African Forest Forum

A platform for stakeholders in African forestry

# Forests and Climate Change Adaptation

A COMPENDIUM FOR SHORT COURSES IN AFRICAN FORESTRY

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***Correct citation:*** African Forest Forum. 2022. Forests and Climate Change Adaptation: A Compendium for Short Courses in African Forestry



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**Front cover photos:** Fog in tropical green rainforest during rainy day. Credit: Pratan Ounpitipong (left); West African rain forest, Liberia, West Africa. Credit: Fabian Plock (middle); Quiver tree in Namibia, Africa Galyna Andrushko. Credit: Galyna Andrushko

**Back cover photo:** A colorful vegetation of Kakamega rain forest in Western Kenya, Africa. Credit: Margus Vilbas Photography

**Design & layout:** Conrad Mudibo, Ecomedia

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# Acknowledgements

This compendium has been developed through an organic process that initially led to the development of "Training modules on forest-based climate change adaptation, mitigation, carbon trading, and payment for other environmental services". These were developed for professional and technical training, and for short courses in sub-Saharan African countries. The compendium provides the text required for effective delivery of the training modules; in other words, it is structured based on the training modules, but updated and strengthened based on new and emerging issues in the context of forestry and climate change adaptation and mitigation, as well as case studies from various African forestry landscapes. In this context, many people and institutions, including those from government, civil society, academia, research, business, private sector, and other communities, have contributed in various ways in the process that culminated in the development of the compendium. This has been through their inputs as reviewers, resource persons and participants to the validation of the draft documents. We wish to collectively thank all these individuals and institutions for their invaluable contributions, given that it is difficult in such a short text to mention them individually.

We also appreciate the kind financial support received from the Government of Switzerland through the Swiss Agency for Development and Cooperation (SDC) to implement an AFF project on "African forests, people and climate change" that generated most of the information that formed the basis for writing this compendium. AFF is also indebted to the Swedish International Development Cooperation Agency (Sida) for its support of another AFF project on "Strengthening management and use of forest ecosystems for sustainable development in Africa" that also provided inputs into the compendium, in addition to helping facilitate various contributors to this compendium. The issues addressed by the two projects demonstrate the interest of the people of Switzerland and Sweden in African forestry and climate change.

We are also particularly grateful to the lead authors, the contributors mentioned in this compendium and the pedagogical expert.

We hope that the compendium will contribute to a more organized and systematic way of delivering training in this area, and eventually towards better management of African forests and trees outside forests in the context of changing climate.

# Preface

African forests and trees support the key sectors of the economies of many African countries, including crop and livestock agriculture, energy, wildlife and tourism, water resources and livelihoods. They are central to maintaining the quality of the environment throughout the continent, while providing international public goods and services. Forests and trees provide the bulk of the energy used in Africa. Forests and trees are therefore at the centre of socio-economic development and environmental protection of the continent.

Forests and trees outside forests in Africa are in many ways impacted by climate change, and they in turn influence climate. Hence, African forests and trees are increasingly becoming very strategic in addressing climate change, as captured in African countries' Nationally Determined Contributions (NDCs). The great diversity of forest types and conditions in Africa is at the same time the strength and the weakness of the continent in devising optimal forest-based responses to climate change. In this regard, given the role of forests and trees to socio-economic development and environmental protection, actions employed to address climate change in Africa must simultaneously enhance livelihoods of forest dependent populations and improve the quality of the environment. It is therefore necessary for Africa to understand how climate change affects the inter-relationships between food, agriculture, energy use and sources, natural resources (including forests and woodlands) and people in Africa, and in the context of the macro-economic policies and political systems that define the environment in which they all operate. Much as this is extremely complex, the understanding of how climate change affects these inter-relationships is paramount in influencing the process, pace, magnitude and direction of development necessary for enhancing people's welfare and the environment in which they live.

At the forestry sector level, climate affects forests but forests also affect climate. For example, carbon sequestration increases in growing forests, a process that positively influences the reduction in the level of greenhouse gases in the atmosphere, which, in turn, may reduce global warming. In other words, the forests, by regulating the carbon cycle, play vital roles in climatic change and variability. For example, the Intergovernmental Panel on Climate Change (IPCC) special report of 2018 on the impacts of global warming of 1.5 °C above pre-industrial levels underscores the significance of afforestation and reforestation, land restoration and soil carbon sequestration in carbon dioxide removal. Specifically, in pathways limiting global warming to 1.5 °C, agriculture, forestry and land-use (AFOLU) are projected with medium confidence to remove 0-5, 1-11 and 1-5 GtCO2 yr-1 in 2030, 2050 and 2100, respectively. There are also co-benefits associated with AFOLU-related carbon dioxide removal measures such as biodiversity conservation, improved soil quality and local food security. Climate, on the other hand, affects the function and structure of forests. It is important to understand adequately the dynamics of this interaction to be able to design and implement appropriate mitigation and adaptation strategies for the forest sector.

In the period between 2009 and 2011, the African Forest Forum (AFF) sought to understand these relationships by putting together the scientific information it could gather in the form of a book that addressed climate change in the context of African forests, trees, and wildlife resources. This work, which was financed by the Swedish International Development Cooperation Agency (Sida), unearthed considerable gaps on Africa's understanding of climate change in forestry, how to handle the challenges and opportunities presented by it and the capacity to do so.

The most glaring constraint for Africa to respond to climate change was identified as the lack of capacity to do so. AFF recognizes that establishment and operationalization of human capacities are essential for an effective approach to various issues related to climate change, as well as to improve the quality of knowledge transfer. For example, civil society organisations, extension agents and local communities are stakeholders in implementing adaptation and mitigation activities implicit in many climate change strategies. In addition, civil society organisations and extension agents are more likely to widely disseminate relevant research results to local communities, who are and will be affected by the adverse effects of climate change. It is therefore crucial that all levels of society are aware of mechanisms to reduce poverty

through their contribution to solving environmental problems. Training and updating knowledge of civil society organisations, extension service agents and local communities is one of the logical approaches to this. Also, professional and technical staff in forestry and related areas would require updated knowledge and skills in these relatively new but highly dynamic areas of work.

It was on this basis that AFF organized a workshop on capacity building and skills development in forest-based climate change adaptation and mitigation in Nairobi, Kenya, in November 2012 that drew participants from selected academic, research and civil society institutions, as well as from the private sector. The workshop identified the training needs on climate change for forestry related educational and research institutions at professional and technical levels, as well as the training needs for civil society groups and extension agents that interact with local communities and also private sector on these issues. The training needs identified through the workshop focused on four main areas, namely: Science of Climate Change, Forests and Climate Change Adaptation, Forests and Climate Change Mitigation, and Carbon Markets and Trade. This formed the basis for the workshop participants to develop training modules for professional and technical training, and for short courses for extension agents and civil society groups. The development of the training modules involved 115 scientists from across Africa. The training modules provide guidance on how training could be organized but do not include the text for training; a need that was presented to AFF by the training institutions and relevant agents.

