices used by farmers in producing these crops?
- Which crops are produced for the family (food crops)? Which are produced for the market? Or both?
- Have there been any changes in the crops or varieties grown in recent years (new crops added, others abandoned)? Why were the changes made?
- What are the biggest challenges farmers have experienced in producing these crops?
- What are roles of men and women in producing the different crops?

EXERCISE A-2

How is the weather changing?

Background:

After you have created the basic cropping season calendar, it is important to identify the weather events that farmers have observed which threaten their agricultural activities. You will want to indicate when these weather events most commonly occur within the cropping season calendar that you created in Exercise A-1. Farmers growing beans, for example, may be able to easily recall specific events such as flooding caused by heavy early rains or damaging dry spells that occurred while their crops were very young and sensitive to these types of stresses. In dryland areas, farmers growing sorghum and millet may have noticed rainy seasons that ended sooner, causing lower yields due to moisture stress during the crop's grain-filling stage. The intent is to have farmers think back over the past 5–10 years and indicate at what point in the growing season specific types of weather threats most often occur in their area. Individual threats may occur at more than one time during the season.

Optimum balance

Areas with two rainy seasons, perhaps known locally as long and short seasons, will be more complicated to represent than areas that have only a single rainy season. Always seek a balance between completeness and simplicity, so that calendars do not become too complicated and unreadable. In areas with two rainy seasons, you may need to record the information about the different seasons on two separate calendars.

Learning objective:

Develop a calendar that identifies when, within the agricultural season, important weather stresses most commonly occur and how these might be changing.

Materials/preparation:

Paper/flip chart and markers.

Timing:

Before the start of the field school.

Time:

1–1.5 hours.

Steps:

To begin, start in a single large group. Later, if you formed smaller groups for Exercise A-1, you may want to ask participants to return to these same groups for Exercise A-2.

To create the weather threat calendar, start a brainstorming session with farmers to identify weather threats that occur during the agricultural season that harm one or more of the crops they grow. On a flip chart or piece of paper, have farmers make columns for the months of the year or according to local divisions of the agricultural season – it is important to divide the agricultural season in the same way as in Exercise A-1. Create a new row for each type of weather threat that is identified. Keep adding new threats until the list is complete. Next, have farmers return to their smaller groups, if you used these in Exercise A-1, otherwise you can remain in a large group. For each weather threat, have farmers indicate when the threat most commonly occurs during the agricultural season, as shown Figure A-2. Remember, threats may occur at more than one time during the season.

If you formed smaller groups, bring them back together at this point and allow each group to present and explain their calendars. As with Exercise A-1, it is useful to build a single calendar containing all the weather threats identified by the different groups.

Figure A-2: Farmers' observation of weather threat calendar

Weather risk	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heatwave												
Dry spell												
Flood												

Farmers' observation

Once you have indicated on the calendar the weather threats that farmers have observed, you can add information that you have gained from other sources, such as researchers, the meteorological service or climate change studies (see **Figure A-3**). Add this additional information to the calendar using different colours or symbols for each different source of information as in Figure A-3. It is good to discuss with farmers any difference between their observations and those from other sources, and to reach an agreement on the best way to represent recent weather patterns.

Depending on the type of information that you have access to, you may be able to further modify the weather threat calendar to include anticipated, future weather conditions. Including this additional information will allow you to use the weather threat calendar to discuss with farmers what has occurred in the past, up until the present, and also what is anticipated in the future. Comparing and discussing the two situations – the past and the future – will be helpful in understanding climate change trends and what challenges may be coming (see **Figure A-4**). Looking only

Figure A-3: Farmer–research observation of weather threat calendar

Weather risk	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heatwave				X X	X							
Dry spell					X X	X						
Flood								X X	X			

Farmers' observation   **X** Research observation at what happened in the past may lead to mistakes in anticipating what conditions will be like in the coming decades.

NOTE: Special climate change studies, with estimates of future conditions, are often very general and not organized in a way that will allow you to place the information on a cropping calendar. For example, the results of a vulnerability study may simply state that dry spells are predicted to be more frequent by 2050. If this is the case for the information that you have access to, simply make a list off to the side of the major climate changes that are anticipated. You can use this information, together with information on the changes that farmers have observed, when discussing what the future might look like. This additional information may confirm what farmers are already observing, or it may differ, indicating that more – or less – change may be anticipated in the future.

Figure A-4: Farmer–research–future weather threat calendar

Weather risk	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Heatwave							X	X (shaded)	X (shaded)	X (red, shaded)														
Dry spell									X (shaded)	X (shaded)	X (shaded)	X (red)		(shaded)	(shaded)									
Flood													(shaded)	(shaded)	X (shaded)	X	X							

(shaded) Farmers' observation X Research observation X (red) Future threats

Discussion questions:

- What are the main threats identified? Have these threats been changing in recent years? More or less common? More or less severe?
- Which weather threats are most common? Most severe?
- Are the threats more severe, or do they occur most often in particular locations or types of fields?
- Is more information on weather patterns needed? Where can we find more information? Is there information that we can collect ourselves that will help us to monitor future changes to the weather?

EXERCISE A-3

When are crops most exposed to weather risks?

Background:

After farmers have created calendars of the cropping system and weather threats, it is time to bring these two calendars together to identify any areas of overlap (see Figure A-5). Any areas of overlap indicate particular crops or activities that are potentially at risk of specific weather stresses. You will want to look in greater detail at these potential risks because they represent areas where adaptive actions may be needed.

Learning objective:

Develop a list of which crops are most exposed to the observed weather threats and at what time in the agricultural season.

Materials/preparation:

Figures produced in Exercise A-1 and Exercise A-2, and markers.

Timing:

Before the start of the field school.

Time:

30 minutes.

Steps:

For this exercise you will want to keep all of the participants in a single group. Start with the weather threat calendar that you prepared in Exercise A-2 and, for each of the weather threats identified, locate the time(s) of year when the threat most commonly occurs. Next,

Figure A-5: Linking agricultural activities and weather threats

Key crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cotton (irrigated)												
Vegetable (irrigated)												
Maize (rainfed)												
Beans (rainfed)												
Rice (irrigated)												

Weather risk	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heatwave				X X	X X							
Dry spell					X X	X X						
Flood								X X	X			

Farmers' observation   X Research observation   X Future threats move to the cropping system calendar that you developed in Exercise A-1 and locate the same time of year to see which crops are being grown. These are crops that are potentially most **exposed** to that particular weather threat. Repeat this process for each of the weather threats, recording on a sheet of paper – the name of the crop, the type of field, the weather threat and the time of year within the agricultural season when **exposure** is most common. You will use this list in the next two exercises.

Discussion questions:

- What crops, varieties and types of fields are most affected by weather threats? Why? Are there particular crops/varieties that are difficult to grow because of these weather threats? Which ones? Are there particular types of fields that are most affected? Which ones?
- Do you think it is possible to anticipate what might happen with the weather in the next season?

EXERCISE A-4

When are crops most sensitive to weather stresses?

Background:

As discussed earlier in this guide, the same weather stresses can have very different impacts on crop growth and productivity – their sensitivity – depending on when they occur, at what stage of crop development. You will also want to pay particular attention to possible combined effects – high temperatures occurring at the same time that crops are under moisture stress – because the impacts from combined weather stresses are generally much greater. Just as you used a variety of sources of information to determine how the weather has changed over recent decades, you can use this same approach to gain a better understanding of the climate change sensitivities of local farming systems – local crops in local fields. The information available from the farmers that you work with and from researchers and other development partners will be equally important. From researchers you will likely get general information about the sensitivity of particular crops or species to various climate stresses, as well as very specific and important details of crop growth and reproduction. Farmers, on the other hand, will have the most detailed knowledge about the sensitivities that they have observed in local varieties under local conditions. Both sources of information will be important in identifying what adaptive actions may be needed.

Learning objective:

Develop a timeline for each crop, indicating those stages of development when the crop is most sensitive to different weather stresses.

Materials/preparation:

Paper/flip chart and markers, crop list produced in Exercise A-3.

Timing:

Before the start of the field school.

Time:

2–3 hours.

Steps:

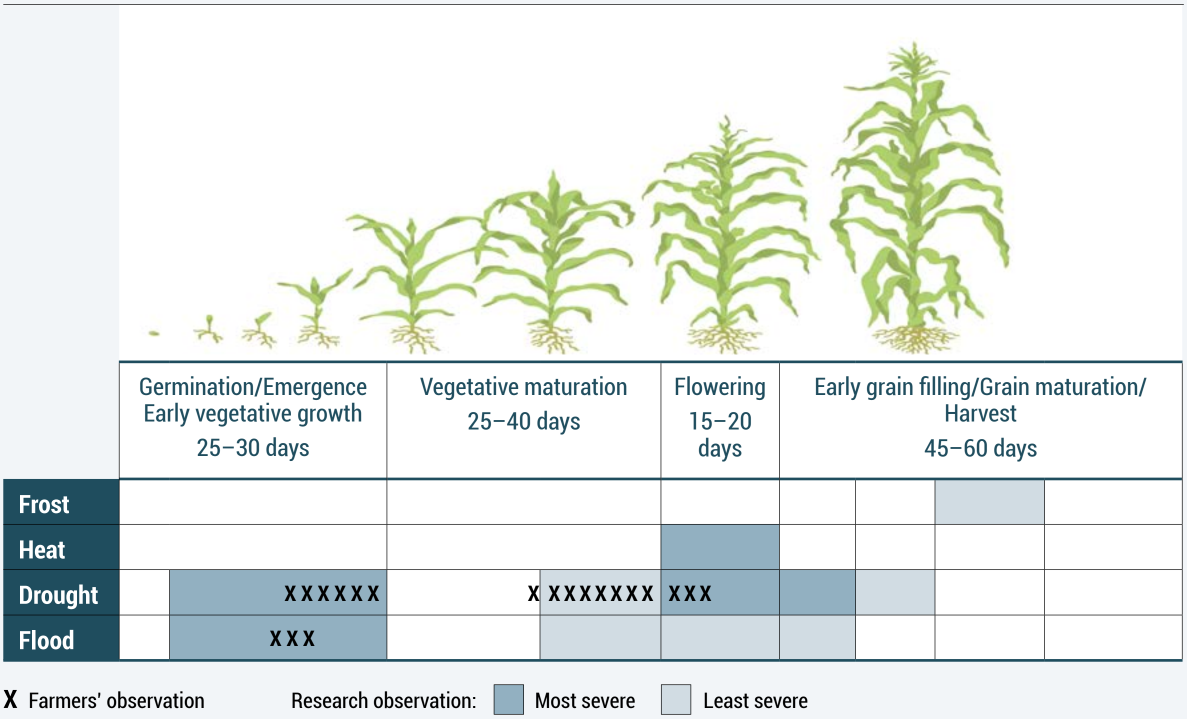
To organize information on how **sensitive** the specific crops are to various weather stresses, you will want to create a crop development timeline for each crop, showing each stage of plant growth, starting with seeding and crop germination (the use of drawings is helpful, see **Figure A-6**). You will need to develop a separate crop development timeline for each of the affected crops identified in Exercise A-3 as these are the crops most exposed to specific weather threats.

Organize farmers in a single group for this exercise. (NOTE: If the list of crops identified as being exposed to weather threats is long, you can have farmers break into smaller groups and allow each group to develop one or more crop timelines following the steps described below.) Farmers should lead this exercise, dividing the stages of each crop's development in the way that makes sense to them. Make sure, however, that the crop development timelines include the critical stages of germination, plant reproduction (flowering), yield formation and harvest, as these are times when all plants are most sensitive to weather stresses. The timelines should indicate how long the crop is in each development stage, typically counted in the number of days (or weeks). Try to make the boxes indicating the different stages proportional to the length of that stage – longer boxes for long stages, narrower boxes for short stages (see **Figure A-6**). Use a separate piece of paper for each crop timeline.

After farmers have created the crop development timelines, review each of the timelines and add any important information that you may have learned from researchers or other partners related to important stages of growth and development where crops are particularly vulnerable to specific weather stresses.

To the left of the timeline you will next want to create rows for each type of weather threat that the crop is most sensitive to. You can generate the list of weather threats as a brainstorming exercise with farmers, adding a new row for each type of weather threat. Beneath the picture of each stage of plant growth, indicate those stages where each identified weather threat is most harmful,

Figure A-6: Stages of plant growth and vulnerabilities to weather threats



as shown in the bottom part of **Figure A-6**. Threats may appear in more than one stage of development. It is best to guide farmers through this exercise first, then add any additional information that you might have collected from researchers or other sources, using a different colour marker or symbol. When you have finished, you will have created an accurate diagram of the stages of crop development showing when each crop species is most **sensitive** to each specific weather threat.

Discussion questions:

- For each crop covered in the exercise: How do the different weather threats affect the crop? What are some of the signs that farmers notice? At which stages is the crop most sensitive? Are there yield losses when these weather threats occur? What happened exactly?
- Are the threats that occur in the most sensitive stages becoming more or less common? What have you learned from other sources about future weather conditions? Will the threats become more or less common?

EXERCISE A-5

Putting it all together – where are adaptive actions needed?

Background:

This exercise is a continuation of Exercise A-4. You will use the materials that farmers have prepared – the crop development timelines (Exercise A-1) and observed weather threat calendar (Exercise A-2) – to identify areas of overlap, as shown **Figure A-7**.

Learning objective:

You will produce a list of adaptation needs, based on when crops are most sensitive to particular weather stresses, and when during the agricultural season exposure to these stresses most commonly occurs.

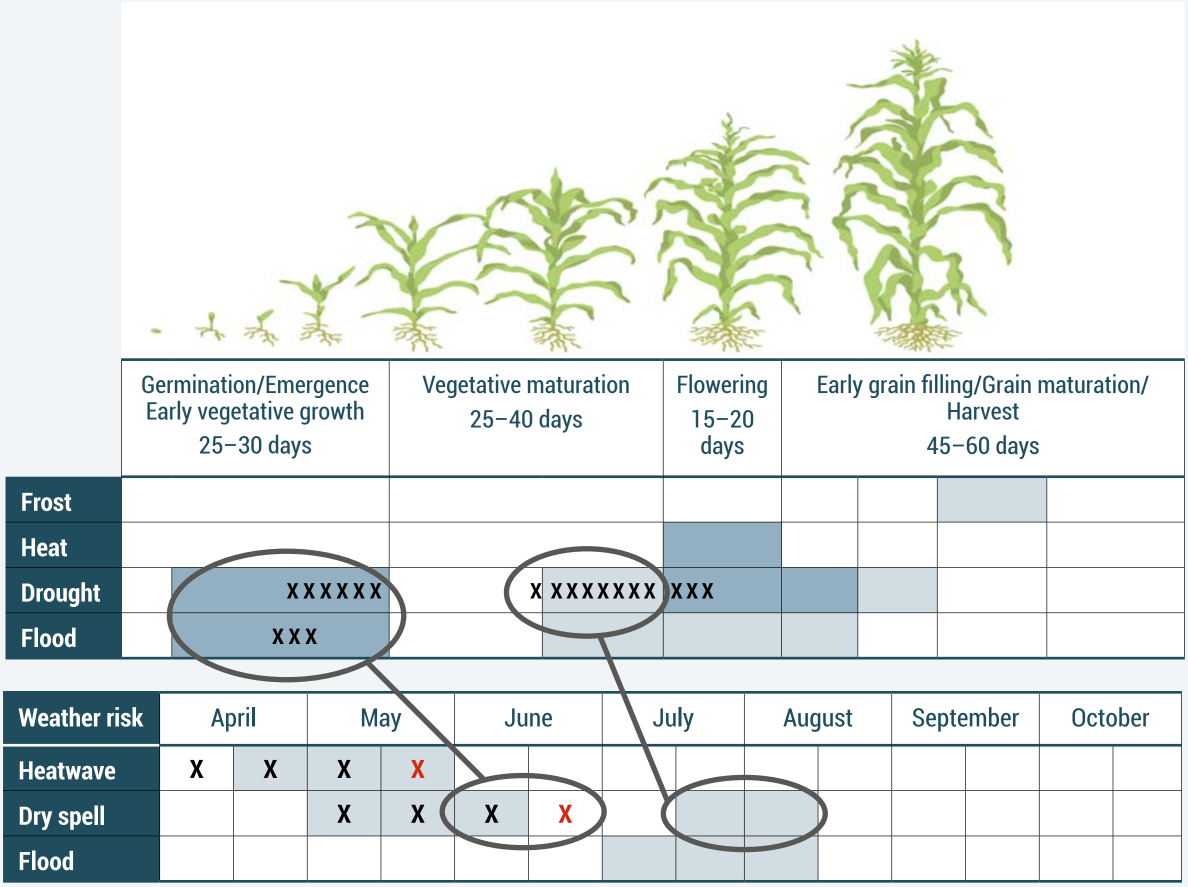
Materials/preparation:

Paper/flip chart, markers, and figures produced in Exercise A-2 and Exercise A-4.

Timing:

Before the start of the field school.

Figure A-7: Linking crop sensitivity and weather threat calendar



Time:

1–1.5 hours.

Steps:

Return to the observed weather threat calendar that you created in Exercise A-2. Attempt to match the first crop development timeline (Exercise A-4) with the calendar so that the beginning of the box indicating crop germination lines up with the time in the agricultural season when planting occurs on the weather threat calendar (see **Figure A-7**). You may need to draw connector lines on the crop development timeline to more accurately show when, on the weather threat calendar, the various stages of crop development occur.

HINT: try to draw mostly on the crop timeline pages, and not on the weather threat calendars, as the calendar will get very confusing as you proceed through all the crop pages.

Next, look for any overlap between the individual stages of crop development and the weather threat calendar. You are looking for any stages of crop development where the crop is particularly sensitive to a weather stress, and when that weather stress has been observed to commonly occur. If you find areas of overlap, write these down on a separate piece of paper, indicating: the name of the crop, the critical stage of crop development and the specific weather stress to which it is sensitive and exposed. You will need to repeat this exercise for each of the crops for which you developed sensitivity calendars in Exercise A-4. The final list is very important. It identifies areas of greatest vulnerability within farmers' cropping systems. You will use this list in identifying adaptive practices to test in the field studies and special studies of the FFS.

