Climate Change and Food Security

Climate Change Adaptation and Mitigation in Agriculture

Learners’ Notes

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Learning objectives

At the end of this lesson, you will be able to:

• understand the concept of adaptation to climate change;
• understand the concept of mitigation of climate change; and
• identify adaptation and mitigation strategies in the agricultural sector.

Introduction

Climate change has several impacts on ecosystems and societies and we have to protect ourselves from these impacts. But we are not only victims of climate change, we also contribute to it. Human activities, including agricultural sector activities, are causing climate change through increasing concentration of greenhouse gases in the atmosphere.

So, what can we do to address climate change? What actions can be taken in the agricultural sector?

Adaptation and mitigation

There are two main actions we can take:

• on the one hand, we need to adapt to climate change effects (adaptation);
• on the other hand, we should intervene on its causes (mitigation).

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<th>Adaptation</th>
<th>Mitigation</th>
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<td>Adaptation measures deal with the <strong>impacts</strong> of climate change and have the objective of reducing the vulnerability of human and natural systems.</td>
<td>Mitigation addresses the <strong>causes</strong> of the problem, which involves reducing greenhouse gas concentration in the atmosphere.</td>
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Adaptation measures are adjustments to current or expected climate change effects, while mitigation measures aim to attenuate climate change effects by reducing concentrations of GHG.
What is adaptation?

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

Adaptation is defined as activities that aim “to reduce the vulnerability of human or natural systems to the impacts of climate change and climate-related risks, by maintaining or increasing adaptive capacity and systems resilience” (OECD-DAC, 2011).

Vulnerability
Vulnerability is the degree to which a system or society is susceptible to, and unable to cope with adverse effects of climate change, including climate variability and extremes.

Adaptive capacity
Adaptive capacity is the ability of a system to adjust to climate change (climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. (IPCC 4th assessment report)
Resilience
Resilience is the ability to absorb disturbances, to be changed and then to re-organize and still have the same identity (retain the same basic structure and ways of functioning). ResAlliance.

What does adaptation mean for farmers and the agriculture sector?

Look carefully at the graphs below to understand how adaptation measures can increase the range of climate conditions farmers and ecosystems can cope with.

Let us assume that the y-axis refers to the mean annual air temperature fluctuating between years. Farmers can cope with this variability within a certain range (coping range). They are vulnerable to temperature extremes outside this range (climate shocks).

Through adaptation measures farmers are able to increase their resilience to extremely low and high temperature. Thus, adaptation increases the coping range.
Adaptation and development

Current and future impacts of climate variability and climate change threaten development achievements and stall further progress. Adaptation can reduce these threats. In turn, development, if appropriately planned, can help to enable climate change adaptation.

Adaptation to climate change is not fundamentally different from development activities aiming at reducing vulnerability of people to current stresses. However, adaptation puts emphasis on reducing those vulnerabilities that result from current and future climate change impacts. Adaptation measures should be integrated into policy and programme design.

Adaptation strategies

Adaptation strategies in agriculture are based on a combination of:

- specific actions (e.g. switching from one crop variety to another); and
- systemic changes (e.g. diversifying livelihoods against risks or an institutional reform to create incentives for better resource management).

The time span of adaptation actions can vary considerably. For example, while farmers can adjust timing of farming operations almost ad-hoc, changes in entire farming or food systems may require several years to decades.

Adaptation strategies include a broad set of activities ranging from activities that focus on reducing drivers of vulnerability to interventions aimed at confronting not yet experienced climate change impacts. In between, there is a broad spectrum of activities with gradations of emphasis on vulnerability and impacts that aim to build response capacity and better manage climate risks.

Based on these gradations, adaptation strategies can be grouped in the following categories:

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<th>The adaptation continuum</th>
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<td>Addressing Drivers of Vulnerability</td>
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**VULNERABILITY FOCUS**

**IMPACT FOCUS**
In the next sections you will find a description of each category with examples from agriculture, forestry and fishery.