Between 2015 and 2018, AFF brought together 50 African scientists to develop eight compendiums in a pedagogical manner, namely:

1. Basic Science of Climate Change: A Compendium for Professional Training in African Forestry 01- https://afforum.org/publication/basic-science-of-climate-change-a-compendium-for-professional-training-in-african-forestry-01/
2. Basic Science of Climate Change: A Compendium for Technical Training in African Forestry 02- https://afforum.org/publication/basic-science-of-climate-change-a-compendium-for-technical-training-in-african-forestry-02/
3. Basic Science of Climate Change: A Compendium for Short Courses in African Forestry 03- https://afforum.org/publication/basic-science-of-climate-change-a-compendium-for-short-courses-in-african-forestry/
4. Carbon Markets and Trade: A Compendium for Professional Training In African Forestry 04- https://afforum.org/publication/carbon-markets-and-trade-a-compendium-for-professional-training-in-african-forestry/
5. Carbon Markets and Trade: A Compendium for Technical Training in African Forestry 05- https://afforum.org/publication/carbon-markets-and-trade-a-compendium-for-technical-training-in-african-forestry/
6. Carbon Markets and Trade: A Compendium for Short Courses in African Forestry 06- https://afforum.org/publication/carbon-markets-and-trade-a-compendium-for-short-courses-in-african-forestry/
7. Climate Modelling and Scenario Development: A Compendium for Professional Training in African Forestry 07- https://afforum.org/publication/climate-modelling-and-scenario-development-a-compendium-for-professional-training-in-african-forestry-07/
8. International Dialogues, Processes and Mechanisms on Climate Change: A Compendium for Professional and Technical Training in African Forestry 08- https://afforum.org/publication/international-dialogues-processes-and-mechanisms-on-climate-change-a-compendium-for-professional-and-technical-training-in-african-forestry-08/

From 2019 to 2022, AFF mobilized 75 African forestry stakeholders to continue the development of the compendiums including updating, strengthening and contextualizing them with case studies, new and emerging issues in forestry and climate change in order to produce six new compendiums as follows:

1. Forests and climate change adaptation: a compendium for professional training in African forestry
2. Forests and climate change adaptation: a compendium for technical training in African forestry
3. Forests and climate change adaptation: a compendium for short course in African forestry
4. Forests and climate change mitigation: a compendium for professional training in African forestry
5. Forests and climate change mitigation: a compendium for technical training in African forestry
6. Forests and climate change mitigation: a compendium for short course in African forestry

These compendiums are being translated into French for the benefit of the Francophone African forestry stakeholders.

Another notable contribution during the period 2011-2018 was the use of the training module on "Carbon markets and trade" in building the capacity of 574 trainers from 16 African countries on rapid forest carbon assessment (RaCSA), development of a Project Idea Note (PIN) and a Project Design Document (PDD), exposure to trade and markets for forest carbon, and carbon financing, among others. The countries that benefited from the training are: Burkina Faso (35), Côte d'Ivoire (31), Ethiopia (35), Guinea Conakry (40), Kenya (54), Liberia (39), Madagascar (42), Niger (34), Nigeria (52), Sierra Leone (35), Sudan (34), Swaziland (30), Tanzania (29), Togo (33), Zambia (21) and Zimbabwe (30). In addition, the same module has been used to equip African forest-based small-medium enterprises (SMEs) with skills and knowledge on how to develop and engage on forest carbon business. In this regard, 63 trainers of trainers were trained on RaCSA from the following African countries: Angola, Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Democratic Republic of Congo, Ethiopia, Kenya, Gabon, Gambia, Ghana, Guinea Conakry, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Republic of Congo, Senegal, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia and Zimbabwe.

In 2021 and 2022, the validated training compendiums on "Forests and climate change mitigation: a compendium for short courses in African forestry" and on "Forests and climate change adaptation: a compendium for short course in African forestry" were used to train 165 African forestry stakeholders from forestry administrations, private sectors, civil society and community based organizations from 29 African countries including 10 from Francophone (Algeria, Benin, Burkina Faso, Chad, Mali, Mauritania, Niger, Tunisia, Togo and Senegal); 15 from Anglophone (Botswana, Egypt, Ethiopia, Kenya, Gambia, Lesotho, Liberia, Malawi, Namibia, Nigeria, Rwanda, Uganda, Tanzania, Zambia, Zimbabwe) and 2 from Lusophone Africa (Angola and Mozambique).

An evaluation undertaken by AFF has confirmed that many trainees on RaCSA are already making good use of the knowledge and skills gained in various ways, including in developing bankable forest carbon projects. Also, many stakeholders have already made use of the training modules and the compendiums to improve the curricula at their institutions and the way climate change education and training is delivered. In the same vein, an evaluation done at the end of the training workshops using the compendiums for short courses indicate that the skills gained, and experiences shared were relevant to improve the capacity of trainees in developing and implementing activities, projects, programmes and policies related to forest and tree-based mitigation and adaptation in their national contexts.

These compendiums and training workshops were largely financed by the Swiss Agency for Development and Cooperation (SDC) and with some contribution from the Swedish International Development Cooperation Agency (Sida).

The development of the compendiums is therefore an evolutionary process that has seen the gradual building of the capacity of many African scientists in developing teaching and training materials for their institutions and the public at large. In a way this has cultivated interest within the African forestry fraternity to gradually build the capacity to develop such texts and eventually books in areas of interest to the continent, as a way of supplementing information otherwise available from various sources, with the ultimate objective of improving the understanding of such issues as well as to better prepare present and future generations in addressing the same.

We therefore encourage the wide use of these compendiums, not only for educational and training purposes but also to increase the understanding of climate change aspects in African forestry by the general public.