Remember: Pay particular attention to the estimated future climate changes if you have been able to include this information on the weather threat calendar. These estimations will help to reinforce areas of concern – things that may be getting more common or severe with time; they may also help you to identify potential threats that are not currently a problem but may become a problem in the future.

The ability to anticipate increasing or future problems is key to successful climate change adaptation.

Annex B.
Example field studies

FIELD STUDY 1

Impact of sensitivity to heat stress resulting from livestock housing

LIVESTOCK; ENVIRONMENT CHANGE

Animals are vulnerable to direct and indirect effects of the weather – in particular, increase in temperature, increase in the number of hot days and number of heatwaves. The productivity of livestock systems is negatively affected by their sensitivity to hot environments (Bernabucci, 2019). In a hot environment, animals reduce their feed intake and in the process, milk production is reduced. The housing environment of livestock can influence the ambient temperature (i.e. the temperature surrounding the animal), as well as the animal's ability to cope with the effect of heat stress and its milk production.

Learning objective:

To observe and compare the influence of housing on milk production of livestock.

Timing:

Any time during the FFS but preferably during the hot season.

Time required:

Full season. Normal visits to collect data (daily, at the same time, for temperature data) and management operations (especially for cooperating farmers) throughout the season.

Materials/preparation:

Selection of, and agreement with, two cooperating farmers to use their animals for the study. The cows should be the same age and status and preferably at the same stage of lactation. Select one farmer whose livestock housing has less favourable conditions – made of materials that absorb and retain heat (e.g. G.I. sheets), exposed to the sun and without trees to provide shade and cooling. Select another farmer whose livestock housing has comfortable conditions – made of materials that keep the environment cool, located under trees for shade, good ventilation etc.

Before the start of the study, make sure to set up thermometers in the housing facilities to monitor the temperature (see **Special Topic 1b**).

Methods/procedures:

Two basic treatments:

T1. Housing is exposed to the sun, without shady trees and has higher ambient temperature.

T2. Housing has comfortable microclimate conditions (e.g. good ventilation, shady trees around, materials repel heat).

- All practices used for the two treatments should be the same. The only difference would be the housing for the livestock.
- Ensure that the two cooperating farmers are aware of and provide the nutrient requirements of their cows.
- Ensure that the cooperating farmers take the temperatures in the housing daily at the same time and record the information. Likewise, data on daily milk yield should be taken and recorded.

Things to observe and measure :

- For livestock:
    - Ambient temperature
    - Body weight
    - Body measurement
    - Daily milk yield
    - Feeding routine
    - General appearance of hair/coat condition
    - General health condition
    - Movement
    - Activity level
    - Injuries
    - Presence of parasites/insects
    - Total cost of inputs, income (from cost–benefit analysis at the end of the season)
- At the end of the season (you can calculate):
    - Milk production (kg/cow/day)
    - Total cost of inputs, income (from cost–benefit analysis)

Discussion questions:

Carefully compare the data on the various measurements you took during the season and at harvest.

- What was the average ambient temperature in each treatment? What happens if the temperature is high?
- Were there any important weather stresses during the season? At what stage in the production cycle? How did the livestock respond to the weather stresses when they occurred?
- Was there a difference in yield between the treatments? Which treatment gave the highest benefits? What could be the reason for the difference?
- What improvements could be made to the shelter/housing? What are locally available materials that can be used to improve housing for livestock?

FIELD STUDY 2

Impact of heat stress on growth and yields of fish

AQUACULTURE/FISHERIES; ENVIRONMENT CHANGE

Fish cannot regulate their body temperature because they are cold-blooded. When the temperature of the water becomes warmer, they need more oxygen to maintain their bodily functions. But warmer water also holds less oxygen (The Washington Post, 2018). Fish breathe through their gills but the gills cannot keep up with the demand for oxygen resulting in smaller fish size (Pauly and Cheung, 2017). On the other hand, the temperature of the water in a pond can be decreased in the hot season to avoid heat stress and associated problems with fish. Providing temporary shade or cover over part of the pond during hot periods or growing trees for shade (as a long-term solution) will help.

Learning objective:

The objective of the study is to observe and compare the impact of heat stress on growth and yields of fish.

Timing:

Any time during the FFS but preferably during the hot season.

Time required:

Full season. Normal visits to collect data (daily at the hottest time of the day – e.g. 12.00 hours – for temperature data) and management operations (especially for cooperating farmers) throughout the season.

Materials/preparation:

Selection of, and agreement with, two cooperating farmers to use their fields for the study. The fields should be about the same size and depth and adjacent to each other. One field should not have any shade (or cover) at all (i.e. exposed to the sun the whole day). The other field should have trees in the right locations to provide shade to the pond. Otherwise, construct a temporary cover to provide shade.

Before the start of the study, make sure that thermometers are available to monitor the temperature of the water (see **Special Topic 1b**).

Methods/procedures:

Two basic treatments:

T1. Field without shade.

T2. Field with shade (e.g. trees) or construct a cover over one part of the field.

- All practices used for the two treatments should be the same (e.g. stocking density, depth of water, feed etc.). The only difference would be the shade/cover.
- Ensure that the two cooperating farmers are aware of and provide the nutrient requirements of their fish and that they maintain the ponds well.
- Ensure that the cooperating farmers take the temperature of the water daily at the

hottest time of the day – e.g. 12.00 hours and record the information. For Treatment 2, take the temperature of the water in the part of the pond under the shade/cover.

Things to observe and measure:

- For the fish:
  - Size of fish at regular intervals during the growing season
  - Weight of fish at regular intervals during the growing season
  - Yield of fish
  - Total cost of inputs, income (from cost–benefit analysis at the end of the season) from fish

Discussion questions:

Carefully compare the data on the various measurements you took during the season and at harvest.

- What was the average ambient temperature in each treatment? What happens if the temperature is high?
- Were there any important weather stresses during the season? At what stage in the production cycle? How did the fish respond to the weather stresses when they occurred?
- Was there a difference in yield between the treatments? Which treatment gave the highest benefits? What could be the reason for the difference?
- What improvements could be made to reduce heat stress for the fish? What are locally available materials that can be used to make a refuge to improve the temperature of the pond?

FIELD STUDY 3

Moisture stress during the growing season

CROP; ENVIRONMENT CHANGE

Under rainfed conditions, moisture stress at all stages of crop development is a challenge that farmers have always faced, even without climate change. Farmers in your FFS may have observed that changing patterns of rainfall are making this worse, with more frequent or longer periods without rain. Higher temperatures and stronger winds can make these dry spells even more damaging. There are a number of ways that farmers can change how their farm looks and functions (environmental changes) that will help to capture more of the rain that comes, hold more of the moisture that enters the soil, for longer, and protect the stored moisture from evaporation. By adopting one or more of these practices, farmers can reduce their crops' sensitivity to dry spells during the growing season.

One of the most effective environmental changes that farmers can make in helping to improve soil moisture conservation is the **use of mulch**. By covering the soil surface between crops and rows with a layer of crop residues, compost, green or animal manure, farmers can greatly reduce the amount of soil moisture lost through evaporation. In addition to protecting soil moisture, mulch provides three other important benefits: reducing, even stopping soil erosion caused by heavy rainfall and wind; supplying the soil with additional nutrients as the mulch material breaks down, while building up soil organic matter capable of holding even more moisture; and making it difficult for weeds to become established and compete with crops for soil nutrients and moisture.

Testing more than one mulch type is recommended, as it will give farmers a better understanding of how well these different materials work in practice. Crops that produce large amounts of residue are ideal, such as rice, maize, millet and sorghum. As a comparison, other crop residues and materials can also be used, such as crops that produce more leaves than thick stalks (e.g. bean, groundnut or soybean hay), cut grass, and compost material that has not completely broken down. Different types of mulch material will provide varying levels of protection against heavy rainfall events and soil moisture loss.

NOTE: Before introducing this field study it is recommended that you facilitate the exercises under **Special Topic 8** (Mulching and mulches).

Learning objective:

To observe and compare the benefits of using different quantities of mulch, and different types of mulch, as a way of reducing the effects of dry spells during the cropping season.

Timing:

At the start of the FFS.

Time required:

Full season. It will take 1–2 hours to explain how the use of mulch functions and the benefits that using mulch provides (see **Special Topic 8**). You will also need to assess the types of mulch materials that are locally available and to select those for use in the study. Normal visits to collect data and management operations throughout the season.

Materials/preparation:

Sufficient seeds to plant all of the treatment plots with a minimum size of 10 m × 20 m (use the same variety for all the plots), sufficient mulch material to cover each of the treatment plots, a scale or means of measuring the weight or volume of mulch material, string and ruler to measure the plots, stakes and signs to mark the test plots, record book and pen.

Methods/procedures:

Three basic treatments:

T1. Local practice (LP): use typical local practices, as identified with farmers, to prepare, plant and manage this plot (you can refer to the description of local practices for each crop that was completed in Exercise A-1). This plot will not receive any compost or mulch.

T2. Crop residue 50 percent: prepare this plot in the same way as T1. In addition, add enough mulch to cover only 50 percent of the soil surface area between rows and planting pockets.

T3. Crop residue 100 percent: prepare this plot in the same way as T1. In addition, add enough mulch to completely cover 100 percent of the soil surface area of the plot (twice as much as T2).

HINT: The use of mulch is one of the practices that improves over time. That is, the positive effects of using mulch in a field increases in the second, third and fourth years. If possible, you are strongly encouraged to continue this field study for more than one season – maintaining the same treatments, in the same treatment plots, each year. Another reason to maintain this field study for more than one season is that the weather in the first year may not cooperate. It is hard to see the benefits of using mulch to reduce the negative impacts of dry spells if there is sufficient rainfall, well-distributed throughout the growing season!

NOTE: If your field study site has soils where a hard surface crust has formed, this may need to be broken by first hand-hoeing before crop residues are put in place.

Things to measure:

- The quantity of mulch used in the each of the trial plots. This can be done by weight, if you have a hanging scale, or use a local measure of volume, such as a bundle or cart load. Simply collect the mulch from one of the treatment rows, weigh or measure, and then multiply by the number of rows for that plot. After measuring carefully, replace the mulch. You will want to do this before seeding the plot so as not to disturb your planting rows.
- The number of days after planting until the first seedlings emerge in each plot; the number of days until all of the seedlings have emerged.

- Number of seedlings germinating and surviving the early stages of plant growth in each plot.
- Plant height at regular intervals during the early part of the growing season (every 1–2 weeks).
- Observations on plant health (pest and disease), crop responses to weather events, especially any dry spells, or heavy rains.
- Number of weeds emerging 2 weeks after planting, 1 month after planting.
- Observations on ease or difficulty in performing management operations, such as weeding.
- The number of earthworms in the soil after 1 month (collect the soil from an area 30 cm × 30 cm and 30 cm deep, and count all of the earthworms).

Measure, Divide, Multiply

To help farmers estimate the amount of mulch they will need to cover a normal production field you will need to scale up the application rate from the field study plot to the field level. First, measure the amount of mulch used in the field study plot with the desired application rate using the steps described above. Next, multiply the width and length of the field study plot to determine the total surface area. Then, determine the surface area of the farmer's field where the mulch will be applied. Divide the surface area of the farmer's field by the surface area of the test plot, then multiply that number by the quantity of mulch used in the field study plot. The result is the quantity of mulch required to cover the farmer's field. For example:

> Quantity of mulch used in the field study plot: 80 kg
>
> Surface area of the field study plot: 10 m × 20 m = 200 m^2
>
> Surface area of the farmer's field: 100 m × 100 m = 10 000 m^2 (1 ha)
>
> Quantity of mulch needed for the farmer's field:
> 10 000/200 = 50 → 50 × 80 kg = 4 000 kg (4 tonnes) of mulch

These same calculations can also be used to determine the quantity of mulch material produced in different locations. Simply collect and weigh a sample of mulch material from an area that you have measured (width and length), and use these numbers to calculate how much mulch material might be produced from the entire field (you will also need to measure the entire field). For example:

> Quantity of mulch produced in the sample plot: 60 kg
>
> Surface area of the sample plot: 10 m × 10 m = 100 m^2
>
> Surface area of the entire field: 100 m × 100 m = 10 000 m^2 (1 ha)
>
> Quantity of mulch material produced in the entire field:
> 10 000/100 = 100 → 100 × 60 kg = 6 000 kg (6 tonnes) of mulch

- The yield from each test plot.
- Record of the date and quantity of rainfall over the entire growing season. Pay particular attention to any dry spells, recording the length of the dry period (number of days), the temperature, the development stage of the crop and crop response in the different treatment plots.
- Total cost of inputs, income (from cost–benefit analysis at the end of the season).

Discussion questions:

At harvest, review and discuss the differences observed in the measurements that were collected during the season:

- How did each of the different application rates of mulch compare to the plot with bare soils on the different measures? Which treatment worked the best? On all measures, or only certain ones?
- If you compared different types of mulch material, were there any differences between the different types used? Which performed best on the different measures? Did the benefits change through the season? On all measures, or only certain measures?
- Review the results of Exercise A-2. Were there any important weather stresses during the season? At what stage of crop development? How did the crops in the different treatment plots respond to the weather stresses when they occurred? Were there any differences in yields from the field study plots?
- What were the advantages vs disadvantages of mulching vs not mulching? Can something be done or changed to overcome the disadvantages?

CASE STUDY

Viet Nam: Boosting farm incomes with no tillage potato IPM

In 2008, FAO introduced Viet Nam to the concept of no tillage potato growing using integrated pest management (IPM) in lowland rice production systems. Rice fields are not ploughed, or tilled, after harvesting. Instead, the paddies are drained using drainage furrows that result in raised beds ideal for growing potatoes without the usual need for labour-intensive ploughing, or tilling. The potato seed tubers are simply placed on the beds and after adding fertilizer to the soil around the tubers, the beds are covered with straw left over from the recent rice harvest. Twice during the growing season more fertilizer and rice straw must be added to the potato beds. Four hectares of rice produce enough straw to grow one hectare of potatoes. Using leftover rice straw for mulch reduces the emission of greenhouse gases, because traditionally the rice straw was burned.

The straw mulch creates an important habitat for many of the potato's natural enemies. Also known as "friends of farmers", these insects and microorganisms are vital if the plant pest population is to be successfully regulated in a natural organic way. Importantly, mulching with rice straw reduces the need for irrigation from 5 000 m^3 of water to just 900 m^3 per hectare. Using the IPM system to grow potatoes, farmers report a substantial reduction in the use of fertilizers and pesticides, and a dramatic reduction in labour. IPM reduces the time involved in land preparation, planting, irrigation, agrochemical application and harvesting by some 45 percent when compared to the conventional method of growing potatoes.

Urbanization and the migration of rural youth to nearby cities in search of better-paid employment opportunities leaving farm activities mostly to women, especially the elderly, used to be a problem. But today, elderly women in the northern Thai Binh province grow potatoes using a labour-saving method and sell the farm produce to raise money to pay for their grandchildren's school! Between 2009 and 2011, profits from growing potatoes increased by 60–73 percent using no tillage potato IPM compared with conventional potato growing methods.

From 25 farmers in a farmer field school in one province, the practice was adopted in 15 provinces. As a result, no tillage potato IPM was recognized as a promising model and, in 2011, the Ministry of Agriculture and Rural Development issued a directive calling for all potato-producing provinces in Viet Nam to apply the practice.

Sources: FAO. 2017; Ngo *et al*. 2018.

No tillage potato IPM production in Viet Nam

FIELD STUDY 4

Adaptive varieties – comparison of yields of different grass fodder varieties[1]

LIVESTOCK; GENETIC RESOURCES

Fodder is used specifically to feed domesticated livestock (e.g. cattle, sheep, horses). Fodder crops may be either temporary (i.e. cultivated and harvested in the same year) or permanent (relating to land use – 5 years or more) (FAO, 2011). Grass is an excellent feed for animals. Unfortunately, in many places, grasslands and pastures have not always been managed well. For example, human activities such as overuse of nitrogenous fertilizer, frequency of cutting grass, overstocking and even simply conversion of grasslands for arable production have resulted in degradation and loss of products and ecosystem services grasslands. In addition to being the main plant type for animal feed, grass can improve soil organic matter, reduce soil erosion, absorb manure and store carbon dioxide from the atmosphere.

The adaptability of different grass types to locations varies. High-quality and high-yielding grass (feed) that causes fewer greenhouse gas emissions is desired.

Learning objective:

The objective of the study is to identify varieties that tolerate or better respond to changing weather patterns and stresses.

[1] Adapted from Draaijer (2016).

Timing:

At the start of the FFS.

Time required:

Full season. Normal visits to collect data and management operations (especially for host farmers) throughout the season.

Materials/preparation:

Selection of and agreement with host farmers to use their farms. Sufficient lead time should be allowed for land preparation. Fencing must be constructed before the plot becomes open to animal grazing, especially in the dry season.

Three different varieties of grass of the same species, fertilizer (10 kg NPK [nitrogen, phosphorous, potassium], 10 kg CAN (calcium ammonium nitrate), 300 kg manure, tools (hoe, rake and machete), weighing scale, ropes, measuring tape. The dosage and types of fertilizers may vary depending on the local requirement and soil characteristics/properties.

Methods/procedures:

Three basic treatments with two replications per fodder type:

T1. Variety 1 (could be the local variety, a grass that farmers in the locality have been using for a long time).

T2. Variety 2 (could be *Pennisetum purpureum*).

T3. Variety 3 (could be *Brachiaria cv. Mulato* or *cv. Mulato II*).

- Participants decide on what varieties (i.e. three varieties of the same species) of grass to use for the study.
- The same conditions should apply to all treatments and replications: plots of equal size (10 m × 10 m) and grown on the same soil; same type and quantity of manure/fertilizer; all rainfed; 6-month duration; all other management practices similar, including weeding.
- Assign the plots randomly and mark the six plots (two for each fodder type) clearly.

Things to observe and measure:

- Agro-ecosystem analysis weekly, collecting data on the following:
  - Basic characteristics of plants (size of leaves, colour of leaves etc.)
  - Height of plants
  - Spread of plants
  - Plant vigour
  - Presence of weeds
  - Diseases/pests and their significance
  - Soil conditions: dry, moist, wet etc.
  - Weather: sunny, windy, rainy, cloudy etc.
- At the end of the season:
  - Yields
  - Total cost of inputs, income (from cost–benefit analysis)
  - Carbon sequestration (tonne/ha), possible with assistance from local experts

Discussion questions:

Carefully compare the data on the various measurements you took during the season and at harvest.