1. Addressing drivers of vulnerability

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These most vulnerability-oriented adaptation efforts overlap almost completely with traditional development practice, where activities take little or no account of specific climate change impacts and have many benefits in the absence of climate change (so called “no-regret” options).

These activities buffer households and communities from the effects of climate change simply because they buffer them from nearly all sources of harm.

Examples

- Diversify sources of household income
- Participate in income stabilization programmes
- Introduce initiatives that transfer income or assets to the poor, protect the vulnerable against livelihood risks, and enhance the social status and rights of the marginalized (social protection)
- Promote community based risk management measures to face crop failures and soaring food prices (grain banks, self help groups)
- Develop innovative risk financing instruments and insurance schemes to reduce climate-related risks (e.g. weather/climate indexed crop insurance)
The following is an example of this kind of strategy:

Weather-based index insurance for small-scale farmers in Malawi

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

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

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

In 2007, the pilot was expanded to cash crops. By 2008, the number of participants had increased significantly, with 2,600 farmers buying policies worth US$2.5 million. However, the project also clearly stated that index-based insurance is not a panacea and it seems to be more effective when part of a larger package of risk management strategies and services.
2. Building response capacity

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VULNERABILITY FOCUS IMPACT FOCUS

In this zone of the continuum adaptation focuses on building robust systems for problem solving. Examples include the development of communications systems and planning processes, and the improvement of mapping, weather monitoring and natural resource management practices (NRM).

See below examples of NRM activities with reference to land and water resources; and crop, livestock, forest and aquatic resources.

Examples of management of land and water resources

- Reducing soil erosion and land degradation (improved soil management).
- Improving water use efficiency and availability.

For example:
- improving infrastructures for small-scale water capture, storage and use;
- improving demand management and water allocation to encourage efficiency of use;
- reducing distribution losses of irrigation water and reuse wastewater for agriculture;
- encouraging improved irrigation methods like drip and sprinkler irrigation and line canals with plastic films.

- Changing land topography to improve water uptake and reduce wind erosion.

For example:
- subdividing large fields;
- maintaining grass waterways;
- roughening the land surface;
- building windbreaks.
Examples of management of crop, livestock, forest and aquatic resources

- Conservation of genetic resources.
- Change farming practices to conserve soil moisture, organic matter and nutrients.

For example:
- use mulch stubble and straw;
- rotate crops;
- avoid mono-cropping;
- use lower planting densities;
- change timing of farm operations;
- advance sowing dates to offset moisture stress during warm periods.

- Adopt “best practices” that improve forest resilience and promote healthier forests.

For example:
- appropriate thinning regimes,
- reduced impact logging, and
- fire and pest management.

- Adopt livestock grazing practices to improve soil cover, increase water infiltration/retention and promote natural soil forming processes.
- Implement co-management systems to improve the governance of fisheries.
- Strengthen institutions in order to maximize responsiveness to change at all levels.

The following is an example of a strategy aiming at building response capacity:

**The Soil and Water Management Network in Africa**

For generations, smallholder farmers in Eastern and Central Africa have used their accumulated knowledge and ingenuity to improve and maintain soil quality. In recent years, however, as growing populations have put pressure on scarce land, these techniques are proving inadequate. As a result the soil has steadily deteriorated – a process exacerbated by alternating floods and
droughts which have further degraded the land and in some countries led to famines.

In response, scientists and institutions in the region have established the Soil and Water Research Management Network (SWMnet) which helps them share knowledge and technologies and also aims to enable farmers, communities and countries to adapt to and cope with climate variability. In addition, the network tries to enhance investments in soil and water management, to improve productivity and to increase the competitiveness of agricultural enterprises.

Much of this involves technology transfer. Since many technologies developed in one area have failed elsewhere, SWMnet facilitates and supports research to establish how these technologies can successfully be translated to different conditions.