**Macarthy Oyebo**
Président du Conseil d'administration du AFF

**Godwin Kowero**
Secrétaire exécutif du AFF

# Abbreviations and Acronyms

| | |
|---|---|
| ACPC | African Climate Policy Centre |
| AFF | African Forest Forum |
| AFOLU | Agriculture Forestry and Other Land uses |
| CCA | Climate Change Adaptation |
| $CO_2$ | Carbon dioxide |
| COP | Conference of Parties |
| COMESA | Common Market for Eastern and Southern Africa |
| CBFM | Community Based Forest Management |
| CBD | Convention on Biological Diversity |
| DRR | Disaster Risk Reduction |
| ENSO | El Niño-Southern Oscillation |
| EWS | Early Warning Systems |
| EbA | Ecosystem-based adaptation |
| FAO | Food and Agriculture Organisation of the United Nations |
| GCA | Global Climate Action |
| GEF | Global Environment Facility |
| GHG | Greenhouse Gas |
| INDC | Intended Nationally Determined Contributions |
| IPCC | Intergovernmental Panel on Climate Change |
| IUCN | International Union for Conservation of Nature |
| LDC | Least Development Countries |
| LDCF | Least Development Country Fund |
| LP | Liquid Petrolium |
| LULUCF | Land Use, Land-Use Change and Forestry |
| NAPs | National Adaptation Plans |
| NAPA | National Adaptation Programme of Action |
| NHMS | National Hydro Metrological Systems |
| NDC | Nationally Determined Contribution |
| NTFPs | Non-Timber Forest Products |
| REDD | Reducing Emissions from Deforestation and Forest Degradation |
| SADC | Southern African Development Community |
| SCCF | Special Climate Change Fund |
| SIDS | Small Island Developing States |
| SPD | Strategic Priority for Adaptation |
| SDGs | Sustainable Development Goals |
| SFM | Sustainable Forest Management |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WB | World Bank |

# Compendium Overview

This compendium provides essential information on the interactions between forests and climate change, the concept of adaptation, and the role of forests in climate change adaptation. These interactions are motivated by the diverse functions and services provided by forests such as the provision of wood and non-wood forest products, enhancement of soil fertility, water regulation and biodiversity conservation. These goods and services ensure that forests play potentially significant roles in climate change adaptation approaches undertaken in different natural resources and land-based sectors, including agriculture, energy, rangeland, transport and water management. Moreover, trees and shrubs in farming systems, including agroforestry, have always played important roles in protecting agricultural soil from erosion, loss of fertility and sandstorms, thus, contributing to sustainable agricultural production and food security. In this regard, forests enhance the ability of people to access ecosystem services and goods, which reduce social vulnerability and improve human well-being. Therefore, adaptation strategies, which promote sustainable community-based forest management, increase the protection of land and people from some of the harmful effects of climate change. Forests also provide opportunities for sustainable rural development and alleviate poverty through income generation and creation of employment opportunities.

This compendium therefore delves into the concepts of climate change adaptation, national adaptation plans; and strategies for climate change adaptation, monitoring and evaluation. The compendium is divided into four chapters: definitions and concepts of adaptation; forest-based adaptation; non-forest-based adaptation, and challenges, gaps and barriers to climate change adaptation.

## Compendium learning objectives

To equip learners with knowledge and skills to design and implement climate change adaptation strategies.

## Learning outcome:

At the end of this compendium, learners should be able to:

- Define and describe concepts of climate change adaptation.
- Outline forest-based climate change adaptation options in different landscape.
- Describe climate change adaptation in other sectors and the appropriate adaptation strategies; and
- Describe the challenges, gaps and barriers to climate change adaptation and how they can be addressed.

# Chapter 1. Definitions and Concepts of Adaptation

## 1.1 Chapter Overview

A forest is a complex ecological system in which trees are the dominant life form. Forest resources are renewable natural resources that are exhaustible and thus require proper management to ensure their sustenance and continuous availability. Globally, forests cover 31% of the land area, with approximately 50% of forest area still relatively intact, while about one-third is naturally regenerated forests (FAO, 2020). Forests are the largest reservoir of biodiversity, at all levels, ranging from habitat to gene levels, making forests to be among the most treasured ecosystems in the world. Forest ecosystems play significant roles in regulation of climate systems due to their ability to sequester huge quantities of carbon (C) in biomass, litter and soil. The importance of forests has been highlighted in scientific studies and policy of climate change mitigation, but their role should be explicitly articulated for appreciation and understanding by policy makers, professionals and local communities among other stakeholders. Climate change mitigation includes interventions to reduce greenhouse gases in the atmosphere and storing carbon in biomass and soils. The importance of forests in adaptation to climate change should also be recognised. In this chapter the following items and terms related to climate change adaptation will be covered: definitions and concepts of climate change adaptation, vulnerability, impact, determinants and types of adaptation and how these can be incorporated into development process. Furthermore, the chapter gives some examples of how people and forests are adapting to climate change.

**Learning objectives**

By the end of this chapter, the learner should be able to:

- Define terms used in climate change adaptation.
- Relate climate with adaptation and mitigation.
- Discuss adaptation strategies at global, regional and national levels.
- Explain the role of NAPs, NAPAs and NDCs in climate change adaptation.
- Describe requirements for an effective early warning system.
- Relate concept of disaster management to climate change adaptation.
- Clarify maladaptation, temporal and spatial scales of adaptation; and
- Analyse how adaptation can be mainstreamed into development processes.

# 1.2 Definitions and concepts of climate change adaptation

Climate change and variability and associated actions of mitigation and adaptation are described by several terminologies used in discussions. These will be defined and elaborated in this section of the Chapter. This is because an understanding of adaptation to climate change requires one to be conversant with the meanings of some of these key operational terms and concepts as used in the text.

**Learning outcomes**

By the end of this session, the learner should be able to:

i. Define operational terms relevant to climate change and adaptation;
ii. Describe the vulnerability factors and indicators for assessing the dynamics of the main sectors affected by climate change; and
iii. Describe different adaptation measures.

**Activity 1.1 Brainstorming (15 Minutes)**

- Mention and share your views on any two concepts and terminologies that you think are important in climate change adaptation.

## 1.2.1 Climate Change

Climate change is a combination of increased temperatures, changing and erratic precipitation, altered patterns of extreme events, and changing disturbance regimes affecting forest ecosystems and human livelihoods (Steffen et al. 2015). Davis and Joubert (2011) showed that there are changes in many of the climatic characteristics of the southern African climate. Forests are able to respond to climate change through local site conditions and their ability to adapt to environmental changes. However, climate change may trigger changes in plant communities (Naidoo et al. 2013) and diminish provision of ecosystem services from forests, such as timber production, protection against natural hazards, water provision and biodiversity (Jandl et al. 2019).

## 1.2.2 Adaptation

Adaptation is the process of adjusting to an expected or a particular climate and associated effects. In human systems, adaptation moderates harmful or exploits beneficial opportunities whilst in natural systems, human intervention may be needed to facilitate adjustment to the expected climate and its effects (Noble et al. 2014). Adaptation is reflected when natural and man-made systems (e.g., tourism, agriculture) survive the effects of climate change with the least damage possible or when the systems take advantage of the possible positive effects of climate change (IPCC 2001a). Climate change adaptation involves taking actions that help to reduce the negative impacts of climate change, while identifying and utilising the advantages of potentially new opportunities. It relies on the adjustment of policies and actions based on observed or expected changes in climate. Thus, adaptation can be reactive (based on response to climate impacts) or anticipatory (in terms of actions taken before climate change impacts are observed). In most situations, anticipatory adaptations entail lower long-term costs and are more effective than reactive adaptations.