- How do the different treatments and replications compare? Are there important differences during the season? What could the differences indicate?
- Were there any important weather stresses during the season? At what stage in the production cycle? How did the varieties respond to the weather stresses when they occurred?
- Was there a difference in yield between the treatments?
- Which treatment gave the highest benefits?

FIELD STUDY 5

Adaptive varieties – temperature and moisture stress tolerant and early maturing varieties

CROP; GENETIC RESOURCES

One way of helping farmers to respond to damaging high temperatures, or more common periods of moisture stress during the growing season, even changes to the length of the growing season, shorter or longer, is the use of varieties and crops that tolerate or respond to these conditions. If you identified one of these climate stresses – hot temperatures, moisture stress, shorter or longer growing period – in Exercise A-2 as something that requires an adaptive response (listed in Exercise A-3), you may want to include a variety test as one of your field studies.

An easy way to think about the use of genetic resources in responding to climate change stresses is through a two-step process. The first step is to look for options of changing varieties – those that match the new or emerging conditions. Changing varieties has the advantage that farmers will still be able to grow the same crops, those that they are familiar with, that fit their production systems, meet their food preferences and supply the same markets if they are sold. If new varieties are not available that respond to the identified weather stresses, or the stresses are so great that new varieties cannot help, the second step is to change crops, selecting a crop that better tolerates or even prefers the new weather patterns. Ultimately, farmers may find that some field types or areas may need to be used for other purposes, such as grazing or tree planting.

Note: If you plan to conduct a field study testing varieties tolerant to specific weather threats, such as heat and moisture stress, it will be essential that you have a means of accurately measuring local weather conditions (see **Special Topic 1 – Using local weather data**). You will want to use the crop sensitivity calendar that you created for your study crop in Exercise A-2 to help compare how the tolerant and non-tolerant varieties responded to hot or dry conditions during those critical periods of plant development noted on the calendar. For more rapid maturing varieties – those with the potential of escaping the effects of an earlier end to the rainy season, or avoiding yield damage caused by hot spells during the flowering period of longer maturing varieties – you will also need to have a record of local weather conditions. In conducting any field study using new varieties, you will also need to carry out a seed germination test to make sure the new seeds are of good quality (see **Special Topic 7 – Testing seed germination**).

Learning objective:

To identify new varieties that tolerate or better respond to changing weather patterns and stresses.

Timing:

3–4 weeks before the start of the growing season; you will need time to identify an appropriate site for your field study, or sites if more than one replication is to be used (recommended); locate a source of seeds and test the germination quality of each variety (see **Special Topic 7**).

Time required:

Full season. To set up the trial, a half-day to full day will be required, depending on the number of varieties being tested and replications.

Materials/preparation:

A sufficient quantity of seeds of each new variety and a local variety[2] to plant a minimum of one 10 m × 10 m plot. You will need more seeds if you will be establishing more than one replication of the study (if farmers are willing to do this, this is strongly recommended); all other inputs or equipment normally used in planting and managing the crop until harvest; string (5–10 m), ruler or tape measure and stakes to measure and mark the boundaries of all your field study plots; materials to create signs for each variety at each location; and a notebook and pen for keeping records.

Methods/procedures:

Three to four treatments (depending on the number of varieties selected):

T1. Traditional variety with traditional practices.

T2. Test variety with traditional practices.

T3. Test variety with traditional practices.

T4. Test variety with traditional practices.

- After selecting the site for your field study carry out all of the normal steps of land preparation, then carefully measure and stake out the boundaries of your test plots. If you have received any specific recommendations regarding land preparation for planting the new varieties being tested, be sure to follow these instructions, and use the same procedures for the plots where the local variety will be planted so that the only difference between the test plots is the varieties used.
- A good minimum size for a variety trial is 10 m × 10 m; plots of 5 m × 5 m can be used, but if you use this size you should establish multiple (2–3) replications of the field study plots. (NOTE: It is always good practice when comparing varieties to establish multiple plots, in different fields if possible, regardless of the plot size).

HINT: Leaving a small gap (e.g. 50 cm) between the subplots is helpful as it will allow field school participants and visitors to more easily move among the plots.

- Sow each of the test plots with the different varieties. If the new variety comes with specific instructions on planting – planting depth, seed and row spacing – follow these instructions and use the same practices when planting the local variety. If there are no special planting instructions, follow farmers' traditional practices for all the varieties. Using the same planting practices for all the varieties is important – the

[2] If farmers have one or more local varieties that are thought to be tolerant to the stress to which you are seeking adaptive responses, be sure to include this in your study as one of the adaptive varieties. In this case, you will then need to use a different variety as your local check.

purpose of the field study is to test the differences in the varieties, not "packages" of different management practices.

- You will want to immediately place a sign in each the subplots and record the location of each subplot in your field study logbook. This is essential. Once the seeds germinate and start growing it may be impossible to tell the difference between the varieties. The material used for the signs and writing should be durable, able to last through the entire season. As a minimum, signs should include the name of the variety. You should also include the date of planting.

NOTE: You may find that weather conditions do not cooperate with your field study. Testing a drought-tolerant variety in a season when there is plenty of rainfall, or a rapid maturing variety in a year when the rains continued longer than usual, will not allow you to see the benefits of varieties tolerant to these conditions. To test drought-tolerant or rapid maturing varieties, you can conduct your field study during the dry season (if you are located in an area with distinct wet and dry seasons). Use irrigation water to establish the trial plots, then withhold water at different times in the season to create your own drought conditions, or stop irrigation completely to create conditions of a season where the rains end early. For temperature stress, there is nothing that can be done to simulate high temperatures. You may simply need to repeat the study in the following season, and perhaps the season after.

Measurements:

- Number of seedlings germinating and surviving the early stages of plant growth.
- Plant height at regular intervals during the growing season (every 1–2 weeks).
- Number of tillers or branches per plant.
- Incidence of pest or disease damage.
- General appearance of the plants, especially in response to weather conditions, such as drooping during periods of moisture stress, or high temperatures.
- Date of first flowering; date when 50 percent of the plants are flowing; date of harvesting (this is especially important when testing rapid maturing varieties).
- Number of seedpods or heads per plant; number of seeds per pod or head; weight of yield per plant; total weight of yield from each subplot.
- Ease of harvesting, threshing, preparation for cooking, cooking, food taste, quality of leftovers.
- Total cost of inputs, income (from cost–benefit analysis at the end of the season).

Discussion questions:

Carefully compare the data on the various measurements you took during the season and at harvest.

- How do the different varieties compare? Are there important differences at the various stages of crop development? Are there differences between the varieties on all measures, or only some?
- Were there any important weather stresses during the season? At what stage of crop development? How did the different varieties respond to the weather stresses when they occurred? Was there a difference in yield?

FIELD STUDY 6

Comparison of yields and benefits from rice only and integrated rice–fish–aquatic biodiversity production systems

AQUACULTURE/FISHERIES AND CROPS; OTHER MANAGEMENT PRACTICES

Farmers today are confronted with unprecedented and intersecting challenges like increased competition for land and water, rising fuel and fertilizer prices, and the impact of climate change amidst the need to produce food for the growing global population. However, the reality is that misuse and overuse of chemicals – particularly in rice production – in efforts to increase yields damages terrestrial and aquatic biodiversity, that could otherwise be sources of income, additional food and ecosystem services. Sustainable diversification of production by integrating rice–fish–aquatic systems as mitigation and adaptation strategies will enhance resilience to climate change and ensure food safety.

Learning objective:

The objective of the study is to observe and compare yields and benefits from rice only and integrated rice–fish–aquatic biodiversity production systems, as a way of reducing the effects of climate variability.

Timing:

At the start of the FFS.

Time required:

Full season. Normal visits to collect data and management operations throughout the season.

Materials/preparation:

Selection of and agreement with cooperating farmer(s) to use their field(s) (adjacent to each other) for the study.

Methods/procedures:

Two basic treatments:

T1. Field planted to rice only.

T2. Field integrating rice–fish–aquatic organisms (including aquatic plants, insects, amphibians such as frogs, crustaceans).

- Participants decide on good agronomic practices to employ including wider plant spacing/reduced seeding rate, improved water management, use of biological control as alternative to chemical pesticides. They also decide on the species of fish and/or aquatic organisms to integrate.
- After selecting the site for your field study, carry out all the normal steps of land preparation, following specific recommendations especially regarding the layout of the treatment integrating fish and aquatic biodiversity (e.g. canals for refuge). Follow the recommendations for stocking density, feed etc.
- A good size for the plots would be about 300 m^2 per treatment, but this would depend

on what is available in the locality. The size should be reasonable so that participants can manage the studies well and data collection does not become cumbersome.

- Throughout the season, participants use goods and services of paddy-based farming systems including conservation and management of aquatic biodiversity (e.g. captured and cultured fish species). All management practices for rice production in both treatments will be the same.

Things to observe and measure:

- For the rice crop:
  - Plant height at regular intervals during the growing season (every 1–2 weeks)
  - Number of tillers
  - Incidence of pest or disease damage
  - General appearance of the plants, especially in response to weather conditions, such as drooping during periods of moisture stress, or high temperatures
  - Number of panicles
  - Yield
  - Total cost of inputs, income (from cost–benefit analysis at the end of the season)
- For fish and other aquatic organisms:
  - Size of fish at regular intervals during the growing season
  - Weight of fish at regular intervals during the growing season
  - Yield of fish
  - Total cost of inputs, income (from cost–benefit analysis at the end of the season) from fish
  - Yield of other aquatic organisms
  - Total cost of inputs, income (from cost–benefit analysis at the end of the season) from other aquatic organisms

Discussion questions:

Carefully compare the data on the various measurements you took during the season and at harvest.

- How do the different treatments and replications compare? Are there important differences during the season? What could the differences indicate?
- Were there any important weather stresses during the season? At what stage in the production cycle? What actions did the group take to address the threat?
- How did the fish and aquatic organisms respond to the weather stresses when they occurred? What about the crop?
- Was there a difference in yield between the treatments?
- Which treatment gave the greatest benefits?

CASE STUDY

Save and Grow practices utilizing integrated rice–fish–aquatic biodiversity increases gross income by 210–550 percent, Viet Nam

The Regional Rice Initiative (RRI), a pilot of Strategic Objective 2 "Sustainable Management of Agriculture, Forestry and Fisheries" of the Food and Agriculture Organization of the United Nations (FAO), was designed to focus on the importance of goods and services produced by and available from rice ecosystems, and to identify and locally test sustainable practices to enhance resilience and increase efficiencies in rice production to improve food security amidst challenges brought about by climate change. The project, implemented initially in three pilot countries, sought to address the concerns of governments to promote more efficient use of diminishing resources by farmers (i.e. Save and Grow) and better management and use of agro-ecological processes for sustainable intensification of agricultural production.

In 2014, the RRI was expanded to include other countries. Rice FFS farmers in northern Viet Nam explored diversifying production and making optimal use of multiple goods and services of paddy-based farming systems – including conservation and management of aquatic biodiversity (i.e. both captured and cultured fish species) – in combination with improved agronomic practices such as wider plant spacing/reduced seeding rates and improved water management. IPM and the use of biological control agents as alternatives to chemicals and natural biological control provided by ecosystem services were employed for pest management. The results of the field studies at the end of one season are summarized in the table.

Yields and benefits from rice only and integrated rice–fish–aquatic biodiversity production systems

Parameters	Total Bac Giang	Total Quang Binh	Average
A. Rice yield (kg/ha)	6 120	5 417	5 769
B. Gross income from rice production only (USD/ha)	2 215	1 569	1 892
C. Yields of fish and other aquatic organisms (kg/ha)	7 913	1 860	4 886
D. Gross income from fish and other aquatic organisms (USD/ha)	9 981	1 738	5 860
E. Gross income from rice, fish and other aquatic organisms [B+D] (USD/ha)	12 196	3 307	7 751
F. Input costs (USD/ha)	4 547	1 402	2 975
G. Profits [E - F] (USD/ha)	7 649	1 905	4 776
H. Difference in gross income between rice production only and integrated rice – fish – aquatic biodiversity production (% increase)	551%	211%	381%

Exchange rate: USD 1: VND 21.405

The integrated rice–fish–aquatic production system gave an average gross income of USD 7 751 compared to USD 1 892 obtained from producing only rice. There was a difference in gross income of 211–551 percent resulting from the use of integrated rice–fish–aquatic biodiversity production practices compared with producing rice only. The big difference in benefits stemmed from aquatic biodiversity species and numbers – especially fish. The experience convinced members of the community about the advantages of diversification (e.g. integrated farming systems) in terms of increasing productivity and adaptation to climate change. One important result of the experience was the involvement of the entire community in the preparation of a community action plan for improvement of the rice ecosystem health to ensure the sustainability of integrated rice–fish–aquatic biodiversity production.

Sources: ICERD, 2021. Ketelaar *et al.*, 2020.

Woman harvesting fish from rice–fish system

FIELD STUDY 7

Responding to an increasingly uncertain start to the growing season with a) seed priming/seed soaking and b) dry seeding

CROP; OTHER MANAGEMENT PRACTICES

Under rainfed conditions, determining the exact moment to plant is farmers' greatest challenge. Planting too early can result in crop failure if there is not sufficient rainfall for the newly germinated seeds to survive. Similarly, planting too late can result in the loss of potential yield from taking advantage of soil moisture and nutrients early in the season. In extreme cases, losses can be very large if planting takes place too late and the season ends before the crop has completed its reproduction cycle.

There are several management practices that farmers can use to help them adapt to an increasingly uncertain start to the rainy season. Examples of two field studies are provided herein. Each responds to different conditions, using a different adaptive strategy. The first is **seed priming** or **seed soaking**. This technique is useful when rains are delayed and farmers need to get their crops growing as quickly as possible, when the loss of even a few additional days may be critical. The second is **dry seeding**, useful in situations when the start of the season is truly unknown. Depending on the outcome of your assessment of weather risks completed earlier, one of these practices (but not both) may be useful for the situation faced by farmers in your FFS.

NOTE: These two practices cannot be used at the same time.

a) Seed priming/seed soaking

Seed priming is a technique used by farmers to accelerate seed germination and crop establishment. The technique is simple and requires very little equipment, but can result in significant yield gains. Before planting, seeds are soaked in water for 6–12 hours (most commonly overnight for 6–8 hours), then surface dried (on a clean surface under shade for about 1 hour) before sowing. The soaking helps to start the early stages of seed germination – called pregermination. The soaking period, however, should not be so long that the seeds begin the advanced stages of germination. If this happens, the seeds can be damaged, resulting in a lower germination rate. If you cannot get specific information from your research partners on the safe time limit for soaking seeds of particular crops, you may need to carry out an experiment with farmers to find the safe limit for soaking the varieties that farmers use. Each crop species, even each variety, can have different soaking requirements.

Learning objective:

To test the effectiveness of seed soaking and determine the optimal soaking time in helping crops to quickly establish themselves in response to a delay in the start of the growing season.

Timing:

This field study can be conducted either during the dry season, or during the actual growing season. If you plan the field study for the dry season you will need to be able to water or irrigate the test plots to simulate rainfall throughout the crop's growth cycle. During the regular growing season, the study should ideally be carried out at the time of the first planting rains; this may be challenging as the farmer will need to tend their own production fields. Having all of the materials ready and explaining the steps of the field study beforehand will be essential, as the test plots will need to be planted the day after the first soaking rains when most farmers are planting.

Time required:

Full season. You will need 30 minutes to explain the field trial, 16 hours to complete preparation of the seeds, 2 hours to plant the test plots. Preparations will generally need to be spread over 2 days.

Materials/preparation:

Sufficient seeds of the selected variety to plant up to five 5 m × 5 m test plots, four buckets or containers, four mesh sacks or open containers for storing the seeds before planting, clean water, a place to dry the seeds before planting (e.g. a woven mat), a clock or watch, string and ruler to measure the plots, stakes and signs to mark the test plots, record book and pen.

Methods/procedures:

Five treatments are suggested:

T1. No seed soaking.

T2. 4 hours seed soaking.

T3. 8 hours seed soaking.

T4. 12 hours seed soaking.

T5. 16 hours seed soaking.

- Select the variety that you want to use in the trial. The day before planting the test plots (after the first planting rains), measure out five equal volumes of seeds that you will use for the study, enough to plant five 5 m × 5 m test plots. It is important to have conducted a germination test of the seeds that you will use beforehand to ensure that the seed stock has a high germination rate (see **Special Topic 7**). Prepare the test plots for planting, using normal land preparation practices; measure, mark with stakes and place signs for each of the five treatments, and enter this information into your field study logbook.
- Set aside one of the five measures of seeds. These seeds will be your local practice control; they will not receive any treatment but will be used to compare with the other seeds that receive the treatment. Place three of the remaining four measures of seeds into separate containers – these three measures of seeds will be allowed to soak for 8, 12 and 16 hours. Add enough clean water to each bucket, so that there is 2–3 times more water than seeds. Record the time. It is best to do this in the late evening of the day prior to planting.
- The next morning, drain the water from the first bucket with the seeds soaking for 8 hours. It is important to do this after exactly 8 hours, or your test will not be accurate. Once thoroughly drained, spread the seeds out on a clean dry surface in a shaded area. A mat can be used. Allow the

seeds to become surface dry (dry to the touch), then place them in a clearly marked breathable bag or open container and store the container out of the sun and heat until planting. It is important that the seeds are surface dry; if they are stored while still wet they will continue to "soak" and this will influence the results of your test. Repeat this process for the seeds in the other buckets after 12 hours and 16 hours of soaking. It is critical that the seeds from the different batches are not mixed, and that you know which seeds have soaked for the different amounts of time.

- After draining, drying and planting the seeds that have been soaking for 8 hours and 12 hours, place the last quantity of seeds in a bucket and fill with water. These seeds will soak for 4 hours only. After 4 hours, these seeds **and** the seeds that have been soaking for 16 hours, should be drained and dried like the others.
- Once the appropriate soaking time for the different treatments is completed, and the seeds have dried sufficiently so that they can be planted in an even stand, sow the seeds in the 5 m × 5 m test plots that you have prepared and marked using normal row and seed spacing. Make sure that the signs and the soaking time for each group of the seeds match! Record the location of each trial in your field study logbook.