As part of this process SWMnet tries to ensure intensive, systematic and detailed stocktaking of knowledge and experience at local, national and international levels and consults with a wide range of groups, from individual farmers to non-government organizations (NGOs) to private enterprises and international agricultural research institutes.

Introducing these ideas can be difficult. Many countries in the region have very weak capacity for agrometeorology, so neither individual farmers nor national policymakers can take much account of climate variability. And regional planning has yet to fully exploit opportunities for trade and commodity exchange across zones and countries. Nevertheless, SWMnet has fostered an active dialogue between practitioners and is supporting institutional development.

(Source: UNFCCC 2006)
3. Managing climate risks

The adaptation continuum

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VULNERABILITY FOCUS  IMPACT FOCUS

In this zone of the continuum adaptation efforts focus more specifically on climate change hazards and impacts.

In areas under frequent threat of climate-related emergencies disaster risk reduction (DRR) and disaster risk management (DRM) are key entry points for climate change adaptation.

For example, availability and accessibility of good quality seeds is paramount in enhancing the resilience of food production systems to climate-related hazards and other shocks and minimizing dependence on direct external assistance.

Example: Availability and accessibility of good quality seeds

Activities aimed at enhancing availability/accessibility of seeds include:

- Making **short-cycle seeds** available in vulnerable areas exposed to cyclic environmental stresses, thus increasing future resilience to hazard impacts.

  **Short-cycle seeds**
  Short-cycle seed varieties allow for harvesting before the peak of the cyclone season or for a quick harvest following re-planting after cyclones and flooding.

- Establishing strategic and cyclone-proof seed stocks, minimizing losses during the cyclone season and improving availability of and accessibility to quality seeds.

The following is an example of a strategy aimed at managing climate risk:
Early warning systems in Bangladesh

Every year millions of people in coastal areas of Bangladesh are exposed to flooding. While much of this is beneficial, indeed essential, for agriculture, in some years it can be on a catastrophic scale, resulting in epidemics and in thousands of deaths as well as causing serious damage to habitats, agricultural production, fisheries and livestock.

Bangladesh has therefore been developing more effective early warning systems. Among these is a five-year project, the Community Flood Information System (CFIS).

Community Flood Information System (CFIS)
The project is funded by United States Agency for International Development (USAID) and operated by the United States company Riverside Technology in partnership with two Bangladeshi institutions: the Center for Environmental and Geographic Information Services, and the Bangladesh Disaster Preparedness Centre. Experience has shown that those best placed to prepare for and respond to disasters are local people.

Prior to the project, most people obtained flood forecast information from a combination of sources: word of mouth, traditional knowledge and local media. But the first two are often inefficient and hit-or-miss, whereas local media reports can be difficult for people to understand.

The CFIS is designed to help Bangladeshi communities to adapt to the risks of floods and cyclones through a system of flood monitoring and forecasting and has already shown that timely flood warnings can prompt communities to protect crops, habitats and livestock. The Government of Bangladesh has recommended that the model be replicated in other flood prone areas.
(Source: UNFCCC 2006)
4. Confronting climate change

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**VULNERABILITY FOCUS**  IMPACT FOCUS

This category includes highly specialized activities exclusively targeting distinct climate change impacts and clearly falling outside the realm of development as we know it. Their benefits will materialize only if expected climate impacts come about.

**Examples**

Examples include activities that explicitly confront climate change and target climate risks that are far outside of historic climate variability, such as:

- relocation of communities due to sea level rise,
- responses to glacial melting,
- building large scale irrigation systems, or
- plant breeding in response to shifting agro-ecological zones and new stresses.

The following is an example of anticipatory development planning that targets a clear impact of climate change:

**Risk of glacial lake outburst in Nepal**

With climate change, glaciers are melting and the volume of water stored in glacial lakes is growing. This heightens the risk of the moraine dams being breached, suddenly releasing huge volumes of water downstream.