> Adaptation entails actions that nations must take in response to climate change impacts currently affecting them, while simultaneously preparing for future impacts. Actions can include manipulating processes, habits and structures to reduce vulnerability to the impacts of climate change (e.g. reduce food insecurity) and maximising any positive prospects connected to the changing climate, such as extended growing seasons in some regions or increased crop yields (IPCC 2001a).

Adapting to adverse effect of climate change is one of the major areas of concern of the United Nations (UN) climate regime (UNFCCC.int 2020b). Climate change adaptation involves the maintenance or strengthening of resilience against existing disturbances and the capacity for long term planning (Cardona et al. 2012, Adger et al. 2013). In addition, socio-economic activities also contribute significantly to increasing or regulating individual and community capacities to adapt to the impacts of climate change (Engle 2011).

## 1.2. Extreme events

An extreme event occurs when weather, climate, or environmental conditions such as temperature, precipitation, drought, or flooding, rank above a threshold value which is near the upper or lower ends of the range of historical measurements in a particular place or at a particular time.

According to McCarthy et al. (2001), extreme climate event or extreme weather events are events that are rare at a particular place and time of the year. The characteristics of extreme weather may vary from one place to the other in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classified as extreme, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season) (IPCC 2014). However, a weather event classified as extreme in one area may be fairly typical at others. Besides the changing climate being demonstrated by the extreme weather events, climate variability also exposes different sectors to negative climate effects (UNFCCC 2010, Honda et al. 2012).

### 1.2.4 Climate variability

Climate variability refers to spatial and temporal variation of a climatic parameter of a region from its long-term mean. The variability may be internal (emanating from natural processes in the climate system) or external (because of human or natural influences out of climate system) (FAO 2008). Therefore, uncertainty assessments are done to identify the magnitude of the vulnerability of a system to climate change and its potential.

### 1.2.5 Vulnerability

Vulnerability is the extent to which a natural or social system is susceptible to sustaining damage from climate change. Vulnerability is a function of the sensitivity of a system to changes in climate (the degree to which a system will respond to a given change in climate, including beneficial and harmful effects), adaptive capacity (the degree to which adjustments in practices, processes, or structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate), and the degree of exposure of the system to climatic hazards (IPCC 2014).

Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, and the sensitivity and adaptive capacity of the system. The potential impact is, therefore, determined by exposure and sensitivity, while the overall vulnerability may be moderated by adaptive capacity. Assessment of the potential impacts of climate change involves evaluation of the magnitude of potential effects of climate change, strictly depending on exposure and sensitivity (Fellmann 2012).

Vulnerability can be defined as either physical or biophysical vulnerability (the degree of, and sensitivity to, damage resulting from climate-related incidents or disasters), or social vulnerability (the inability of individuals, organizations and societies to withstand adverse impacts of multiple stressors, due partially to characteristics inherent in social interactions, institutions) (Adger et al. 2013).Vulnerability is also defined by the IPCC (2007) as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.

## 1.2.6 Vulnerability to climate change

This is demonstrated by how systems respond to extreme weather events (e.g., heat waves, drought, floods) that rarely occur in a particular place and season. Vulnerability depends on the character, rate and magnitude of climate change extremes and variations that a system is exposed to, the sensitivity, and also the adaptive capacity of the system (Giordano 2014). The adaptive capacity of the system determines the extent of damage. The vulnerability of nations and societies is determined by their sensitivity and ability to cope or adapt to match the stress and prevailing environmental conditions. A community's vulnerability is, however, determined by the way social factors are linked to social class and other cultural issues, poverty, health status, political and institutional issues, environmental conditions and processes and food and nutritional security (IPCC 2007a, Lavell et al. 2012).

The potential climate change impact is determined by sensitivity and exposure which add to the overall vulnerability, as compromised by adaptive capacity (Figure 1). The assessment of the size of possible effects of climate change, can reveal the potential climate change impacts depending on sensitivity and exposure (Fellmann 2012).

Vulnerability = Potential Impact– Adaptive Capacity, and

Potential Impact = Exposure x Sensitivity

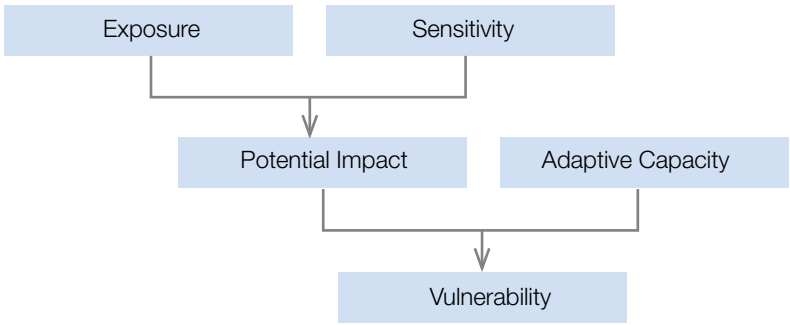


**Figure 1: Four components associated with climate change vulnerability (Fellmann 2012)**

Each of the components of climate change vulnerability is briefly explained below:

**Exposure**

Exposure to climate change exists when ecosystems or species, people, and other organisms and resources (economic, infrastructure, cultural or social) are in areas or places that might be affected by changing climate. Exposure indicators can consist of biophysical factors such as drought, heavy rains, high temperatures, and rising sea level. According to the IPCC (2007a), climate change impacts will remain as long as the probability of occurrence of the extreme weather events over time remains.

**Sensitivity**

Sensitivity shows the extent to which a species or system is positively or negatively and directly or indirectly affected by climate change or variability. Change in crop yields in response to changes or variability of temperature is an example of a direct effect whilst damage caused by an increase in the frequency of coastal flooding when sea level rises is an example of indirect effect. Positive effects may include increases in crop growth resulting from increased rainfall whilst negative effects are associated with death of plants or animals following a drought (IPCC 2007b). Sensitivity to climatic effects increases with dependence of processes and activities on climate e.g. fisheries, agriculture, forestry and certain coastal activities that support livelihoods. Consequently, a sensitive system can be affected by slight changes in the climatic factors. Therefore, sensitivity can reflect how the system responds to climate effects and the extent to which the changes in climate might affect the system in its present form (IPCC 2001a).

Indicators of sensitivity can include geographic circumstances, land management, demography, social and industrial/economic activities. For instance, the extent of industrial diversification and dependency on rain-fed agriculture are major drivers that could increase sensitivity to climate change (United Nations Task Team on Social Dimensions of Climate Change 2011, Ludena et al. 2015, Fronzek et al. 2019). In forestry, sensitivity can imply the degree to which forest growth, health, structure and composition are altered by a variation in climate. Different forest types vary in their sensitivity to climate impacts, e.g. some species are more tolerant to drought than others.