Suggested soaking procedure

	Day 1	Night	Day 2 Morning	Midday
T1: No soaking	–	–	–	plant
T2: 4 hours	–	–	soak	dry and plant
T3: 8 hours	soak	soak	dry and plant	
T4: 12 hours	soak	soak	dry and plant	
T5: 16 hours	soak	soak	soak	dry and plant

Measurements:

- Number of days until the first seedlings emerge in each plot; the number of days until 50 percent of the seedlings have emerged.
- Number of seedlings germinating and surviving the early stages of plant growth.
- Plant height at regular intervals during the growing season (every 1–2 weeks).
- Number of tillers or branches per plant.
- Incidence of pest or disease damage.
- General appearance of the plants, especially in response to weather conditions, such as drooping during periods of moisture stress, or high temperatures.
- Date of first flowering; date when 50 percent of the plants are flowing; date of harvest and yield.
- Number of seedpods or heads per plant; number of seeds per pod or head; weight of yield per plant; total weight of yield from each subplot.

- A record of the rainfall during the season either from a rain gauge, or simply noting the days in which rain fell and the approximate quantity (light, medium, heavy, very heavy).
- Record of any other significant weather events (date and what occurred).
- Total cost of inputs, income (from cost–benefit analysis at the end of the season).

Discussion questions:

- Are there differences between the timing (number of days) of seedling emergence in the plots where seed soaking was used and the local practice? Any differences in the timing of emergence between the different soaking times?
- Were there any differences in the germination rate between the difference plots? The number of young seedlings surviving?
- Any differences in crop development? Response to weather stresses? Incidences of disease or insect attack? Differences in final yield?

b) Dry seeding

Dry seeding is a technique used by some farmers when the start of the rainy season – the point when there is sufficient moisture in the soil for seeds to germinate – is very uncertain. Some farmers also use the technique in seasons when a first planting has failed, due to a long dry spell after the seeds had germinated, and they only have a small quantity of seeds remaining with which to establish a crop.

Dry seeding involves planting seeds deeper than usual, when the soil is dry, before there has been any rainfall. Once planted, the seeds then do the waiting. When there has been enough rainfall to moisten the soil to the depth where the seeds are located, the seeds will germinate and begin to emerge. The appropriate depth will depend on the crop and the type of soil. In sandy soils, seeds need to be planted more deeply to ensure that there is enough soil moisture for them to survive. In heavier soils, which can hold more moisture, the planting depth can be shallower. For example, dry-seeded maize can be planted at a depth of 10 cm in heavier soils and up to 15 cm in sandy soils. If seeds are planted too deep, however, they may not have enough energy to emerge, resulting in low numbers surviving. Farmers then need to fill in gaps, using additional seeds and labour. Farmers also need to be aware if the soils in their fields tend to form dry, hard crusts after the first rains. Such soils have lost their structure, and some crops may not be able to break through the crust after they have germinated. Crops that are commonly dry seeded are maize, millet, sorghum and wheat. Soybean and cotton are also sometimes planted using dry seeding. This technique may provide an alternative in situations where the start of the rainy season is becoming less certain, but you will first need to determine the appropriate planting depth for the varieties and soils in your area.

Learning objective:

To determine the best planting depth for dry seeding for the soils in your area and the varieties farmers are using.

Timing:

Since this is a planting technique intended to be used prior to the start of the rainy season, you will need to pay close attention to the weather patterns as the traditional planting season draws near. The test plots can be established a week or more prior to the estimated arrival of the rains. Planting earlier than this increases the risk of seeds being attacked by termites, birds or other pests. This field study can also be conducted during the dry season, before the start of the actual rainy season. Conducting this field study in this period will allow farmers to determine the appropriate planting depth before the arrival of the rains, allowing them to take advantage of this practice in the first season. If you plan the field study for the dry season, you will need to be able to water or irrigate the test plots to simulate rainfall from seed germination through plant emergence.

Time required:

Through plant emergence. It will require 30 minutes to explain the technique of dry seeding and why it can be a successful adaptive practice to the uncertain start to the growing season, and another 2–4 hours to establish the test plots.

Materials/preparation:

Sufficient seeds to plant five 5 m × 5 m test plots, a planting hoe and chalk or mechanical planter, string and ruler to measure the plots, stakes and signs to mark the test plots, record book and pen.

Methods/procedures:

Five treatments are suggested:

T1. Planting depth of 5 cm.

T2. Planting depth of 10 cm.

T3. Planting depth of 15 cm.

T4. Planting depth of 20 cm.

T5. Local practice/control plot.

- Select the variety that you want to use for the trial. Measure out five equal volumes of seeds that you will use for the study, enough to plant five 5 m × 5 m test plots. It is important that you have conducted a germination test of the seeds that you will use beforehand to ensure that the seed stock has a high germination rate (see **Special Topic 7**). Prepare the test plots for planting, using normal land preparation practices; measure, mark with stakes and place signs (include planting date, crop and treatment) for each of the four dry seeding treatments (planting depth of 5 cm, 10 cm, 15 cm, 20 cm), plus the control plot. In this field study, the control plot will be planted with the first planting rains, following local practice, not before. (If you are conducting the field study during the dry season, a control plot will not be used.) Record the location of each test plot in your field study logbook.

- Use chalk or another object to draw a line across the back of the hoe at the first planting depth (5 cm). (This may need to be repeated while each plot is being planted if the mark wears off.) If you have access to a mechanical seeder that can be adjusted to plant seed sufficiently deep, this can also be used. Plant the seeds in each plot at the appropriate depth by sinking the hoe to the depth indicated by the line you have placed on the back of the hoe blade. Use normal row and seed spacing. Since this is a test of the effects of dry seeding and planting depth, care should be taken when completing the planting of each plot to ensure that seeds are placed to the correct depth. Plant the other plots (10 cm, 15 cm and 20 cm) using the same technique.
- Once the seeds have germinated and the young plants emerge, follow all other normal management practices for that crop.

Measurements:

- Number of days after planting until the start of the rainy season (the date when the control plot is planted); number of days after planting rains (when the control plot is established) until the first seedlings emerge in each plot; number of days until 50 percent of the seedlings have emerged.
- Number of seedlings germinating and surviving the early stages of plant growth in each plot; be sure to note any observable losses of seeds to pests, birds or animals prior to emergence in the treatment plots with different planting depths.
- Plant height at regular intervals during the early part of the growing season (every 1–2 weeks); date at harvest and yield.
- Record of the date and quantity of rainfall over the start of the growing season.
- Total cost of inputs, income (from cost–benefit analysis at the end of the season).

Discussion questions:

- Were there any differences between the timing of seedling emergence in plots where dry seeding was used and the local practice? Any differences in timing of emergence between the different dry seeding planting depths?
- Were there any differences in the germination rate between the different plots? The number of young seedlings surviving to the vegetative growth stage? Is there an optimal planting depth for the crop/variety used in the trial?
- Any differences in crop development? Response to weather stresses? Incidence of disease or insect attack? Differences in yield?

FIELD STUDY 8

Effect of silvopastoral systems on yields, income and resilience to climate change

LIVESTOCK AND FORESTRY; OTHER MANAGEMENT PRACTICES

Silvopastoral systems (SPS) integrate trees, shrubs and fodder (e.g. grasses and leguminous herbs) in a beneficial interaction to provide good animal nutrition and enhance benefits from environmental services. In contrast to traditional livestock production systems based on grass monoculture that continuously depletes natural resources, SPS nurtures both agriculture and the environment. Trees provide shade for cattle so they graze more and yield more meat and milk. Pasture, legumes and shrubs can serve as forages. Increased organic matter in the soil improves fertility. Trees provide timber and sequester CO_2 emissions and therefore help mitigate climate change. The agroforestry arrangements employed by SPS promote productivity, profitability and sustainability compared to specialized forestry or livestock production only (FAO, 2019).

Learning objective:

To observe and compare the benefits of using silvopastoral practices on milk production and income, and promote practices that contribute to adaptive benefits.

Timing:

At the start of the FFS.

Time required:

Full season. Normal visits to collect data and management operations (especially for cooperating farmers) throughout the season.

Materials/preparation:

Selection of and agreement with cooperating farmers to use their dual-purpose farms. The farms should have both livestock and forest production activities. The number of farms could be at least three, which would mean three replications for the field study.

Methods/procedures:

Two basic treatments:

T1. Traditional system: cows will be fed using the traditional system (i.e. animals are kept year-round on open pastures dominated by natural species).

T2. Silvopastoral system: cows will be fed with improved pasture with trees, cut-and-carry fodder banks of forage grass in the locality (e.g. *Pennisetum purpureum*) and woody fodder (e.g. *Gliricidia sepium* and *Cratylia argentea*).

- Participants decide on good practices to employ (e.g. efficient use and conservation of water and manure management suitable to the farm's biophysical requirements and on their socio-economic conditions).

- Ensure that the cooperating farmers are aware of and provide the nutrient requirements of their cows.

Things to observe and measure:

- For livestock:
  - Body weight
  - Body measurement
  - Daily milk yield
  - Feeding routine
  - General appearance of hair/coat condition
  - General health condition
  - Movement
  - Activity level
  - Injuries
  - Presence of parasites/insects
  - Total cost of inputs, income (from cost–benefit analysis at the end of the season)
- For pasture:
  - Percentage of desirable plants
  - Percentage of legumes in the pasture
  - Plant residue
  - Plant diversity and vigour
  - Insect and disease pressure
  - Soil fertility and compaction
- At the end of the season (you can calculate for two seasons, i.e. wet and dry):
  - Milk production (kg/cow/day)
  - Total cost of inputs, income (from cost–benefit analysis)
  - Carbon sequestration (tonne/ha)

Discussion questions:

Carefully compare the data on the various measurements you took during the season and at harvest.

- How do the different treatments and replications compare? Are there important differences during the season? What could the differences indicate?
- Were there any important weather stresses during the season? At what stage in the production cycle? How did the livestock respond to the weather stresses when they occurred? What about the pastures? Trees?
- Was there a difference in yield between the treatments?
- Which treatment gave the highest benefits? What could this imply for adaptive benefits and resilience to climate change?

CASE STUDY

Developing climate-smart cattle ranch in the central region of Nicaragua

The Livestock and Environmental Management Programme at the Tropical Agricultural Research and Higher Education Centre (CATIE) in Nicaragua has been implementing participatory training processes in Central America with cattle producers since 2004. Using farmer field school approaches, CATIE has promoted the adoption of silvopastoral systems (SPS) and good practices to improve income, food security and ecosystem services while addressing climate change adaptation and mitigation measures. In one case, seven dual-purpose farms (i.e. dairy producers with milked cows with calf at foot) were selected and divided into two treatment groups. One used an innovative silvopastoral system where cows were fed improved pasture with trees, cut-and-carry fodder banks of forage grass (*Pennisetum purpureum*) and woody fodder (*Gliricidia sepium* and *Cratylia argentea*). The other group followed a traditional system (i.e. keeping the animals on open pastures dominated by natural species of forage grass throughout the year).

Results of the study showed that SPS farms gave higher annual milk production per cow than the traditional farming system. Farmers had more income and more carbon was sequestered and stored in the soil (see table).

The study recommends that participatory training approaches – such as those used in FFS – and incentive mechanisms are needed to scale up SPS. The incentives may take the form of soft credits with below-market interest rates, certification and access to markets linked to green value chains. In order to achieve the goals of climate-smart agriculture, farmers must, using their own assessments, design proposals on silvopastoral systems and apply good practices – such as efficient use and conservation of water – appropriate for the requirements of the biophysical characteristics of their farms as well as their socio-economic conditions. SPS can help farmers improve the productivity of and resilience to climate change of their agricultural ecosystems.

Source: FAO, 2017.

Productive, economic and environmental performance of silvopastoral and traditional cattle farms

Indicator	Cattle ranch with silvopastoral practices	Traditional cattle ranch
Milk production (kg/cow/day)		
Rainy season	7.4	4.7
Dry season	4.4	2.9
Rank of income (USD/ha/year)	346.3 – 519.6	227.7 – 327.8
Carbon sequestration (tonne/ha)	11.0	5.3

FIELD STUDY 9

Comparison of benefits between traditional forest enterprise and farm forestry enterprise[3]

FORESTRY; OTHER MANAGEMENT PRACTICES

Forests play a key role in the carbon cycle and in removing carbon dioxide from the air. They provide habitat for different species of flora and fauna thus protecting biodiversity. Forests regulate ecosystems, provide livelihoods and food security as well as supply goods and services that support sustainable growth. The processes of deforestation (from expansion of agricultural areas, mining, urbanization) and degradation (e.g. overgrazing, excessive logging, harvest of fuelwood and charcoal) caused by human activities contribute to greenhouse gas emissions. In turn, temperatures increase, weather and water patterns change and the frequency of extreme weather events increases. Sustainable forest management is crucial to climate change mitigation and adaptation and sustainable development.

Learning objective:

To evaluate the effect of social forestry practices and enterprises (e.g. tree nurseries, intercropping and income-generating activities [IGAs], fodder banks, woodlots, fruit orchards, food cropping with improved techniques) in increasing productivity and income, and promote practices that contribute to carbon sequestration.

[3] Adapted from FAO, JICA and KFS (2011).

Timing:

At the start of the FFS.

Time required:

Full season. Normal visits to collect data and management operations (especially for host farmers) throughout the season.

Materials/preparation:

Selection of and agreement with host farmers to use their farms. Sufficient lead time should be allowed for land preparation, terracing in sloping areas etc. The size of pits will depend on the type of trees to be planted (i.e. larger water harvesting structures for fruit trees). Whole farm or individual tree fencing must be constructed before the plot becomes open to animal grazing, especially in the dry season.

Methods/procedures:

Two basic treatments:

T1. Traditional system: primary forest, planted with trees only.

T2. Farm forestry system: forestry activities plus (i.e. incorporating other enterprises such as tree nurseries, intercropping and IGAs, fodder banks, woodlots, fruit orchards, food cropping with improved techniques).

- Participants decide on what other enterprises they want to include in their FFS plots (e.g. tree nurseries, intercropping and IGAs, fodder banks, woodlots, fruit orchards, food cropping with improved techniques).

- After selecting the site for the field study, carry out all of the normal steps of land preparation and also following instructions especially for terracing, construction of pits and water harvesting structures, whole farm or individual tree fencing (live fences of, for example, pigeon pea can be used around plots) to protect against damage.
- The field size should be reasonable so that participants can manage the studies well and data collection does not become cumbersome.

Things to observe and measure:

- For trees: Agroforestry ecosystem analysis (AFESA) every 2 weeks or monthly because trees grow more slowly:
  - Overall health of trees
  - Growth measurement of trees
  - Interaction between trees/crops
  - Diseases/pests and their significance
  - Soil conditions: dry, moist, wet etc.
  - Weather: sunny, windy, rainy, cloudy etc.
- For food crops: Agroforestry ecosystem analysis (AFESA) can be done every week:
  - Overall plant health for the particular stage
  - Growth measurement of the crops
  - Weeds and their coverage
  - Diseases/pests and their significance
  - Soil conditions: dry, moist, wet etc.
  - Weather: sunny, windy, rainy, cloudy etc.
- At the end of the season:
  - Yields
  - Total cost of inputs, income (from cost–benefit analysis)
  - Carbon sequestration (tonne/ha), possible with assistance from local experts

Discussion questions:

Carefully compare the data on the various measurements you took during the season and at harvest.

- What are the products and services derived from a system where there is only a primary forest? From farm forests?
- How do the different treatments compare? Are there important differences during the season? What could the differences indicate?
- Were there any important weather stresses during the season? At what stage in the production cycle? How did the trees respond to the weather stresses when they occurred? What about other crops?
- Was there a difference in yield between the treatments?
- Which treatment gave the highest benefits? What could this imply for adaptive benefits and resilience to climate change?

CASE STUDY

The Intensified Social Forestry Project (ISFP) in Kenya

The Intensified Social Forestry Project (ISFP) in Kenya was conceived to address the desire of the Government of Kenya to find ways to develop forestry activities in the expansive arid and semi-arid lands (ASAL) of the country to improve living standards of communities while enhancing sustainable environmental conservation. The forests (i.e. woodlands, bushlands and wooded grasslands) in the ASALs are increasingly being degraded and reduced in coverage as a result of population pressure, management practices and the land tenure of farmers. Low production technologies and unreliable rains contribute to poor agricultural productivity and poverty. On the other hand, improved technologies and efficient management practices could provide livelihoods from tree-based production systems, contribute to forest conservation and ultimately to mitigating climate change.

Farm forestry farmer field schools (FFSs) were used as the ISFP platform to train farmers. Farmers were encouraged to engage in farm forestry (i.e. grow trees to produce products like timber and oil) on marginal lands or bushes and diversify crops and land use. The FFS provided farmers with the opportunity to try out and innovate practices as well as improve decision-making for sustainable land uses. By working together, farmers realized the importance of collective capacities and supporting each other to adapt to the ever-changing environment and accompanying challenges. (For details on how the

Woodlot with food crop in FFS, Kenya

FFSs were implemented, see the *Farmer field school implementation guide. Farm forestry and livelihood development* (FAO, JICA and KFS, 2011).

In 2005, when drought was experienced, FFS farmers with enhanced technical capacity were better able to cope with the extreme weather while non-FFS farmers were more affected. By the end of March 2007, a total of 122 FFS had been completed and 2 130 farmers had graduated. A project results assessment carried out in 2007 showed an increase in the number of tree seedlings and the number of trees produced annually by individual farmers on their individual farms compared with neighbouring non-FFS farmers. Trees absorb greenhouse gases in the atmosphere and to this end, their role in carbon sequestration in crucial.

To intensify social forestry activities, enterprises such as tree nurseries, intercropping and income-generating activities (IGAs), fodder banks, woodlots, fruit orchards, food cropping with improved techniques were introduced in the FFSs. The impact assessment showed that FFS members had continued to apply what they had learned in their own farms as well as continued with group enterprises practising social forestry activities beyond the field school. The results assessment also indicated that FFS alumni shared knowledge and experience with other community members and changes in practices of other farmers and community members were also observed.