In August 1985, an avalanche dumped tons of ice into the Dig Tscho glacial lake in eastern Nepal. The resulting 5-meter wave overtopped the moraine dam and released a flood that destroyed homes, bridges, farmland, and a nearly completed hydropower plant.

The glacial lake was drained within six hours. Four or five deaths resulted from this event - a figure
that could have been much higher had the flood occurred during the height of the tourist season.

The risk of another Dig Tscho-type outburst flood is growing, as temperature increases at high altitudes in the Himalayas correlate with increasing glacial lake volumes. There are about 20 sites at risk in Nepal. Among the most dangerous sites is the Tscho Rolpa glacial lake, situated 4,580 m above sea level and fed by the rapidly retreating Tradkarding glacier. The glacial lake had grown from an area of 0.23 square kilometers (km²) in the late 1950s to 1.65 km² in 1997. At this size, the lake stored 90-100 million cubic metres (m³) of water, at least a third of which would be released downstream if the 150-m-tall moraine dam were breached.

Recognizing the risk this high-altitude warming and lake expansion posed to rural communities and infrastructure, such as the Khimiti hydropower plant, in 1998 the Government of Nepal initiated a project to drain down the Tscho Rolpa glacial lake. An expert group recommended cutting a channel into the moraine to reduce lake levels by 3 m, which was expected to reduce outburst flood risk by 20%. This measure was carried out in conjunction with the establishment of early-warning systems in 19 downstream villages. However, experts are warning that total outburst flood prevention will require a further draining of as much as 17 m, a costly endeavour.
What is mitigation?

Let’s now look at what “mitigation” means.

**Mitigation activities**

- promote efforts to reduce or limit greenhouse gas emissions or to enhance greenhouse gas sequestration” (OECD-DAC)...
- …including “technological changes that reduce resource inputs and emissions per unit of output” (IPCC).

The agricultural sector has a substantial potential for mitigation. About 30% of the global greenhouse gas emissions is due to agriculture activities and deforestation.

The diagram below shows the percentage contribution of all sectors to GHG emissions.

![Pie chart showing GHG emissions by sector]

**Agriculture 13.5%**

Emissions from agriculture (13.5% of global GHG emissions) come mainly from:

- Nitrous oxide from soils
- Methane from ruminant livestock digestion
- Burning of living and dead vegetation
- Rice production
- Manure management
Forestry 17.4%
Land use, land-use change and forestry (LULUCF) are responsible for 17.4% of global GHG emissions, largely through tropical deforestation.

However, the agriculture sector has also a relevant potential to absorb GHG from the atmosphere through carbon sinks.

Carbon sinks
Carbon sinks can be created through carbon sequestration and conservation:

- Carbon sequestration refers to enhancing carbon storage in soils and biomass above and below ground – e.g. through afforestation, reforestation and re-vegetation, such as restoration of degraded lands, agro-forestry, cropland and grazing management.
- Carbon conservation refers to the conservation of carbon stocks in forests and agricultural systems, through improving management practices (e.g. selective felling, reduced impact logging), or conservation/ protection measures (forest conservation, soil conservation, fire protection), within forest and agricultural systems.

Mitigation strategies
In the agricultural sector, there are three major options to mitigate climate change:

1. **Reducing emissions**: Agriculture releases to the atmosphere significant amounts of CO2, CH4, or N2O. The fluxes of these gases can be reduced by more efficient management of carbon and nitrogen flows in agricultural ecosystems, leading to less carbon dioxide, nitrogen and methane released.

2. **Avoiding or displacing emissions**: The energy efficiency of the agriculture sector can be improved. In addition, fossil fuel energy used in agricultural production can in some cases be replaced by biofuels. Greater use of wood products can also lead to displacing CO2 emissions.

3. **Removing emissions**: GHGs can be absorbed from the atmosphere through sinks. A sink is any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere.