**Potential impacts**

Impact is the detrimental and/or beneficial consequences of climate variability and climate change on natural and/or human systems. Potential impacts are those impacts of climate change that could affect human (e.g. health, agriculture, tourism, etc.) and natural (e.g. biodiversity, water resources, forest resources, soil, etc.) systems. These are impacts that may occur under some particular projected climate change scenarios, without considering adaptation (McCarthy et al. 2001, Norwegian Red Cross 2019). They are represented by the extent of damage to natural and human systems being either direct or indirect, negative or positive, tangible or intangible, long or short-term (Usman et al. 2013).

**Adaptive capacity**

Adaptive capacity is the ability of a system to transform in order to match climate change, reduce potential damages, exploit opportunities, or manage the circumstances. It includes the ability of institutions, humans, and other organisms to adjust to potential damage, by taking advantage of opportunities, or responding to consequences (Millennium Ecosystem Assessment, 2005). The capacity to adapt and cope with climate change depends on a multitude of socio-economic factors that are generally complex in developing countries, especially in rural communities. These factors include level of education, wealth status, access to information, governance, institutions, technology and skills, access to resources, infrastructure, political influence and kinship networks (Smit and Wandel 2006). For example, Abdul-Razak and Kruse (2017) showed that economic resources, technological capacity and awareness/training were the most important and most relevant adaptation options for smallholder farmers in Ghana. Based on this understanding, adaption is not usually considered as standalone actions but as adaptation plans that accommodate sets of interlinked actions and involving different actors as in climate change National Adaptation Plans (NAPs).

Furthermore, Beever et al. (2015) and Nicotra et al. (2015) revealed that adaptive capacity of species and populations in an ecosystem is a combination of evolutionary potential, life-history traits, dispersal ability and phenotypic plasticity, that are influenced by behavioural, genetic, epigenetic and acclimation processes. Ecosystem services are one of the main values derived from forest ecosystems. Ecosystems services are the aspects of ecosystems that are utilised (actively or passively) to support human well-being (Fisher et al. 2009). The linkages between ecosystem services and vulnerability to climate change are shown in Figure 2.

The way in which climate change is experienced or described at community or individual level/sectoral or departmental levels affects the timing and manner of adaptation and the adaptation measures to be implemented as well as the adaptation capacity. It is possible to identify organisations that are able to manage ecosystems or lead communities in implementing adaptation projects that eventually decrease vulnerability to impacts of climate change. Giordano (2014) showed that adaptive capacity can be affected by the following factors:

- Availability of resources to finance adaptation.
- Access and skill to manage information.
- System's flexibility to adjust in response to some climate stimuli.
- Preparedness to adjust and adapt; and
- Capacity of ecosystems to expand into new zones or of species to migrate.

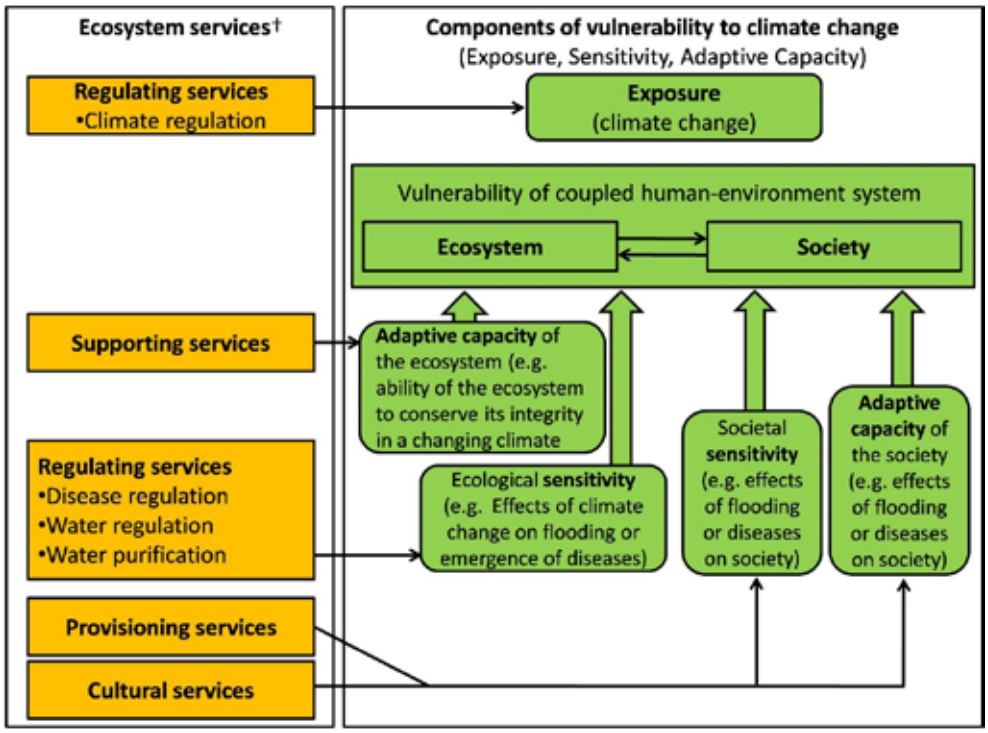


**Figure 2: Ecosystem services and their links to vulnerability to climate change (After Locatelli et al 2008)**

## 1.2.7 Measures for adapting to climate change

Adaptive actions in low-income countries are more of reactive/responsive than proactive, focusing on avoiding, coping, retreating, adjusting, accepting, spreading risks, or securing income or resources (Berrang-Ford et al. 2011). Several possible measures can be implemented to tackle climate change and Burton et al. (1993) identified eight categories of measures that can be used to adapt to climate change impacts. These are discussed below:

**Bearing losses**

Implemented when those affected are not able to respond (e.g. underprivileged communities) or when the cost of adaptation measures is higher than the anticipated damages or predicted risk.

**Sharing losses**

When losses from climate change impacts are shared among community members. For example, sharing of losses by way of rehabilitation, relief aid and reconstruction projects paid through public funds in complex

high-tech societies. In this regard, the taxation is a system used to ensure that all citizens contribute to climate-induced losses. Sharing losses can be done at local level or can extend to global level. Private insurance arrangements can also be made for vulnerable people through the purchase of insurance cover.

Emergency relief and other forms of assistance from foreign governments and international agencies are provided when losses exceed the response capacity of a national government. For instance, in March 2019, Southern African countries; Malawi, Mozambique and Zimbabwe, were hit by Cyclone Idai, which destroyed human life and infrastructure. Governments from Africa and beyond contributed to emergency relief and rehabilitation of infrastructure. Similarly, in the private sector, when insurance companies find that claims exceed their capacity, they turn to reinsurance companies that provide insurance for the insurance industry. This is common for several sharing arrangements that are used concurrently, with more elaborate insurance schemes operating at one level in the formal economy, and the more socially based or traditional forms of sharing operating in the informal economy.