Sources: FAO, JICA & KFS. 2011. FAO & JICA. 2007.

References for Annex B

Bernabucci, U. 2019. Climate change: impact on livestock and how can we adapt. *Animal Frontiers*, 9(1): 3–5.

Center for Initiatives on Community Empowerment and Rural Development (ICERD). 2021. Stories from the field. In: *ICERD* [online]. Hanoi. [Cited 17 May 2021]. https://icerd.vn/stories-from-the-field

Draaijer, J. 2016. *Dairy farmer field schools curriculum.* Project UTF/NEP/073/NEP. FAO Internal Document. Kathmandu.

FAO. 2011. *Save and Grow: A policy makers guide to the sustainable intensification of smallholder crop production.* Rome, FAO. (also available at http://www.fao.org/3/i2215e/i2215e01.pdf).

FAO. 2017. *Climate smart agriculture sourcebook* [online]. Rome. [Cited 17 May 2021]. http://www.fao.org/climate-smart-agriculture-sourcebook/enabling-frameworks/module-c1-capacity-development/c1-case-studies/case-study-c15-zero-tillage-potato-integrated-pest-management-ipm-for-climate-mitigation-in-viet-nam/es

FAO. 2017. *Climate smart agriculture sourcebook* [online]. Rome. [Cited 17 May 2021]. http://www.fao.org/climate-smart-agriculture-sourcebook/production-resources/module-b2-livestock/b2-case-studies/case-study-b2-2/en

FAO. 2019. *Silvopastoral systems and their contribution to improved resource use and sustainable development goals: Evidence from Latin America.* Rome. (also available at http://www.fao.org/3/ca2792en/ca2792en.pdf).

FAO & JICA. 2007. *Kenya. Intensified Social Forestry Project in semi-arid areas. Impact assessment report.* (also available at http://www.ipcinfo.org/fileadmin/user_upload/fsn/docs/Mathe_KEN-ISFP-Complete.pdf).

FAO, JICA & KFS. 2011. *Farmer field school implementation guide. Farm forestry and livelihood development.* Rome, FAO. (also available at http://www.fao.org/3/i2561e/i2561e00.htm).

Ketelaar, J.W., Morales-Abubakar, A.L., Phasouysaingam, A., Chanthavong, V., Ngo, D.T., Rojas, M.F., Mishra, A. & Sprang, P. 2020. Save and Grow: sustainable intensification of crop production and innovative market linkages for building resilient rural economies in the Greater Mekong Subregion. *In* U.S. Nagothu, ed. *The bioeconomy approach: Constraints and opportunities for sustainable development*, pp. 107–129. New York, Routledge.

Ngo, D.T., Nagothu, U.S., Morales-Abubakar, A.L., Ketelaar, J.W. & Tesfai, M. 2018. Innovative practices in potato production for food and nutrition security. *In* U.S. Nagothu, ed. *Agriculture development and sustainable intensification-technology and policy challenges in the face of climate change,* pp. 111–135. London, Earthscan.

Pauly, D. & Cheung, W. 2017. Is climate change shrinking our fish? *Environmental Science Journal for Teens* [online]. USA. [Cited 8 November 2020]. https://sciencejournalforkids.org/articles/is-climate-change-shrinking-our-fish

The Washington Post. 2018. With warmer water, fish need more oxygen than their gills can supply. Climate. In: *Bangor Daily News*, 23 April 2018 [online]. [Cited 17 May 2021]. https://bangordailynews.com/2018/04/23/outdoors/with-warmer-water-fish-need-more-oxygen-than-their-gills-can-supply

Annex C.
Example special topics

This annex gives examples of **new Special Topics** that have been designed especially for this guidance note on integrating climate change adaptation in FFS.

Some **existing Special Topics** that have been used in FFS in the past but are being revisited with a "climate change lens" are also included in this section.


©D.T. Ngo

SPECIAL TOPIC 1

Using current local weather data

Unless your FFS is located close to a weather station where daily rainfall and temperature data are being collected, and you have access to that data, it is valuable to introduce farmers to the collection of local weather data as part of your FFS activities. If you are testing varieties tolerant to specific weather stresses (**Field Study 2**), management practices that avoid specific types of weather risks (**Field Study 5**) or changing the farm environment to be less sensitive to weather threats (**Field Study 1**), access to detailed weather information will be essential in order to compare the performance of the different practices and technologies with the weather conditions at the various stages of development of the crop, livestock or fish. Through past projects, some of the farmers in your FFS may already have experience with collecting rainfall data using a rain gauge, but for most it will be completely new. Few field programmes, however, have invested in collecting local temperature data, as temperatures were thought to be stable and unchanging. With climate change, we know this is no longer true. Temperature data will also need to be collected (see **Field Studies 1 and 2**).

Due to wide variations that can occur in weather conditions, even over short distances, beginning to keep local records of weather events will be an important resource for farmers in understanding what is happening to the weather where they live, and how they might need to adapt. The longer the duration of records, over many seasons, and the more accurate and consistent they are, collected at the same time every day, the more valuable records will become in being able to identify trends in temperature and rainfall – increases or decreases, and differences in timing (e.g. when rains start and stop). Farmers will begin monitoring climate change in their locality. It all starts with acquiring the necessary tools, using them correctly and recording the information accurately.

NOTE: The three topics included here can be covered at three different times, depending on the overall learning programme of your FFS. There are more detailed exercises and topics on using weather data in other field guides such as the *Participatory Integrated Climate Services for Agriculture (PICSA): Field manual* (Dorward, Clarkson and Stern, 2015) that may be explored, depending on the interest of the FFS farmers and the design of the FFS programme.

Special Topic 1a. Using a rain gauge

Learning objective:

To correctly set up a rain gauge and begin collecting and recording rainfall data.

Materials/preparation:

Rain gauge, wood or metal pole 2.5–3 m in length, hoe, shovel, 2 m of string, saw and bucket of water to simulate rainfall after the gauge has been put in place. You will also need a small notebook for keeping records and a pen.

NOTE: Commercially available "farmer rain gauges" do not need any conversions/calculations and readings can be noted down directly in mm. If constructing a homemade rain gauge, make a deep enough cylinder – the size taking into account the daily amount of rainfall in the location – and use a wettable dipstick to measure the contents. For more details about rain gauges, see FAO (1989).

Timing:

Before the start of the FFS; ideally before the first rains of the rainy season. This will allow you to record the rainfall at the start of the rainy season in the first year of data collection. For crops, starting data collection at the beginning of the rainy season may be essential if you are conducting a field study on adaptive varieties and planting techniques that respond to conditions at the start of the rainy season.

Time:

A half-day will be needed to find a location, set up the rain gauge and practise how to accurately read the gauge and record information. Setting up the record-keeping logbook, discussing the procedures of collecting data and allowing farmers to practise will take an additional hour, but does not have to be done in the field.

Steps:

- You will first want to choose a location where the rain gauge (and thermometer, if you will be using one) can be placed. It is best to place the rain gauge at your field study site, using more than one gauge if you have multiple study sites. Gauges should be placed away from buildings, trees and tall vegetation (at least 30 cm above the tallest surrounding vegetation), anything that might interfere with rainfall reaching the gauge. Other considerations in selecting a site include ease of access (readings will need to be taken every day) and a site away from roadways or livestock routes where there is a chance that the gauge might be disturbed or stolen.
- The gauge itself should be positioned about 1.5 m above the ground. After choosing the location, clear vegetation away (2–3 m) from around the spot where the pole will be placed. Use the shovel to dig a hole sufficiently deep so that the pole can be well seated in the ground. The gauge needs to be placed on a solid, immovable support. Tie a rock to one end of the string, and hold the string next to the pole, using it as a guide so that the pole be placed perfectly vertical in the ground – this is critical, as a gauge that is placed on an angle will not give accurate readings. Attach the gauge to the pole using nails, wire or attachment materials provided with the gauge. Use the saw to cut off any

excess length of the pole; none of the pole should extend above the mouth of the gauge where it might interfere with rainfall entering the gauge.

NOTE: Purchased rain gauges will generally come with instructions from the manufacturer on how to set up and correctly read the gauge. These instructions should be followed.

- Once the rain gauge has been correctly installed you will want to carefully explain how readings of the rain gauge are taken. If markings are not engraved on the gauge, a dipstick made of a material that does not absorb water can be used. Cedar wood with a metal bottom protection plate or aluminium are options (see Figure C-2), painted with dark paint to show the wetness (i.e. level of water) better. Pour some of the water from the bucket into the gauge until you have approximately 10–30 cm in the gauge to simulate rainfall. Have a volunteer read the water level and record the information into a practice sheet in your logbook (see **Special Topic 3c** on how to set up your logbook). Empty the gauge and repeat so that each participant has a chance to take a reading and understands how to take and record an accurate measurement.

Figure C-1: Indramayu farmer's homemade rain gauge

Figure C-2: Farmer uses a ruler to measure the wetted part of a dipstick, indicating how many mm of water had fallen over the last 24 hours

Special Topic 1b: Using a max./min. thermometer

Learning objective:

To correctly set up the max./min. thermometer and begin collecting and recording temperature data.

Materials/preparation:

A max./min. thermometer, materials to construct a Stevenson screen and stand for the station (see Figure C-3), white paint, hoe, shovel, 2 m of string. Use the same notebook for keeping records of rainfall for temperature readings, entering the data in the format provided.

Timing:

Before the start of the FFS; ideally before the start of the first field studies.

Time:

1 – 1.5 days will be required to construct and paint the Stevenson screen and thermometer station; a half-day will be needed to find a location, set up the thermometer stand and discuss how to accurately read and record information. Setting up the record-keeping logbook (the same notebook for keeping records of rainfall) and discussing the procedures of collecting data will take an additional hour, but does not have to be done in the field.

Steps:

- Unlike the rain gauge, to get accurate readings from a thermometer it must be placed out of direct sunlight. Typically, a thermometer is placed inside a small box, called a Stevenson screen, which provides shade from direct sunlight, yet allows air to freely circulate. You want to measure air temperature, not the temperature from direct sunlight.
- To get accurate measurements, the Stevenson screen will need to be painted white (this may need to be repeated during the season if the paint begins to wear off). Dark colours, or natural wood, will absorb heat from the sun, turning the box into a small oven and giving you false air temperature readings. This must be avoided.
- Direct sunrays affect mercury. Hence, the door of a Stevenson screen is always towards the north in the Northern

Figure C-3: Stevenson screen

Hemisphere and towards the south in the Southern Hemisphere.

- Your thermometer may come with instructions on how to construct a Stevenson screen. If not, refer to Figure C-3.

HINT: Due to difficulties in accessing appropriate materials and tools, and the need for accurate measurements and high-quality construction, you may find it easier to contract a local woodworker to build the Stevenson screens needed for your FFS sites. Provide a good quality set of instructions, request one unit to be built first, as an example, and make any corrections or modifications needed, before commissioning others to be made. One suggestion is to contact your national meteorological service for assistance in the design and construction of the screen boxes.

NOTE: Purchased thermometers may come with instructions from the manufacturer on how to set up and correctly read the temperature. These instructions should be followed.

- Follow the same steps in selecting the location where you will place the thermometer station as you used for placing the rain gauge. Thermometers should be 1.2–1.5 m above the ground, in an area that is free of vegetation. Make sure that the legs of the stand are sufficiently rigid and sufficiently buried in the ground to prevent shaking. It is a good idea to place both the rain gauge and thermometer in the same location. Because temperatures are similar across locations, you will need only one thermometer station for your FFS, whereas you might have more than one rain gauge.

Special Topic 1c: Taking rainfall and temperature measurements

Learning objective:

To correctly take measurements and record rain gauge and thermometer data.

Materials/preparation:

A max./min. thermometer, materials to construct a Stevenson screen and stand for the station (see Figure C-3), white paint, hoe, shovel, 2 m of string. Use the same notebook for keeping records of rainfall for temperature readings, entering the data in the format provided.

Timing:

Daily, at the same time.

Time:

30 minutes – to collect and record data.

Steps:

- The timing of daily data collection is important. Readings should be taken every day at the same time – 09.00 hours is a commonly accepted time, but this can be earlier if it fits the normal work patterns of the farmers involved.
- The readings taken each morning are entered for the **day before**. The measurements of any rainfall, as well as the maximum and minimum temperatures, are what happen the previous day, not the day the data are collected.

- After taking a reading, the rain gauge must be emptied and returned to its correct position. Likewise, the thermometer should be reset using the instructions that came with the instrument. During the course of the season, it will be important to monitor the condition of the stations and surrounding area – cutting back any vegetation that grows up and looking for termite or other damage to the rain gauge pole or thermometer station.
- This basic template can be used for setting up your record-keeping of rainfall and temperature data. It is a good idea is to set up a **weather team**, with one person volunteering to be responsible for collecting the weather data each day, with two alternate persons who can assist if this should be necessary for any reason (illness, travel etc.). The important thing is to collect the necessary information each day, in the same way, at the same time.

NOTE: The two alternates of the weather team should keep separate copies of the weather records, so that there are backup copies in case the original logbook is damaged or lost. The records can be copied on a weekly basis.

Date	Rainfall (mm)	Max. temp (°C)	Min. temp (°C)	Observations	Person taking reading

Discussion questions:

- Why is collecting rainfall and temperature data necessary when carrying out experiments to adapt to changes in weather patterns?
- Why is the location of rain gauges and thermometers important? Why is it important to keep them well maintained?
- Why is it necessary to collect the information at the same time each day? What are the benefits of collecting information over a long period (many years)?

Figure C-4: Farmer taking readings on commercially available rain gauge while researcher provides guidance in Gunungkidul, Indonesia

© E. Anantasari

See the case study on how local weather data are used in Indramayu Science Field Shops. You can try this in your FFS too!

CASE STUDY

Science Field Shops in Indonesia

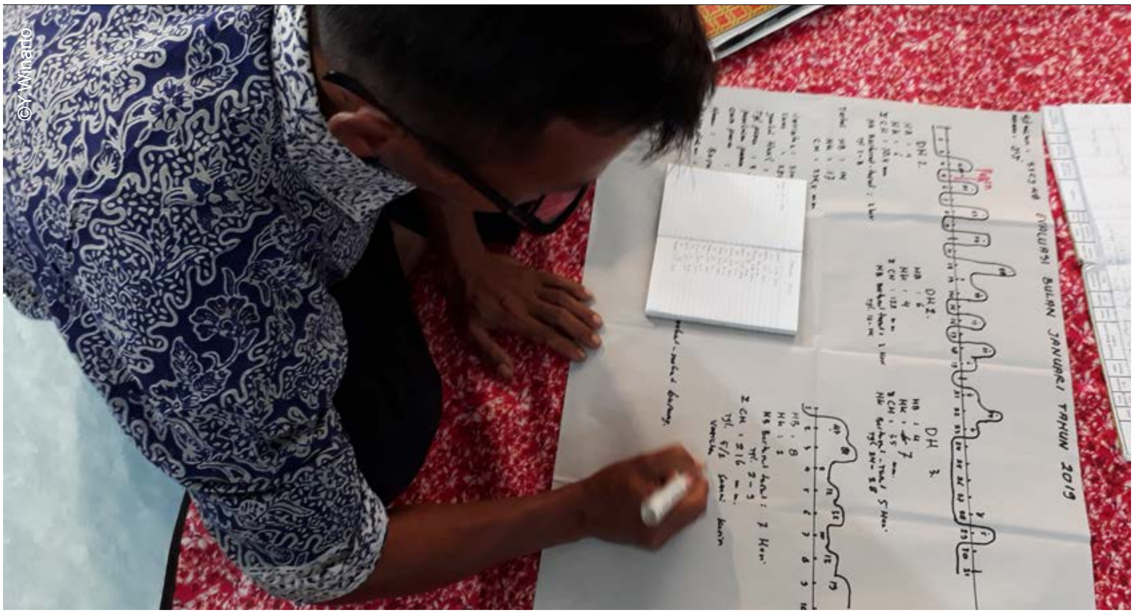
In Indonesia, Science Field Shops (SFSs) bring together farmers and scientists (and extension workers, when possible) to promote farmers' agrometeorological learning. In learning meetings, they discuss vulnerabilities based on farmers' rainfall measurements and observations of agro-ecosystems. Participants share knowledge on how varieties, fields, seasons and years contribute to the yields farmers have obtained. Scientists guide farmers to understand their field conditions that are being affected by a wide range of climatic conditions. Armed with this understanding and with information on forthcoming 3-month seasonal rainfall scenarios, farmers are expected to be able to improve their ability to anticipate increasing or future problems and make decisions towards successful climate change adaptation.

Four climate services (activities) are described; they are provided by SFSs and can be adapted in FFS programmes integrating climate change adaptation. The first two are inputs to the third activity. The fourth activity (see Special Topic 2) can be a stand-alone activity highlighting how farmers and local agrometeorological services can work together to address climate change adaptation.

1. Taking daily rainfall measurements in their own plots

Farmers who participate in SFSs learn to prepare a cylindrical metal rain gauge. When they volunteer to become "rainfall observers", they measure rainfall daily on their own field following a defined set of rules for rain gauge usage (see Winarto *et al.*, 2018).

Drawing a simple rainfall graph in Indramayu, Indonesia



2. Taking daily agro-ecological observations

Rainfall observers are also responsible for taking daily observations of their agro-ecosystem. The development of farmers' analytical capacity in relating rainfall data to agro-ecosystem conditions is of utmost importance to SFSs. Stigler provides a guide for farmers on agro-ecosystem observation in Winarto *et al.* (2018). The parameters for observation can be modified to suit the particular situation in each location. In monthly learning sessions, farmers share their rainfall and agro-ecosystem data and analysis of vulnerabilities and/or opportunities encountered, focusing on the priority problems and identifying solutions.

3. Measuring yields and understanding differences between fields, seasons and years

After the harvest period, farmers evaluate yields according to ecosystem zones *vis-à-vis* rainfall data, ecosystem observations, inputs (e.g. crop varieties, fertilizers, water) and management strategies. Farmers discuss possible factors contributing to yield differences among their fields; similarities or differences in yields across seasons; as well as differences in yields in the same season but different years. The process is envisioned to result in reduction of crop losses/failure and improvement of cropping conditions.