Let’s look at these options in detail.
1. Reducing emissions of carbon dioxide, methane and nitrous oxide

This option includes:

- **Adopting improved cropland management practices**
  Minimal soil disturbance (minimum and zero tillage) and improved grazing management (e.g. stocking rate management, rotational grazing, and enclosure of grassland from livestock grazing) can reduce emissions from volatilization of organic soil Carbon. Integrated nutrient management can reduce emissions by reducing leaching and volatile losses, improving nitrogen use efficiency through precision farming and improving fertilizer application timing.

- **Improving livestock feeding practices**
  Using specific agents or dietary additives, improvements in forage quality and quantity, seeding fodder grasses or legumes with higher productivity and deeper roots, reducing fuel load by vegetation management, can increase efficiency of the digestive process thus reducing emissions from enteric fermentation.

- **Avoiding drainage of organic soils**
  Draining organic soils for cultivation leads to higher GHG emissions. Therefore maintaining a shallower water table, together with avoiding deep ploughing and cropping row crops and tubers can reduce emissions.

- **Reducing deforestation and forest degradation**
  Committing forests for reducing emissions from deforestation and forest degradation (REDD) and adopting sustainable management of existing forests can reduce emissions.

- **Adopting improved aquaculture management**
  Selection of suitable populations of aquatic species, improved energy efficiency, increasing feeding efficiency, switching to herbivorous or omnivorous aquaculture species will reduce emissions from input use.

2. Avoiding and displacing emissions

This option includes:

- **Improving post-harvest practices**
  Reducing post harvesting food losses (improved storage and post-harvest handling) will contribute to decreasing emissions per unit of food consumed.
• **Improving energy use in agricultural production**
  Increasing energy efficiency and replacing fossil fuels with biofuels will reduce emissions per unit of food produced.

• **Use of fishing practices that adhere to the principles of the Code of Conduct for Responsible Fisheries**
  Use of fishing practices that adhere to the principles of the Code of Conduct for Responsible Fisheries will increase input/output ratios therefore increasing greenhouse gas efficiency rates.

3. **Removing emissions**

This option includes:

• **Improved agronomic practices**
  Use of cover crops, avoiding use of bare fallow and incorporation of crop residue generate higher inputs of carbon residue, leading to increased soil carbon storage (systems that retain crop residues tend to increase soil carbon because these residues are precursors of soil organic matter).

• **Improved soil & water management**
  Increased available water in the root zone can enhance biomass production, increase the amount of above-ground and root biomass returned to the soil, and improve soil organic C concentration (for example: construction of soil or stone bunds, drainage measures, irrigation).

• **Agro-forestry, afforestation/ reforestation, forest restoration**
  Carbon storage can be increased through:
  • combining crops with trees for timber and fodder;
  • establishing shelter belts and riparian zones/buffer strips with woody species systems; and
  • conversion from non-forest to forest land use and from degraded forests to fully carbon stocked forests.

• **Replanting mangroves in aquaculture areas**
  Replanting mangroves in aquaculture areas will create carbon sinks.
Summary

- Increasing GHG concentrations is causing climate change with consequent impacts on ecosystems and societies.

- Adaptation aims at reducing the vulnerability of agricultural systems to the impacts of climate change and climate-related risks, by maintaining or increasing adaptive capacity and resilience.

- Key adaptation strategies include a broad set of interventions ranging from activities that focus on reducing drivers of vulnerability to actions aimed at confronting not yet experienced climate change impacts.

- Mitigation addresses the causes of climate change. The mitigation potential of agriculture is substantial as agriculture and deforestation contribute to about one third of global greenhouse gas emissions.

- Key mitigation strategies include actions aimed at reducing GHG concentration and creating Carbon sinks through Carbon sequestration in soils and below and above ground biomass.

- Even with an immediate stop in the GHG emissions, climate change will occur because of the slow reaction of the climate system. Therefore, adaptation and mitigation should be considered as complementary.
If you want to know more...

Online resources

http://www.fao.org/docrep/010/k2595e/k2595e00.htm


Additional reading