**Modifying the threat.**
The threat posed by certain risks can be modified by using some level of control on the environmental event. For example, flood control infrastructural works such as dams, dikes, and levees can be used to modify the effect of natural episodes of events such as floods. The frequency of droughts can be reduced through cloud seeding to provide additional rainfall. Forests reduce climate change impacts through temperature amelioration, reduced soil erosion and water runoff, and increased groundwater recharge.

**Preventing the effects**
Effects of climate change or variability can be prevented by applying adaptation measures following pre-determined steps. Several techniques are used to reduce climate change impacts depending on the sector or regions being affected. Some of the techniques may be traditional or cultural practices that have been previously used extensively as responses to climate variability or extreme events. In cases like this, new measures can be developed following increases in technological choices. For forestry, measures can include manipulation of silvicultural practices such as using hydrogel, growing drought tolerant, disease and pest resistant species and controlling forest fires. In agriculture, measures could include planting traditional crop varieties that are resilient to climate change such as sorghum and cassava.

**Changing use**
This is when a viable activity can be changed when it becomes extremely risky or impossible due to climate change threat. For example, switching to more drought-resistant crops or to crops with lesser water requirements and also planting tree species that grow well in the new and expected climate conditions, or those more resistant to forest fires. In other cases, radical changes can be made in the development of vulnerable and exposed sites such as coastal developments which are at risk of flooding due to sea level rise. Similarly, a forested land which is being converted to open space or public recreation use would have adequate green space integrated into it. As climate change continues, opportunities to reduce the impacts by changing uses would emerge.

**Changing location**
This is a rather risky response to climate change impacts because it goes beyond changing use by also changing the site of economic activities. Relocation is suggested as a key response for plant and animal species after some speculation. For example, speculations about shrinking and expansion of farming regions due to changes in temperature and rainfall patterns. Relocation can also be a result of rising sea-levels, where a number of “climate change” refuges are created. Therefore, the creation of special “migration corridors” has been suggested for unplanned migrations.

**Research**
Research into new technologies and new adaptation methods can improve the process of adaptation. Furthermore, validation and production of evidence-based results can contribute to further sensitize decision makers towards promoting conducive policies.

**Educate, inform, and encourage behavioural change.**
Dissemination of knowledge through education and public information campaigns can lead to behavioural transformation. This is likely to increase value on the importance of these interventions, as the need to involve more communities, sectors, and regions in adaptation becomes apparent.

## 1.2.8 Uncertainty

This is a condition where there is limited knowledge and it becomes difficult to specifically describe the existing situation or prospective outcomes. Uncertainty is used to predict future events, validate existing data, or determine the unknown. When modelling future climate in terms of temperature and precipitation, issues such as insufficient knowledge about the climate system, errors of measurement, and/or the bias of analyst opinion become challenges associated with uncertainty. It is important to note that too much information or information that is contradictory can also increase uncertainty. Three types of uncertainties are usually considered (Kunreuther et al. 2014, Tröltzsch et al. 2016).

***Epistemic uncertainty***
This is when there is no information or knowledge to describe occurrences;

***Normative uncertainty***
This refers to a lack of earlier arrangement to frame problems and outline methods of their scientific investigation.

***Translational uncertainty***
This is inadequate or contradictory scientific findings.

The IPCC (2007) however, classifies uncertainties into 'value uncertainties' and 'structural uncertainties'. Value uncertainties arise from the incomplete determination of particular values or results and are generally estimated using statistical techniques and expressed probabilistically. Structural uncertainties arise from an incomplete understanding of the processes that control particular values or results, generally described by collective judgment of authors' confidence in the correctness of a result. In both cases, estimating uncertainties is intrinsically about describing the limits to knowledge and for this reason involves expert judgment about the state of that knowledge. Systems that are either chaotic or not fully deterministic in nature have a different type of uncertainty arising from limited abilities to project all aspects of climate change.

## 1.2.9 Hazards and risks

A hazard is a potential occurrence of a natural (physical event or phenomenon) or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and cause loss of property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (United Nations 2004). In this compendium, the term hazard usually refers to climate-related physical events or trends and their associated physical impacts. A climate hazard is any physical process or event (phenomena, hydro-meteorological or oceanographic variables) that can harm human health, livelihoods, or natural resources whilst a geophysical hazard refers to land based natural processes and events with the potential to cause harm to human health, livelihoods, systems and natural resources (IPCC 2014).

A risk refers to the potential for consequences where something of human value (including humans themselves) is at stake and where the outcome is uncertain (IPCC 2014). Climate related risks are created by a range of hazards. Some hazards such as changes in temperature and precipitation leading to droughts, or agricultural losses are slow in their onset whilst others such as tropical storms and floods are more sudden and sporadic events (UNFCCC 2020d). Emergent risk is a risk arising from the interaction of phenomena in a complex system, for example, geographic shifts in human population in response to

climate change could lead to increased vulnerability and exposure of populations in the receiving region (IPCC 2014).

## 1.2.10 Resilience

There are several definitions of resilience. The UNISDR (2009), defined resilience as the capacity of a system, society or community to anticipate, prepare, and respond to hazardous events, trends, or disturbances related to climate, by resisting, absorbing, accommodating, recovering or changing in order to reach and maintain an acceptable level of structure and function in a timely and efficient manner. The resistance or change is determined by the extent to which the social system is able to organise itself to increase its capacity to learn from past disasters and apply lessons learnt for better protection and improve risk reduction measures in the future. In addition, resilience demonstrates the capacity of economic, social and environmental systems to cope with hazardous events or trends or disturbances. It ensures the timely responses or reorganisations that maintain essential functions, structure and identity, while maintaining the capacity for adaptation through learning for transformational change in tackling future climate change related impacts (IPCC 2014).

## 1.2.11 Coping and Adaptation

Coping refers to an interim response to climate variability, while adaptation is essentially a system that allows a new coping range to be accepted (Mertz et al. 2009). For example, acclimatization is a form of adaptation which occurs suddenly through self-directed determinations (FAO 2008). There are several possible adaptation measures. In the case of human systems, the process involves engagement and extensive consultation of multiple stakeholders at different levels and in multiple sectors and the analysis of current threats to climate stresses and shocks, and modelling them to predict future climate impacts (CARE International 2009).

The process should understand the prevailing vulnerabilities of individuals, households, and communities. Some of the adaptive measures can be preventative, whilst others respond to changes that have already occurred. Some adaptive actions can be initiated by the state, while others are by private groups or individuals affected. Some activities occur autonomously, while others are planned. Examples of adaptive measures include the planting of drought tolerant trees and crops, crop diversification, rainwater harvesting (Kihila 2018), developing communication systems for improving risk management, and establishing early warning systems (UNFCCC 2010). Consequently, to adapt means a system is able to maintain or strengthen resilience against existing disturbances (Adger et al. 2013). However, it is critical that adaptation plans assess all actions being considered against their potential for maladaptation. Among the considerations of adaptation measures, are the environmental safeguard measures that are necessary for a number of adaptive measures.