In the Indramayu case, taking the analysis a step further from 2016 onwards, the SFSs sought to improve cost–benefit analysis by understanding gross margin in detail. Additionally, farmers analyse the percentage of yield increases/decreases comparing the current to the previous year. This step is foreseen to prepare farmers to plan for future production under similar climatic conditions.

Source: Winarto *et al.*, 2018.

Pak Amin measuring the cracks in the soil in Indramayu, Indonesia

SPECIAL TOPIC 2

Using forecast weather data

The collection of local weather data by farmers as part of the FFS activities is important in understanding what is happening to the weather where they live, and how they might need to adapt. Comparing and discussing the past situation and the future scenario will be helpful in understanding climate change trends and what challenges may be coming. Looking only at what happened in the past may lead to mistakes in anticipating what conditions will be like in the coming years.

More recently, applications have been developed for mobile phones that can help farmers and communities access weather forecasts and meteorological data they can use to make farm management decisions. Some farmers and communities will be more ready to use these applications than others. For those interested, information can be accessed at Nield (2020).

Getting the local meteorological office involved in the FFS for sharing data/information and experiences will be valuable for farmers and the FFS programme. Weather forecasts made by meteorological services help identify potential threats – things that may be getting more common or severe with time or those that are not currently a problem but may become problems in the future. Learning how to use predicted climate conditions helps farmers improve their ability to anticipate weather risks and plan for the future. **The ability to anticipate increasing or future problems is key to successful climate change adaptation.**

Learning objective:

To make decisions and design adaptive strategies based a forecast of expected climate conditions.

Materials/preparation:

Information on monthly weather forecast from the local meteorological office.

Timing:

Before the start of the FFS, coordinate with the local meteorological office to get their agreement on involvement in the FFS and sharing of agrometeorological data; during the season, monthly forecasts should be made available to FFS participants.

Time:

Monthly, about 1 hour during the FFS session.

Steps:

- About 2 weeks prior to the planned session on using forecast weather data, remind the representative of the local weather office about the need for the information and invite them to attend the FFS.

- If the forecast is written in English, the facilitator should first translate it into the local language.
- Review the predicted weather data from the local meteorological office with the FFS participants.
- Discuss what the information means and implies for farmers using the following discussion questions as a guide.

Discussion questions:

- What does the information mean?
- Why is it important to have information on what could happen in the future? What would happen if we only have information on the current weather situation?
- How can the predicted weather information be used by farmers? Do you need to take any action based on the information? What will you do?

Knowing how to set up tools and take rainfall and temperature measurements correctly are not enough! Making agrometeorology relevant to farmers' livelihoods and enabling farmers to adapt their farming activities to increasing climate variability is what counts!

CASE STUDY

Science Field Shops in Indonesia: Disseminating seasonal climate scenarios

Farmers in the SFSs receive information on the seasonal climate scenario from the local meteorological office. This is a monthly summary of the rainfall expected over the next 3 months (i.e. a forecast of the expected climate conditions) according to models and predictions made by national and global climate-related institutions. In Indramayu, the rainfall observers use the data on predicted climate conditions to plan the ongoing and subsequent planting seasons. This knowledge develops the ability to anticipate risks and improves decision-making and design of adaptive strategies. Farmers disseminate information on seasonal climate scenarios to other farmers by text messaging and social media.

The learning process in SFSs results in agrometeorology becoming operationally relevant to farmers' livelihoods and enables farmers to adapt their farming activities to increasing climate variability.

Source: Winarto *et al.*, 2018.

CASE STUDY

How "Katalysis" helped FFS graduates in the Andes to mitigate climate change

Beginning in 2005/06, farmers living in two highly vulnerable, semi-arid highland regions of Bolivia (Plurinational State of) and Ecuador took part in "Katalysis" – a discovery-based, user-centred learning-action approach intended to help innovative FFS graduates to address climate change. Building on their earlier experiences in farmer field schools (FFS), a selection of outstanding graduates at each location came together in teams to identify ways of coping with recent crop and animal production failures.

The Katalysis approach begins with exploratory cross visits, in this case to see and learn about new experiences in soil and water management. Participants work with technical experts to identify knowledge gaps and to strengthen technical skills through open-ended learning experiments. Subsequently, each participant shares her or his "dream map" for the farm and the community. Lastly, participants discuss proposals and work together to bring each plan to fruition – farm by farm, neighbourhood by neighbourhood.

For example, Katalysis participants set up simple weather stations, collect rainfall data from the roof of their houses and fields, and study the flow of streams to fuel subsequent discussions and debates. They make three-dimensional maps to identify high-risk spots and vulnerable families.

FFS graduates address climate change through the Katalysis approach

Following the sharing of historic data and a consultation with weather experts, the initial groups in the remote Andes of Bolivia (Plurinational State of) and Ecuador concluded that as a result of climate change the yearly quantity of rainfall had remained unchanged, but that it now came in fewer, more violent storms, followed by extended periods of drought, even during the wet season – something that they had not experienced before. Previously, the weather was far more stable and predictable. The farmers identified soil conservation and water harvesting and distribution as the most practical, strategic opportunities for enabling them to cope with climate change, and they set off to test and develop alternatives.

At each location, groups of farmer innovators worked together to design and build soil conservation measures and water catchment and distribution systems. Steered by their self-confidence, enthusiasm and creativity as well as the friendships that they had forged through long hours of hard work, subsequently, some groups took on more complex and ambitious tasks. For example, participants in Northern Potosi, Bolivia (Plurinational State of) organized seed exchange systems, and they set up long-term experiments on cover crops and green manures. Four groups from the Ilaló Volcano in Pichincha, Ecuador proposed and began to implement a long-term plan for rescuing an endangered creek and micro-watershed.

By drawing on group learning, farmer-led experimentation and concerted action, Katalysis enabled communities to test alternatives for improving the resiliency of their agriculture as well as to identify high-risk areas. It also helped to build the relationships needed for people to want to continue to organize and work together to address fears and to solve common problems.

For more details about Katalysis:
https://core.ac.uk/download/pdf/29246831.pdf

Source: Sherwood and Bentley, 2009.

SPECIAL TOPIC 3

Benefits from Trees Outside Forests[4]

Trees Outside Forests (TOF) are trees and shrubs occurring on lands not defined as "forests or other wooded lands". Therefore, all trees encountered on agricultural and urban lands are considered as TOF.

Systems that integrate TOF, crops and/or livestock are also commonly referred to as agroforestry. TOF may also take the form of small woodlots or windbreaks that are established in the agricultural landscape. And TOF may even include species such as bamboos and palms, which are technically not trees.

Throughout the world, trees in and around agricultural landscapes are important environmental and socio-economic resources, providing a diverse array of products and services that are essential for the livelihoods and food security of smallholder farmers. In rice production landscapes in Asia, TOF are important for ensuring a sustained flow of valuable products and vital services for farmers and their agro-ecosystems, including products (e.g. food, medicine, forage for livestock) and environmental services (e.g. watershed protection, water level regulation, soil conservation and erosion control, biodiversity conservation, carbon sequestration and storage).

[4] Adapted from FAO (2015).

Learning objective:

Familiarize participants with agroforestry ecosystems, and in particular the services and functions provided by TOF in (rice-based) farming systems.

Materials/preparation:

Select farmer field sites where (rice-based) agroforestry ecosystems can be observed, paper, markers, notebook and pen.

Timing:

Any time during the FFS season.

Time:

1 hour for field walks, observations and discussions with farmers in the field; 2 hours to process the data collected and present outputs to the larger group for discussions and feedback, not necessarily in the field.

Steps:

- Divide the big group into smaller groups, with each small group visiting one selected farmer field site. Where possible, different types of (rice) fields should be selected (e.g. occurring on low/mid/highlands, both rainfed and irrigated).
- At each site, conduct field walks, observations and discussions with farmers to identify what types of TOF are present in

the agroforestry system, and what products and environmental services are provided by the trees (bamboos and palms) and shrubs.

- Return to the discussion area to analyse information collected from the field. The TOF products and environmental services may be recorded using the format (see Figure C-5):

TOF (tree or shrub)	Products	Environmental services

Figure C-5: TOF products and environmental services on Ms Marife Heyrana's farm in Agusan del Norte, Philippines

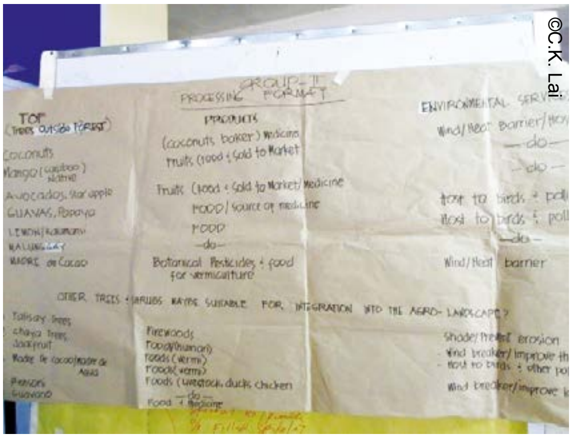
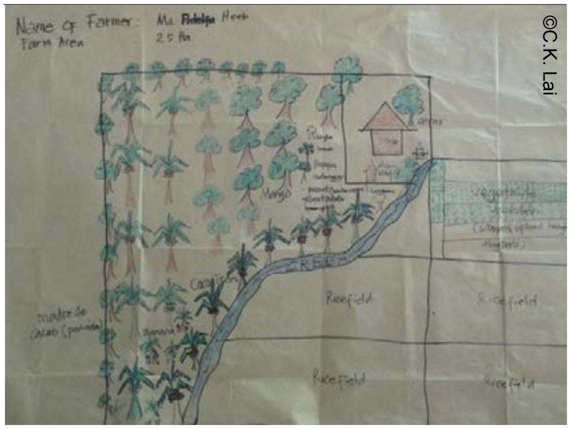


Figure C-6: Map of Ms Maria Adelfa Heeb's farm in Agusan del Norte, Philippines



- Ask each group to present and facilitate discussions on the role, products and services provided by TOF in agroforestry ecosystems, as well as their contributions in different types of (rice) landscapes.

Discussion questions:

- What types of TOF (trees, non-trees such as bamboos and palms, and shrubs) are present in the agroforestry ecosystem?
- Where are they found in the ecosystem?
- What are the products and services provided by TOF?
- How does their contribution change depending on the type of (rice) system where they are found?

You can also discuss with the farmers about the trade-offs involved with TOF in the agroforestry system: weighing the positive effects of TOF on sustainable rice production (e.g. acting as a wind/heat barrier; improving water supply; providing green manure and soil enhancement; serving as habitat for natural enemies such as birds and pollinators) against the negative effects (e.g. hosting insect pests or birds that attack the crops; creating excessive shade on rice; competing with rice for water).

Trees Outside Forests are important resources that can contribute to the microclimate of fishponds (see Special Topic 2) and shelter for livestock (see Special Topic 1) to reduce heat stress.

SPECIAL TOPIC 4

Impact of extreme weather threats

The differences in exposure to weather threats experienced by different production systems is linked to location and timing – when and where the species are during the event. Should you experience a significant weather event (a dry spell of a week or longer, heatwave with extreme temperatures, heavy rain or flooding) during the FFS, you can use this event as an opportunity to observe the differences in exposure and sensitivity of the systems and the production environment. Organize a transect walk to visit the same locations seen during **Exercise 1** (Community resource mapping) to see how different species in these places are responding.

Learning objective:

Observe the differences in exposure and sensitivity of farming systems to various extreme weather events, based on location and timing, what is being raised/grown and what management practices are being used.

Materials/preparation:

Paper, markers, notebook and pen.

Timing:

Variable; whenever a significant weather stress occurs. Unlike other FFS activities, facilitating this transect walk is not something that can be planned beforehand. You will need to be flexible and have farmers keep watch over the local weather patterns during the FFS.

Time:

0.5–1 hour to plan the transect route;
2–3 hours to complete the transect walk, depending on the number and location of sites that will be visited.

Steps:

- The resource map prepared in **Exercise 1**, showing the locations of different field types, can be used to plan a route that passes through areas where different species are raised/grown.
- Things to consider in planning a route include, but are not limited to, the following:
  - differences in soil types (moisture-holding soils versus soils that have more sand and are free draining);
  - production areas in low-lying areas versus those in the uplands; slopes versus those on flat ground;
  - forests, ponds, grazing grounds;
  - fields near the community that may be managed differently from bush fields located further away.
- At each location, stop and discuss with participants, taking detailed notes:
  - how that field's location, its position in the landscape, may, or may not, be contributing to the exposure of farming systems there;
  - how the management practices (e.g. integrated production; crop–fish system; monocropping versus intercropping; the

use of compost or crop residue; presence of trees; water harvesting practices such as bunds, vegetative hedges, rock lines, zaï holes[5]) used in that field may, or may not, be contributing to the severity of the effects of the weather event;
  - what stage of development/production cycle the systems are in, and how sensitive the farming system and species, are to the effects of the weather event;
  - whether it is important to visit the sites again to observe the impacts of the extreme event later in the season and when a return visit should be made.
- By visiting various sites, and making careful observations in each location, you can use the occurrence of an extreme weather event as a natural experiment to observe how a site's location, the management practices used and different crop sensitivities combine to determine the impact of a weather stress. If the event is particularly severe, or if it occurs at a stage of the production cycle when the species are particularly sensitive (see results of **Exercise 2**), it may be useful to repeat the transect walk again later or near the time of harvest to see the effects on yields. Compare your observations at the later stage with the notes taken during your initial walk and discuss again how the exposure and sensitivities observed at the different sites contributed to the vulnerability of the stress and overall impact on the farming system.

[5] A zaï hole is a pit dug in the soil before the season to catch water and materials for composting. Traditionally used in the western Sahel (Burkina Faso, Niger, Mali), the technique restores degraded drylands and increases soil fertility.

Discussion questions:

- What extreme event was the community affected by?
- In which sites did production systems seem to be most exposed to the weather stress? Why?
- Which systems/species appeared to be most sensitive to the weather event? Overall? In particular locations? What were the effects/damages to species/ environment?
- What changes could the farmer make at each of the sites visited to reduce or remove exposure to the weather threat? Sensitivity to the threat? What additional information, skills, materials would the farmer need in order to make the proposed changes? Would these changes increase or decrease the exposure or sensitivity to another type of weather treat?

SPECIAL TOPIC 5

Traditional knowledge on predictors of climate events

There is evidence to show that the climate has been changing for a very long time due to natural processes. However, the process has been hastened and the impacts have become more severe in recent years as a result of human activities. Likewise, for a very long time local communities have relied and continue to rely on their indigenous knowledge systems to make observations on what is going on in the environment and to deal with natural threats and disasters. The use of indigenous knowledge of climate change passed on from generation to generation, has been very important in how communities have been and are able to reduce risks from and manage environmental disasters. Indigenous knowledge of climate change continues to be an important resource especially because in many parts of the world, farmers and farming communities have very little, if any, access to scientific weather information from local weather stations and research institutes. Moreover, often the weather stations are few and far from the communities, resulting in weather forecasts which are little relevant to the specific zone of interest to the community.

Experience and traditional knowledge from generations are important tools and when merged with scientific approaches, concepts and tools can contribute significantly to reducing impacts from risks and hazards of climate change as well as contribute to sustainable production.

Learning objectives:

Discuss examples of traditional weather predictions; explore how traditional and scientific weather forecasting can be integrated and discuss the benefits of combining these systems.

Materials/preparation:

Paper, markers, notebook and pen.

At least 2 weeks before the date when the special topic is to be discussed in the FFS, request a representative from the local weather station to attend the session and bring weather data from about the previous 10–20 years.

Timing:

Any time during the FFS season.

Time:

2 hours.

Steps:

- Start the discussions by asking the group what their sources of weather information are. For example, radio, service providers (e.g. extension workers), indigenous sources (e.g. elders) or their own observations.
- Divide participants into small groups to focus discussions on traditional weather predictions using the format provided. It is important that predictors are linked to specific meteorological events such as arrival of imminent rain, early

end of rainy season, early start of rainy season, drought. It is also important to gather information on the different predictor categories: a) biophysical (environmental elements such as air, sky/stars, water, earth, soil and wind); b) behaviour of animals and insects (birds, frogs, ants; livestock); c) vegetation behaviour (trees, shrubs, grass) and activities such as fruit ripening, foliation and branching.

Climate event	Predictor type	Predictors
Early start of wintering (rain)	Animal	Cows moo much more than usual Group of fish observed sticking their heads out of the water as if they were looking for air Birds place their nests on lower tree branches
	Vegetal	Baobab finds its foliage
Late start of wintering (rain)	Biophysical	Strong wind from west to east
	Animal	Birds place their nests on high tree branches
Early end of winter (from rain)	Biophysical	Dark cloudy sky plus rumble without rain in the morning
Good wintering (sufficient rainfall)	Insects	Ants bring out food reserves from their burrows
Arrival of imminent rain	Vegetal	Fruits of the dimb (tree) ripen
	Biophysical	The two stars located towards the south are parallel
	Animal	Frogs make a lot of noise

- Ask groups to present the outputs of their discussions.
- Ask if anyone can recall during their lifetime (or in the past 20 years) any really significant traditional weather prediction that was made and a serious weather event that happened and ask them to provide details about impacts on production and daily life.
- Ask the representative to present local weather data based on scientific tools to correlate the incidence that was reported using traditional weather predictions.

Discussion questions:

- What does it mean if farmers predicted that there would be a weather event and the local weather data also forecasted a weather event/disturbance?
- How can indigenous weather forecasting be integrated with scientific weather forecasting?
- What are the benefits of combining traditional weather predictions and information from local weather stations?
- How can you use the information to make decisions about your production?
- Are there traditional predictors that are no longer valid due to climate change or other reasons?
- Do you trust both traditional and scientific forecasts? Which is more reliable? Why?

SPECIAL TOPIC 6

Spreading the word and adapting together

The impacts of climate change will affect all farmers, requiring them to adapt. Yet not everyone may be able to participate in an FFS. Depending on the programme design supporting your FFS, the gap between the number of people in a community and the number that are able to directly participate in an FFS may be large. New practices and technologies tested and proven to be useful in the FFS, if used by FFS members in their own fields, may eventually spread to other farmers in the community. To help ensure that the maximum number of people in the community benefit, there are things that the FFS participants can do that will hasten the spread of new practices – more quickly, to more people – through creating organized learning opportunities for the entire community.