## 1.2.12 Maladaptation

Maladaptation occurs when activities being implemented jeopardise the capacity or opportunities for present and future adaptation by increasing vulnerability to climate variability and change, either indirectly or directly. In both developing and developed countries, there are many initiatives that were labelled as “climate change adaptation” but they could not adjust effectively or correctly to the environment or situation, creating a state of maladaptation (Magnan 2014).

Burton and May (2004) defined another term often confused with maladaptation, referred to as adaptation deficit, which implies a gap identified between current and optimal levels of adaptation to climate change. Adaptation deficits can occur in the form of e.g. neglected development and natural resource management efforts in marginal areas, lack of market access for agricultural products, and limited knowledge on climate change and access to credit.

## 1.2.13 Categorisation of adaptation measures.

Climate change adaptation can be considered based on the systems and the processes, climate stimuli, or climate change measures. Analysis of adaptation funded projects through the Global Environment Facility (GEF) has shown that they have supported several kinds of activities. In this regard, Biagini et al. (2014) identified ten types of adaptation categories (Figure 3)

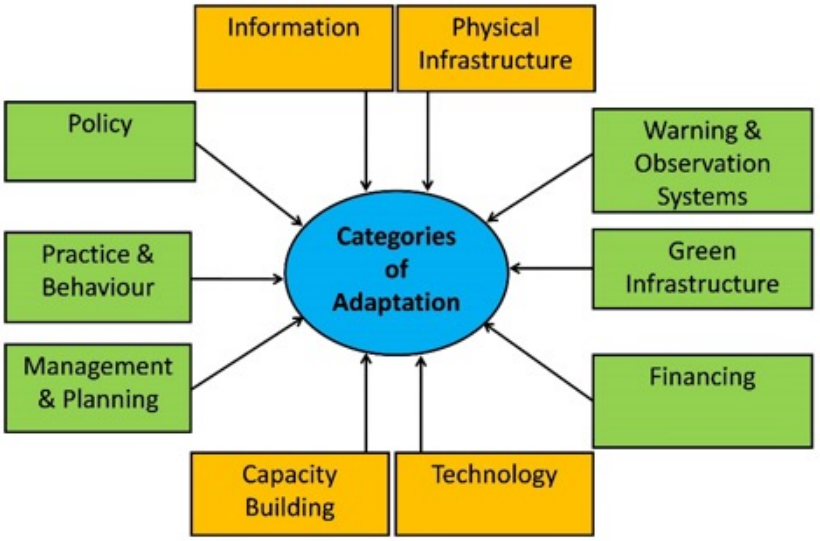


**Figure 3: Categories of climate change adaptation activities (Adapted from Biagini et al. 2014)**

**Activity 1.2 (10 minutes**

1) Define climate and climate change adaptation.
2) Explain any three terms related to climate change adaptation.
3) What are some of the measures that can be used to adapt to climate change?
4) Explain some of the types of adaptation that have been funded by GEF,

**Summary**

In this section we learnt about the concepts of climate change that are linked to adaptation. The terms include climate change, adaptation, extreme events, climate variability, vulnerability (potential impacts, sensitivity, exposure and adaptive capacity), uncertainty, hazards and risks, resilience, coping and maladaptation. We also learnt that there are several measures that can be used to adapt to climate change impacts and these include: bearing losses, modifying threats, preventing the effects, changing use, changing location and research. Climate change adaptation can be considered based on the systems and the processes, climate stimuli, or on climate change adaptation measures.

# 1.3 An overview of impacts of climate change and climate variability

In the previous section we defined and explained some of the important terms in climate change adaptation. You notice that climate change affects both physical and biological systems across the world through changes in temperature and moisture regimes. All sectors of development, including forestry, agriculture (both crop and animal), fisheries and marine resources, tourism, and infrastructure development are affected by the impacts of climate change. The agricultural sector forms the backbone of the economies of most African countries; the impacts of climate change are expected to be more severe here than elsewhere because of the heavy dependence on rain-fed agriculture (Cline 2007). Porter et al. (2014), indicated that climate change contributed to 1-5% global reduction in agricultural production over a 30-year period. In this section we learn about how climate change affects people and ecosystems.

**Learning outcomes**

By the end of this session, the learner should be able to:

i. Identify the impacts of climate change on people and ecosystems.
ii. Explain the impacts of climate change on different development sectors.
iii. Explain the importance of forests and tree resources in climate change adaptation.

**Activity 1.2 (10 minutes**

What are the impacts of climate change in your country?

The African continent is expected to suffer from climate effects such as floods, rising sea level, drought and other extreme events. These will affect food security and increase vulnerability of people and ecosystems to climate change. Possible regional climate change impacts and factors constraining adaptive capacity to determine vulnerability in Africa are outlined in Table 1.

**Table 1: Africa's vulnerability to climate change and adaptive capacity**

| Possible regional climate change impacts | Vulnerability and adaptive capacity |
|---|---|
| Increased flood events, droughts, and other extreme events add stress to food security, water resources, infrastructure and human health thus limiting development. | Low GDP per capita compounded by widespread poverty, unfair land distribution and illiteracy reduce adaptive capacity. There are no social safety nets particularly after crop failure |
| Areas in Western Sahel and Northern and Southern Africa will be affected by changes in rainfall patterns and land use intensification could worsen desertification process. | Specific desertification coping mechanisms already strained thus further worsening poverty. There is greater dependence on rain-fed agriculture. |
| Rising sea level can affect coastal settlements, flooding and coastal erosion, especially along the Eastern Southern African coast | More than ¼ of the population live within 100 km of the coastline and most of the largest cities are built along coasts that are vulnerable to rising sea level, extreme events and coastal erosion. |

| Possible regional climate change impacts | Vulnerability and adaptive capacity |
|---|---|
| Weakened food security particularly in small food importing nations as a result of reduced grain yields.. | Climate change must be acknowledged as a major threat to food security, natural resources productivity, water resources, biodiversity conservation, desertification, human health, and coastal zones. |
| Major rivers are very susceptible to variations in climate and can have decreased runoff and water availability, affecting agriculture and hydro power systems, likely to increase cross border tensions. | Adaptive capacity will depend on magnitude of public order, political integrity and good economic management. |

Climate change affects the provision of ecosystem services through its impacts on water quality and availability, pollination, pests and disease incidences (Noble et al. 2014), fresh water systems and associated livelihoods (Ormerod et al. 2010, Ndhlovu et al. 2017), agricultural productivity (Myers et al. 2017) and downstream businesses and enterprises (Preston and Stafford-Smith 2009). Detailed descriptions of the climate impacts and adaptation on forests and other sectors are discussed in chapters 2 and 3 respectively. Box 1 highlights some of the impacts of climate change in different sectors of development.Box 1: Examples of climate impacts in Africa