Some technologies, such as new varieties, are easy for farmers to try on their own. Other practices, such as the treatment of seeds before planting, may require some basic training or instruction. The spread of practices that require a larger commitment, and the use of more complicated procedures, such as the use of mulch, often benefit from regular opportunities to observe the practice in someone else's field, over a longer period of time, before individual farmers are willing to try the practice in their own field. Due to the unique features of every new technology or practice, different actions may be required to assist farmers in deciding whether or not to adopt.

The activities that can help FFS farmers "spread the word", i.e. disseminate information about their FFS integrating climate change are not very different from how they have been done in the past. FFS master trainers and facilitators are familiar with these activities and may have been organizing these learning opportunities – together with FFS farmers – for their communities before. The only difference with how it will be done now would be some of the climate change-related content of the activities.

As part of your FFS, you may want to work with participants to prepare a plan on how they can help to spread the benefits of the new technologies and practices that prove useful in their field studies. Such a plan should consider the unique features of the practices or technologies, and carefully identify activities that will help others in the community to become aware of and interested in, to assess the potential of using, and to experiment with the new practices and technologies featured in your field studies. By taking this extra step in your FFS, you can greatly expand the number of individuals in each community who benefit from your efforts.

Learning objective:

Prepare an initial community learning plan to expose and support community members in gaining benefits from the activities carried out in the FFS.

Materials/preparation:

Initially, paper/flip chart and markers. Once the plan is prepared, other materials may be required to carry out the activities identified in the plan.

Timing:

Once the curriculum of the FFS is set, and possibly before the start of the field studies. Activities carried out by the FFS members, such as their assessment of the risks of climate change and the sensitivity of various systems and locations (**Exercise 2 and Exercise 3**), can be presented in an initial learning opportunity for the entire community. Other sessions can be added after the field study plots are established and observable differences become apparent. By organizing a series of community meetings and using signs at each of the field study sites, you will allow more people in the community to follow and observe the progress of each of the FFS trials, improving community learning and resulting in greater adoption of the practices being tested.

Time:

2–3 hours; as new activities are introduced through the FFS you will need to revisit the initial plan to add new learning opportunities.

Steps:

- A good place to start would be to organize a presentation of the work done by participants in identifying and assessing the vulnerabilities of climate change-related risks (the outcomes of E**xercise 2 and Exercise 3**). You could also add an explanation of the field studies and special topics the group has selected to work on during the FFS, and more importantly why – linking the identification of climate change vulnerabilities with the adaptive practices being tested **(Exercise 4**).
- After the programme of field studies and special topics has been set, brainstorm with participants:
    - What actions can they take to help others in the community know that new practices and options exist?
    - How can they communicate this information in a way that will interest others in learning more?
    - What additional information is needed, and how they can communicate this to help others assess whether or not they might be able to use the new practices and technologies on their own farms?
    - How can they use the FFS to help others learn how the new practices function and to gain experience in their use?
- You can suggest, based on your experience in implementing FFS programmes, some activities that you have tried before (e.g. making seeds of new varieties available, community learning sessions where FFS members conduct training sessions for other farmers on how to use the practices, hosting a season-long series of open field days to showcase the FFS field studies at critical points in the growing season, informal farmer-to-farmer conversations).
- You may also discuss with the group how they think they can use their mobile phones to share information among themselves. (The use of mobile phones is a fast and easy way to share information and get answers to

questions. In addition to using their phones to access weather information for decision-making, FFS farmers can use them to update other farmers about what is going on in their FFS. Farmers can also use them to communicate directly with potential markets and customers.)

Discussion questions:

- After each community learning session, discuss with FFS members if they are satisfied with how the session went. What went well, what did not? What could they do differently to improve the next session?
- Were there a sufficient number of community members present? Did the community members most affected by climate change participate? How might they get more people involved?
- Are there important follow-on activities that need to be planned for? Materials that other community members need access to? Additional trainings that can be held?
- How can you use your mobile phones to share information with each other? What kind of information can be shared using mobile phones? What applications are you currently using that can be used for sharing climate change-related information and action (e.g. Facebook, WhatsApp)?

SPECIAL TOPIC 7

Testing seed germination

FFS master trainers and facilitators are familiar with this exercise that is usually done in a training of trainers and in FFS. Before starting any field study involving crops you will want to conduct a special topic on testing seed germination. This test is used to ensure that the seeds you are using are of good quality. Seeds are living organisms. Due to age, poor storage conditions, handling and other factors, some seeds will not germinate. The use of poor quality seeds with a low germination rate can give you false or misleading results in your field studies – crops may perform poorly, not because the variety or management practice being studied is less effective, but because fewer seeds germinated. Conducting a germination test before starting a field study is important to assess the percentage of seeds that can be expected to germinate normally. Conducting a germination test is especially important when the field study involves a new variety or a management practice involving different planting methods or pre-planting seed treatments. This is especially important in an FFS integrating climate change that is testing adaptation options. Because FFS field study plots are often small, a low number of seeds germinating can reduce farmers' opportunities to accurately measure the differences between practices and to make other observations that the field study is designed to test. A germination test is simple and should be carried out well before the actual planting date.

Learning objective:

To test the quality of seeds being used in your field study and determine the percentage of seeds from your seed stock that can be expected to germinate.

Materials/preparation:

Seed sample from the seeds that will be used in the field study, a piece of cloth material and a large plate (for small seeds) or small container or plastic bag (for large seeds). If using a plate, the cloth should be approximately three times as wide as the plate so that the cloth can be folded over and completely cover any seeds placed on the plate with a double layer of material. For larger seeds, the material should be at least 50 cm^2. You will also need a small notebook and pen.

Timing:

This special topic should be conducted at least 2–3 weeks prior to planting. The seeds of some crops may take more than a week to germinate. Also, if you discover a problem with the quality of your seeds you will have time to locate new seeds and conduct the test again before planting.

Time:

Initially, 30–45 minutes will be needed to explain the purpose and to set up the study. During the test, a few minutes will be needed each day to check on the seeds and add additional water as needed. A final session of at least 30 minutes will be needed after germination has been completed to review and discuss the results. This final session can be held in combination with other FFS activities.

Steps:

- Take a random selection of seeds from their source. The sample of seeds should be well mixed – not taken from one location in the seed bag or container. Carefully count out the number that you will use to conduct the germination test. Typically, 100 seeds are used, but you can use a smaller number, say 50. Using a smaller number of seeds can be helpful when working with a crop that has large seeds (e.g. common beans or maize). (Using a larger number of seeds will improve the accuracy of your test, but **only** if you count correctly!) It is not recommended to use fewer than 25 seeds.
- For **small seeds**, such as rice, wet the cloth and lay it over the plate. Do this on a table or other clean surface so that dirt and other debris do not stick to the wet cloth. The cloth should be completely wetted, but not dripping. Too much water may cause the seeds to spoil. Arrange the seeds on the cloth, folding one, then the other side of the cloth towards the opposite edge of the plate, making sure that all of the seeds are well covered and there is good contact between the cloth and all of the seeds; they should all be covered with a double layer of additional cloth.
- For **large seeds**, wet the cloth and lay it out on a clean surface so that dirt and other debris do not stick to the wetted material. The cloth should be completely wetted, but not dripping. Arrange the seeds in rows across the cloth leaving 4–5 cm between the sides of the cloth at the start and end of the first row. Leave a larger space (double) between the top edge of the cloth and the first row of seeds. Arrange the seeds so there is a gap of 2 cm between each seed. Create a second row beneath the first, and a third or fourth row as needed, leaving a space of 2–3 cm between each row. The cloth should be large enough so that you can fold it in half from bottom to top, using the remaining cloth, covering all of the rows of seeds. Adjust the spacing of seeds as needed. Once folded, start at the right or left edge and roll the folded cloth. The roll should be firm enough to hold the seeds in place. Next, fold the roll in half to form a "U". Place the folded roll into the container/plastic bag, with the bottom of the "U" pointing downwards.

HINT: FFS master trainers and facilitators would have done this technique during the training of trainers or previous FFS. If not, it is a good idea to practise the technique a few times, before leading farmers in the exercise.

- The covered plate, container or plastic bag should be stored in a safe place where it will not be disturbed. The storage area should be out of direct sunlight. The temperature where you store the seeds is important. For warm season crops, the temperature of the storage area should be approximately 26–30 °C (80–85 °F). If the temperature is lower, the seeds will take longer to germinate. For cold season crops, the temperature should be 12–21 °C (55–70 °F).
- Ask for someone from the FFS to volunteer to maintain the seeds during the test. The volunteer will need to check the seeds each

day, and add water to the cloth holding the seeds so that it stays moist. To add water, use a spray bottle or sprinkle water droplets by hand. If you are using a rolled cloth for larger seeds, the cloth will need to be unrolled for wetting, then carefully re-rolled and returned to the storage container.

NOTE: There are a few crops whose germination is triggered by sunlight or a cold shock. Some varieties may require a period of dormancy before they will germinate – they cannot be harvested and immediately planted, but must rest for several months before the new seeds will germinate. Other varieties may require clipping or cutting of the tip of the seed to initiate germination (this is more common with tree crops). If you have complete, or nearly complete, failure of your seeds to germinate, ask the advice of a research partner or extension worker to determine if the crop or variety that you are working with requires any special conditions for germination. If so, follow the necessary steps and repeat your test as needed.

Measurements:

- During your weekly meetings, have the group check the seeds after the first week to see how many have germinated. You will want to keep a record of the number seeds that have germinated. After counting, carefully remove those seeds that have germinated. After the first week, additional seeds that germinate can be removed daily when additional water is being added. Make a simple record sheet like the example provided herein for recording the number of seeds that germinated and were removed each day. After a period of 3–4 consecutive days when no additional seeds have germinated, you can assume that germination has been completed. For most crops, germination will be completed by the end of the second week.

Name of variety:		Study manager::
Date	Number of seeds germinated	Observations

- At your next FFS meeting you can calculate the germination rate. To do this, add the number of seeds that germinated during the test. Divide this number by the total number of seeds you started with. For example, if 87 maize seeds germinated, and you started with 100 seeds, the germination rate would be:

  87/100 = 0.87 or 87 percent.

- If the germination rate is 80 percent or greater, you can use the stock of seeds for your field study. If it is lower than 80 percent, you should look for a new stock of seeds and re-test the germination rate of the new seeds. Seeds with a lower germination rate can still be used for normal production, but a higher seeding rate will need to be used – more seeds than usual – to compensate for fewer seeds germinating (see next bullet point). For conducting field studies, however, you should use the very best quality seeds possible.

- As an additional exercise, you can show farmers how to adjust the seeding rate for their regular fields if they have seeds with a germination rate below 80 percent.
  - Step 1: Determine germination percentage (e.g. 75 percent or 0.75) using the steps described.
  - Step 2: Determine the weight (or volume) of seeds – the seeding rate – normally used when planting a specific field (e.g. 50 kg or seven large measuring containers to plant the field).
  - Step 3: Divide the normal seeding weight (or volume) by the germination rate, e.g. **50 kg/0.75 = 67 kg or 7 containers/0.75 = 9.3 containers** to obtain the quantity of seeds farmers should use (in the example, in the case of a germination percentage of 75 percent).

Discussion questions:

- What are the germination rates of the seeds tested? Is the germinate rate acceptable? Do you need to find a new source of seeds?
- Do farmers feel confident in repeating this test on their own? Can they perform the calculations needed to adjust their seeding rate?

SPECIAL TOPIC 8

Mulching and mulches

If farmers decide to include **Field Study 3** (Moisture stress during the growing season) in their FFS, it is recommended that you first discuss with them the many benefits that the use of mulch delivers. This is another special topic that FFS master trainers and facilitators are familiar with. There is a list of additional background material included in **Annex C** to help facilitate this discussion. You may also find some of the documents in **Annex D** helpful. The combination of focused discussion and simple demonstrations will help farmers to learn more about how mulch can help them in adapting to changing weather patterns that are creating more frequent or severe periods of moisture stress in the fields where their crops are grown.

You can use some, or all, of the exercises herein to help demonstrate the major benefits associated with the use of mulch – the reduction in soil erosion, soil moisture conservation, and the importance of good soil structure. Especially for an FFS integrating climate change, understanding the benefits of using mulch as an adaptation practice is very important. In addition, you can use your field study plot to help demonstrate the effects of different types of mulch. The field study can also be used to highlight the effects of mulch in reducing the number of weeds that emerge. Simply organize farmers to collect data on the number of weeds emerging from each plot before the first weeding, and then again before the second weeding.

Special Topic 8a: Maximize cover to reduce run-off and erosion[6]

Learning objective:

To demonstrate soil erosion and the crucial role of soil cover to reduce soil losses.

Materials/preparation:

Three large plastic bottles, three small plastic bottles or cups (something to catch water in), three intact/undisturbed soil samples (approximately 10 cm deep and wide and long enough to fit into your cut-off bottle – see Figure C-7), 2 from a bare field and 1 from a grassland sward (with grass still attached), a few handfuls of crop/forest residues, twine, water.

Timing:

Prior to designing the field study on mulch.

Time:

Approximately 1 hour.

Steps:

- Start by brainstorming with the farmers about soil erosion, how and why it happens, and if there are examples of it in the area.
- Divide the farmers into three groups and assign one soil sample per group.

[6] Adapted from FAO (2021).

- Prepare the bottles. Place the large bottles on their sides and slice or cut off the top third from just above the neck all the way down to its base (see Figure C-7). Place the undisturbed soils into the bottles as illustrated in the picture.
- Put the three bottles on a gentle slope and gently pour in water over the soil to simulate heavy rainfall. NOTE: Put the same amount of water in each relative to the size of the bottle.

Figure C-7: FFS master trainers and facilitators performing the soil erosion exercise in the Philippines

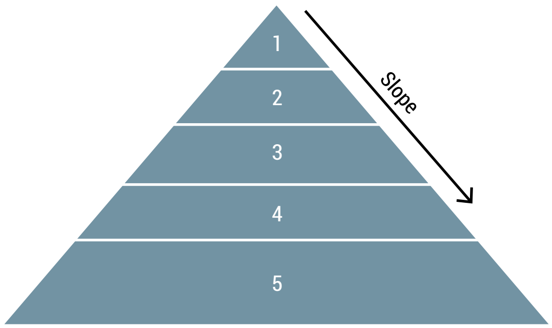
Discussion questions:

- What is the difference between the amount of water in the three cups?
- Are there colour differences in the water? Why are there differences between the three samples?
- In which cup was the colour darker? What makes the water cloudy?
- Imagine if the soil is left bare for 10 years. What would happen to the soil?
- How does the loss of topsoil affect crop performance and health?
- What types of management practices will result in the lowest levels of run-off and erosion?
- What practices should be avoided to prevent run-off?

You can expand the discussion to touch on the aspect of a landscape approach to managing some climate-related risks and the need for communities to work together on climate change adaptation.

Imagine a steep hill divided into five areas owned by different farmers (see **Figure C-8**). Farmers in Area 5 have invested in terrace and other soil conservation practices in order to mitigate run-off. However, when rainfall occurs they are still experiencing excessive water flows that damage their crops. How can they solve the problem? (*HINT: Clearly, they cannot do it alone.*)

Figure C-8: Graphical representation of a hill divided into five areas across the slope



What solutions can farmers put in place collectively?

In this situation, what would be the result of group actions compared with individual interventions?

Do you have other examples of interventions that should be taken by the community (for example, wind erosion)?

You may want to demonstrate this exercise by making a soil heap representing a hill, then simulate rainfall over the hill with a watering can or plastic container with small holes in the bottom (see Figure C-9). Some management practices could also be reproduced (e.g. terracing or mulching parts of the hill).

NOTE: A mulch layer creates a physical barrier, protecting soil from being washed away by heavy rainstorms. The loss of topsoil is particularly important. Not only does topsoil serve as a sponge, soaking up and holding moisture, but it also contains all of the essential nutrients that plants require to grow. Plants grown in soil rich in organic matter are healthier. Healthier plants are better able to tolerate moisture stress and to recover more quickly when conditions improve.

Figure C-9: FFS farmers discussing soil erosion in Andra Pradesh, India

Special Topic 8b: Maximize soil cover to reduce soil moisture losses[7]

Learning objective:

To appreciate the importance of crop residues and mulch in decreasing soil water losses through evaporation.

Materials/preparation:

Stakes for marking out two plots; buckets or a watering can; 30 litres of water; crop residues to cover a 1 m^2 plot.

Timing:

Prior to the start of the rainy season and before designing the field study on mulch.

Time:

First day – 1 hour to introduce and set up the exercise the first day; 2 days later – 30 minutes; 1 week later – 1 hour.

[7] Adapted from FAO (2000).

Steps:

- It is important that no rainfall occurs within the 10 days prior to starting this experiment (or during the experiment itself).
- Select and mark with stakes two plots, each 1 m^2 in size, located within 5 m of each other in a field with no crops and where there is a convenient source of water nearby. To demonstrate the effect of tillage on increasing soil moisture losses by evaporation, a third plot may be included which is tilled after thoroughly wetting the soil and then left bare.
- Remove any weeds, stones or residues from the surface of the two plots and gently (slowly) apply 30 litres of water to each plot, letting the water completely soak into the soil. It is preferable to use a watering can so as not to degrade the surface structure of the soil.
- Guide participants in assessing the similarity of the topsoil moisture content in both plots.

Figure C-10: Mulching in potato fields in Thai Binh, Viet Nam

- Cover one of the plots with a thick layer of crop residues or mulch so that the surface is completely covered. Leave the other plot uncovered.
- Return 2 days later and note the difference in topsoil moisture between the two plots. Take care to minimize soil disturbance and to replace the crop residues completely after checking the soil moisture of the plot with mulch.
- Return 1 week later and compare the difference in soil moisture between the two plots.

Discussion questions:

- Which plot held its moisture the longest? How long? Why?
- If crops were growing in these plots, in which plot would a dry spell have the least effects?
- For which local soil and crops will these practices be most appropriate and feasible?

NOTE: The physical protection provided by mulch also protects the moisture that has soaked into the soil from being evaporated by the sun's energy. With higher temperatures, and perhaps even stronger winds, more and more soil moisture will be lost through evaporation. By adding a thick layer of mulch, farmers can help to conserve the moisture held in the soil, allowing crops to survive for longer periods between rains.

Special Topic 8c: Benefits of soil structure promoted by the use of mulch

Learning objective:

To help farmers see the difference between healthy soils (where the soil particles are held together, i.e. there is structure, indicating the presence of many air spaces which can hold water) and unhealthy soils (those soils that have lost their structure, with little holding the soil particles together, and few places where water can be stored).

Materials/preparation:

For each small group: three soil samples (refer to the first bullet point below for instructions on how to take the samples), 3 empty plastic 1-litre water bottles, 3 pieces of cheesecloth or loose-weave organdie (8 cm × 8 cm), 3 rubber bands, twine, sharp knife, coloured permanent marking pen, 3 clear plastic cups or glasses, sufficient water to cover the soil samples after they are placed in the containers, balance scale.

Timing:

Prior to designing the field study on mulch, and before the rainy season starts (the soil sample must be completely dry).

Time:

1 hour.

Steps:

- Take a quantity of soil that could fill a plastic water bottle and spread it out on a plastic sheet in the sun to let it air-dry for a day or two. Choose soils from three locations so that you have: a) poor and sandy soil; b) local farm soil; and c) compost or soil rich in organic matter. (NOTE: You can prepare soil rich in organic matter by adding compost/manure [about 30% of the total soil] in one of the samples and mark this.)

- Cut the bottom off each plastic water bottle. Turn bottles upside down and put the cloth into the neck area of the bottle from the inside.
- Weigh out a fixed amount of each soil for each bottle (300–600 g) and place it in the inverted bottles.
- Suspend the inverted bottles above the clear plastic cups by hanging them with twine from a horizontal pole (see Figure C-11).
- Take another plastic cup and fill it with water; then add it to each bottle. Do some other activity and return when the water has passed completely through all samples. If the soil in any of the bottles has absorbed all the water, and none has passed through into the cup underneath, you will need to add more water. You will need to add the same amount of water to each sample in order to be able to compare the results at the end. (Attention! Make sure that the cups underneath can hold all the water that will pass through.)
- After all samples have drained completely, line up the cups side by side and compare the results.

Figure C-11: FFS Facilitators trying out the soil water holding capacity exercise in the Philippines

©D. Turner

Discussion questions:

- Are there any differences in the colour of the water? What does this indicate?
- Which of the soils holds (retains) the most water? What factors do you think are responsible for holding more or less water?
- Why is water holding capacity important? How can you best improve the water holding capacity of your soil?
- What is the relationship between water holding capacity and soil structure?
- What was the effect or role of the added organic matter? Why did it have this effect?

NOTE: Soil that is tilled one or more times per year, will eventually lose its structure (i.e. the glue that holds the individual soil particles together). Such soil is less fertile, cannot hold as much moisture and is more easily washed away in rainstorms. By providing a supply of organic material to feed soil organisms, and not tilling the soil, these organisms can rebuild the soil structure. Soils that have regained their structure are like a sponge, containing many tiny tunnels that can trap and hold the moisture that soaks in when it rains.

When special options have been tested and shown to be effective, these adaptive options can be included in the community-based adaptation plan.

References for Annex C

Dorward, P., Clarkson, G. & Stern, R. 2015. *Participatory Integrated Climate Services for Agriculture (PICSA): Field manual.* UK, Walker Institute, University of Reading. (also available at https://cgspace.cgiar.org/bitstream/handle/10568/68687/PICSA%20Field%20guide.pdf).

FAO. 1989. *Irrigation water management: Irrigation scheduling.* Training Manual No. 4. Rome. (also available at http://www.fao.org/3/t7202e/t7202e09.htm).

FAO. 2000. *Guidelines and reference material on integrated soil and nutrient management and conservation for farmer field schools.* Land and Plant Nutrition Management Service, Land and Water Development Division. Rome. (also available at http://www.fao.org/fileadmin/templates/nr/images/resources/pdf_documents/misc27.pdf).

FAO. 2015. *Trees Outside Forests Module for RRI Phase II Training Manua*l. Regional Rice Initiative. FAO Internal Document. Bangkok.

FAO. 2021. *Soil health for paddy rice: a manual for farmer field school facilitators.* Plant Production and Protection Division. Rome. (also available at http://www.fao.org/3/ca8167en/ca8167en.pdf).

Nield, D. 2020. The best weather apps you can get on your phone. In: *Popular Science* [online]. [Cited 17 May 2021]. https://www.popsci.com/best-weather-apps-for-your-phone

Sherwood, S.G. & Bentley, J. 2009. *Katalysis: Helping Andean farmers adapt to climate change.* Participatory Learning and Action. Community-based Adaptation to Climate Change. Nottingham, Russell Press.

Winarto, Y.T., Walker, S., Ariefiansyah, R., Prihandiani, A.F., Tadiuddin, M. & Nugroho, Z.C. 2018. *Institutionalizing Science Field Shops: Developing response farming to climate change.* Rome, GACSA. (also available at http://www.fao.org/3/I8454EN/i8454en.pdf).

Annex D. Technical background resources for facilitators

Batello, C., Wade, L., Cox, S., Pogna, N., Bozzini, A. & Choptiany, J., eds. 2014. Perennial crops for food security. In *Proceedings of the FAO Expert Workshop*. Rome, FAO. 390 pp. (also available at http://www.fao.org/3/a-i3495e.pdf).

Beegle, D.B. & Durst, P.T. 2002. *Managing phosphorus for crop production.* Agronomy Facts 13. Penn State Extension. University Park, PA, Penn State College of Agricultural Sciences.

Beets, W.C. 1982. *Multiple cropping and tropical farming systems.* Aldershot, Gower Publishing Co and Boulder, Colorado, Westview Press.

Beye, A.M., Jones, M.P. & Simpson, B.M. 2011. *Community-based seed system. Rice farmer's guide: Improving seed quality.* Cotonou, Benin, Africa Rice Center.

Beye, A.M., Jones, M.P. & Simpson, B.M. 2011. *Community-based seed system: The case of traditional rice farming systems. The technician's manual.* Cotonou, Benin, Africa Rice Center.

Beye, A.M., Jones, M.P. & Simpson, B.M. 2011. *Community-based seed system. The facilitator's guide.* Cotonou, Benin, Africa Rice Center.

Brentu, C.F., Fening, K.O. & Alidu, A.I. 2014. Hot water treatment to control nematodes and weevils on plantain. In: *Plantwise Factsheets for Farmers* [online]. Plantwise Knowledge Bank. [Cited 8 November 2020]. https://www.plantwise.org/KnowledgeBank/FactsheetAdmin/Images/Uploads/PDFs/20157800451.pdf

Bunch, R. 2012. *Restoring the soil: A guide for using green manure/cover crops to improve the food security of smallholder farmers.* Winnipeg, Canadian Food Bank. (also available at https://agriprofocus.com/upload/Restoring_the_Soil1417003689.pdf).

CARE. 2015. *Adaptation planning with communities: Practitioner Brief 1.* Kenya, CARE International. (also available at https://careclimatechange.org/wp-content/uploads/2014/08/CBA_Planning_Brief.pdf).

Chikowo, R., Snapp, S. & Hoeschle-Zeledon, I. 2015. *Double-up legume technology in Malawi boots land productivity*. Africa Rising Brief 37. Washington, DC, United States Agency for International Development.

Critchley, W., Siegert, K. & Chapman, C. 1991. *A manual for the design and construction of water harvesting schemes for plant production*. Rome, FAO. (also available at https://agris.fao.org/agris-search/search.do?recordID=XF2016035521).

CTA. 2010. *Intensive rice cultivation*. Practical Guide Series No. 17. Wageningen, Netherlands. (also available at https://cgspace.cgiar.org/bitstream/handle/10568/64790/PracGuide17UK.pdf?sequence=1&isAllowed=y).

Dorward, P., Clarkson, G. & Stern, R. 2015. *Participatory Integrated Climate Services for Agriculture (PICSA): Field manual.* UK, Walker Institute, University of Reading. (also available at https://cgspace.cgiar.org/bitstream/handle/10568/68687/PICSA%20Field%20guide.pdf).

Draaijer, J. 2016. *Dairy farmer field schools curriculum*. Project UTF/NEP/073/NEP. FAO Internal Document. Kathmandu.

Fairhurst, T., ed. 2012. *Handbook for integrated soil fertility management.* Pondicherry, India, Africa Soil Health Consortium.

FAO. 1984. *Legume inoculants and their use.* Rome. (also available at https://www.ctahr.hawaii.edu/bnf/Downloads/Training/Legume%20use/Title.PDF).

FAO. 1993. *Collection, storage and treatment of tree seeds: A handbook for small farm tree planters.* Bangkok. (also available at https://agris.fao.org/agris-search/search.do?recordID=XF2016036808).

FAO. 2000. *Guidelines and reference material on integrated soil and nutrient management and conservation for farmer field schools.* Land and Plant Nutrition Management Service, Land and Water Development Division. Rome. (also available at http://www.fao.org/fileadmin/templates/nr/images/resources/pdf_documents/misc27.pdf).

FAO. 2004. *Facilitators' FFS manual. Part II inspirational guide. Exercises and field studies for farmer field schools*. GTFS/REM/070/ITA. Regional Integrated Pest Management Programme in the Near East. FAO Internal Document. Jordan. (also available at https://www.yumpu.com/en/document/read/26300587/facilitators-ffs-manual-regional-integrated-pest-share4devinfo).

FAO. 2008. *Tools for conservation and use of pollination services: Initial survey of good pollination practices.* Rome. (also available at http://www.fao.org/fileadmin/templates/agphome/documents/Biodiversity-pollination/SURVEY_DEC_08_Small.pdf).

FAO. 2010. *Green manure/cover crops and crop rotations in Conservation Agriculture on small farms.* Integrated Crop Management, Vol. 12. Rome. (also available at http://www.fao.org/fileadmin/user_upload/agp/icm12.pdf).

FAO. 2013. *Exchange visits: Advice for improving the impact.* Knowledge Management and Gender. Good Practice Fact Sheet. West Africa. 12 pp. (also available at http://www.fao.org/3/a-aq213e.pdf).

FAO. 2013. *Save and Grow cassava: A guide to sustainable production intensification.* Rome. (also available at http://www.fao.org/3/a-i3278e.pdf).

FAO. 2015. *Climate Change Junior Farmer Field and Life School – Facilitator's guide.* Rome. 26 pp. (also available at http://www.fao.org/3/a-i4320e.pdf).

FAO. 2015. *Trees Outside Forests Module for RRI Phase II Training Manual.* Regional Rice Initiative. FAO Internal Document. Bangkok.

FAO. 2015. *Crops, weeds and pollinators: Understanding ecological interaction for better management.* Rome. (also available at http://www.fao.org/documents/card/fr/c/b04368f8-8512-49e6-99ef-7af58ceb7512/).

FAO. 2015. Technologies and practices for small agricultural producers. In: *Family Farming Knowledge Platform* [online]. Rome. [Cited 8 November 2020]. http://teca.fao.org

FAO. 2016. *Farmer field school guidance document: Planning for quality programmes.* Rome. (also available at http://www.fao.org/3/a-i5296e.pdf).

FAO. 2016. *Modules de formation en bonnes pratiques agricoles d'adaptation aux changements climatiques a travers les champs écoles des producteurs.* Projet GCP/BKF/054/LDF. Ouagadougou, FAO. (also available at http://www.fao.org/3/a-i3948f.pdf).

FAO. 2016. *Formation des maitres formateurs en approche Champ Ecole Agro-Pastoral (CEAP) et adaptation aux changements climatiques.* Projet GCP/BKF/054/LDF. Ouagadougou, FAO. (also available at http://www.fao.org/documents/card/fr/c/CA7790FR/).

FAO. 2017. *Recueil de sujets spéciaux pour les CEAP associes animes par les facilitateurs locaux.* Projet GCP/NER/043/LDF. Niamey, FAO.

FAO. 2017. *Compendium technique sur les bonnes pratiques agricoles et environnementales pour l'adaptation aux changements climatiques et la gestion des risques et desastres.* Projet GCP/HAI/027/LDSF. Port-au-Prince, FAO.

FAO. 2017. Inventaire et capitalisation des bonnes pratiques agropastorales. Rapport Final. Protocole d'Accord No. 097/2016/FRBKF. FAO Internal Document. Ouagadougou.

FAO. 2018. *Agrobiodiversity: A training manual for farmer groups in East Africa.* Rome. 196 pp. (also available at https://books.google.com.ph/books/about/Agrobiodiversity_a_training_manual_for_f.html?id=Mji1DwAAQBAJ&redir_esc=y).

FAO. 2020. *Community engagement in climate smart farmer field schools in Cambodia* [video]. [Cited 7 November 2020]. https://www.youtube.com/watch?v=DfFK27CT2nM

FAO. 2021. *Soil health for paddy rice: a manual for farmer field school facilitators.* Plant Production and Protection Division. Rome. (also available at http://www.fao.org/3/ca8167en/ca8167en.pdf).

FAO. 2020. *Case studies on conservation agriculture*. [e-books] Rome. [Cited 7 November 2020]. http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/scpi-home/managing-ecosystems/conservation-agriculture/ca-cases/en/

FAO, JICA & KFS. 2011. *Farmer field school implementation guide.* Farm Forestry and Livelihood Development. Rome, FAO. 355 pp. (also available at http://www.fao.org/3/i2561e/i2561e.pdf).

Hauser, S. & Messiga, F.N.K. 2010. Nematode control on plantain suckers (*Musa* spp. AAB Genome) through submergence in boiling water: Emergence rates, early growth, bunch yield and root health. *Acta Horticulturae (ISHS)*, 879: 323–331.

ICIPE. 2017. *Climate-Smart Push-Pull: Resilient, adaptable, conservation agriculture for the future*. Brochure prepared for the ADOPT Project. Nairobi, Kenya. (also available at https://technologytransfer.icipe.org/wp-content/uploads/2019/05/Climate-smart_Push-Pull.pdf).

IFAD. 2016. *How to do: Designing and implementing conservation agriculture in IFAD investments in sub-Saharan Africa*. Rome.

ICIPE. 2007. *Push-Pull Curriculum for farmer field schools.* Nairobi, Kenya, International Centre for Insect Physiology and Ecology.

Liniger, H.P., Mekdashi Studer, R., Hauert, C. & Gurtner, M. *2011. Sustainable land management in practice: Guidelines and best practices for sub-Sharan Africa*. Rome, FAO and Bern, WOCAT. 243 pp. (also available at http://www.fao.org/3/a-i1861e.pdf).

National Conservation Agriculture Task Force (NCATF). 2016. *National guidelines for implementing conservation agriculture in Malawi.* Lilongwe, Malawi.

National Research Council (NRC). 1992. *Neem: A tree for solving global problems.* Washington, DC, National Academy Press.

NRC. 1994. *Vetiver Grass: A thin green line against erosion.* Washington, DC, National Academy Press.

PAN Germany. *Online information service for non-chemical pest management in the tropics* [online]. Germany. [Cited 8 November 2020]. http://www.oisat.org/control_methods/cultural__practices/trap_cropping.html

Pieri, C., Evers, G., Landers, J., O'Connell, P. & Terry, E. 2002. No-Till Farming for Sustainable Rural Development. Agriculture and Rural Development Working Paper. Washington D.C., The World Bank.

Ray, M. & Simpson, B.M. 2014. *Agricultural adaptation to climate change in the Sahel: Profiles of agricultural management practices.* United States Agency for International Development, African and Latin American Resilience to Climate Change Project. Washington, DC, TetraTech.

Rice, E.L. 1984. *Allelopathy*. Second edition. Orlando, Academic Press.

Stigter, K., Winarto, Y.T. & Stathers, T. 2011. Rainfall measurements by farmers in their fields. In: *INSAM* [online]. [Cited 8 November 2020]. http://www.agrometeorology.org/images/rainfall-measurements-by-farmers-in-their-fields-1/view

SUSTAINET EA. 2010. *Technical manual for farmers and field extension service providers: Conservation agriculture.* Nairobi, Kenya, Sustainable Agriculture Information Initiative.

UNDP. 2000. Preparation of neem bio-pesticides at farm level. In *Examples of good practices in social policies, indigenous and traditional knowledge, and appropriate technology in the South*, Chapter 13. Sharing Innovative Experiences Vol. 4. United Nations Office for South-South Cooperation. New York, United Nations Development Programme.

Van Den Berg, H. 2001. *Facilitating scientific method as follow-up for FFS graduates*. FAO Programme for Community IPM in Asia. Peradeniya, FAO. (also available at http://www.fao.org/3/ca8266en/ca8266en.pdf).

Vandermeer, J. 1989. *The ecology of intercropping*. Cambridge, Cambridge University Press.

Winarto, Y.T., Walker, S., Ariefiansyah, R., Prihandiani, A.F., Tadiuddin, M. & Nugroho, Z.C. 2018. *Institutionalizing Science Field Shops: Developing response farming to climate change.* Rome, GACSA. (also available at http://www.fao.org/3/I8454EN/i8454en.pdf).

Woomer, P.L. 2010. *Biological nitrogen fixation and grain legume enterprise: Guidelines for N2Africa master farmers*. Nairobi, Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture.

Woperies, M., Mando, A. & Vanlauwe, B. 2008. *Agroecological principles of integrated soil fertility management*: *A guide with special reference to sub-Saharan Africa.* Muscle Shoals, AL, International Fertilizer Development Center.

World Bank. 1993. *Vetiver Grass: The hedge against erosion*. Washington, DC.

Bringing climate change adaptation into farmer field schools

A global guidance note for facilitators

For more information, please contact:

Plant Production and Protection Division
Natural Resources and Sustainable Production

nsp-director@fao.org
www.fao.org/agriculture/plant-production-and-protection
www.fao.org/farmer-field-schools/home

Food and Agriculture Organization of the United Nations
Rome, Italy

ISBN 978-92-5-134846-8

9 789251 348468
CB6410EN/1/09.21