**Box 1: Examples of climate impacts in Africa**

In Uganda, a temperature increase of 2oC is expected to reduce the total area available for growing robusta coffee, restricting it to higher altitude areas. In the Gambia, diarrhoea in young children has been linked with summer rains whilst meningitis has been associated with dust in semi-arid conditions, particularly among people with poor, overcrowded living conditions in West Africa (DFID 2004). In Nigeria, rainfall variation and duration has continued to increase in the southern region and rising sea levels have combined to exacerbate flooding and submersion of coastal lands, while increased frequency of drought periods have continued to disrupt lives in the northern regions. In southern Africa cyclone Idai of 2019 caused widespread destruction resulting in floods (Figure 4)

A B

**Figure 4: Impacts of Cyclone Idai in some southern African countries a.. Mozambique b. Zimbabwe**

Throughout the world, the development of hydropower in the energy sector has been affected by changing weather patterns causing a need for consideration of climate change in medium- and long-term plans in energy sector. For example, Ghana's economic growth shrank by 2% after drought conditions limited hydropower production (OECD, 2010).

Further reading: http://www.ipcc.ch/ipccreports/assessments-reports.htm

**Activity 1.4 (5 minutes)**

- Discuss impacts of climate change on human and natural systems.

**Summary**

In this section we learnt about the effects of climate change on human and natural systems. Climate change has social, economic and environmental impacts in all regions of Africa, affecting food security. There is need for adaptive action to cope with the harsh effects of climate change together. Mitigation is also important. In the next section we discuss strategies adopted by international, regional and national communities to facilitate climate change adaptation.

# 1.4 Adaptation at global, regional and national levels

In the previous section we discussed the impacts of climate change and climate variability on people and ecosystems and the need for adaptation. This section will discuss the adaptive measures at global, regional and national scales. Adaptation measures are discussed at global, regional, and national levels. There are three main international legal instruments used for implementing climate change action under the UN Convention, namely, UNFCCC (1994), the Kyoto Protocol (KP) (1997) and the Paris Agreement (PA) (2015), their bodies, institutional arrangements and organs, including the secretariat (UNCCC 2019a).

**Learning outcomes**

By the end of this session, the learner should be able to:

i. Discuss adaptation at global, regional and national levels.
ii. Assess funding mechanisms for climate change adaptation.
iii. Explain the role of NAPs, NAPAs and NDCs in climate change adaptation.
iv. Explain climate change adaptation communication

**Activity 1.5 Brainstorming (10 minutes)**

- Explain some of the international climate change adaptation initiatives in your country.

Adaptation is a key component of the long-term global response to climate change for protecting people, their livelihoods and ecosystems. In recognition of this, Parties to the UNFCCC acknowledge that the actions for adaptation should be country-driven, participatory, gender-responsive and completely transparent. These actions should consider vulnerable groups, communities and ecosystems, and should be based on and guided by the best available science and, as appropriate, traditional knowledge, knowledge of indigenous peoples and local knowledge systems, with a view to integrating adaptation into relevant socio-economic and environmental policies and actions (UNFCCC.int 2020c). The actions to accelerate and increase climate actions and ambitions given under the Paris Agreement were emphasised at the Climate Summit in 2019. Given the global impacts of climate change, IPCC (2018) stated that the impacts of reducing global warming to 1.5°C would require quick, comprehensive and exceptional changes in all sectors of the society. In this regard, global climate actions are taken with an understanding that human activities are the main cause of climate change. The UNFCCC has established processes and funding mechanisms for climate action at national and global levels. At national level, the mechanisms linked to climate change adaptation include National Adaptation Programmes of Action (NAPAs), National Adaptation Plans (NAPs), Intended Nationally Determined Contributions (INDCs) and Nationally Determined Contributions (NDCs). Furthermore, disaster and risk reduction are important tools for adaptation. The UNFCCC adaptation cycle has four elements as outlined in Box 2.

**Box 2: Adaptation cycle under the UN climate change regime (UNFCCC.int 2020a)**

**Assess climate change impacts, vulnerability and risks.**

Initial assessment of the magnitude to which climate change is affecting or will affect normal systems.

**Plan for adaptation.**

Identify adaptation actions and their assessment, including assessment of benefits and costs, in order to make appropriate choices among options that are available.

**Implement adaptation measures.**

Implementation at local, national, and regional levels using various methods, such as policies, programmes, projects or strategies. Implementation may be a stand-alone process or can be incorporated or mainstreamed into sectoral policies and development strategies.

**Monitoring and evaluation of adaptation.**

Monitoring and evaluation can be done throughout the adaptation process, and the facts and information generated can be used as feedback into the process to ensure adaptive learning and ensure success of future adaptation efforts. Monitoring helps to provide records of progress made in project execution, whilst evaluation determines the effectiveness of adaptation efforts.

The climate actions should be enabled by appropriate capacity building, adequate financial support and appropriate technology. Interested countries submit proposals for funding to the UNFCCC. About 105 concrete projects and programmes were approved for a total financing of US$ 730 million in sectors such as agriculture, coastal zone management, disaster risk reduction, ecosystem-based adaptation, food security, forests, multisector projects, rural development, urban development and water management. Projects funded include; reforestation, sustainable forest management, forest protection, avoided fuel harvest, conservation agriculture, improved plantation, cropland management, avoided grassland conversion, agroforestry, rangeland management, rehabilitation/restoration of coastal wetlands, improved livestock management practices, aquifer recharge and sustainable groundwater management. Djibouti, Rwanda, Mauritius, Morroco, Seychelles are among the beneficiaries of adaptation fund (UNEP 2012, UNFCCC 2020a, b). Funding mechanisms for climate action under the UNFCCC are managed/funded by Global Environment Facility (GEF), the Least Developed Countries Fund (LDCF), the Special Climate Change Fund (SCCF) and the Strategic Priority for Adaptation (SPA) programmes. The GEF became the financial instrument since the Convention's entry into force in 1994. The Parties also established the Green Climate Fund (GCF) at COP 16, (2010) and in 2011 it was designated as an operating entity of the financial mechanism. The financial mechanisms are answerable to the COP, which decides on its policies, programme priorities and funding eligibility criteria. In addition to providing guidance to GEF and the GCF, Parties manage two special funds; the SCCF and the LDCF, both managed by the GEF and the Adaptation Fund (AF) established under the Kyoto Protocol in 2001 (LDC Expert Group 2018). Green Climate fund also supports the development of NAPs and other planning processes (Schalatek et al. 2017, LDC Expert Group 2018). The extent of climate action can be accessed on the Global Climate Action portal.

The funded actions support accomplishment of the Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs). The Least Developed Countries (LDC) Work Programme of the UNFCCC, requires LDCs to develop NAPAs for implementation through the support of the LDCF under GEF. The UNDP is one of the implementing agencies of the LDCF that has supported the design and implementation of priority NAPA interventions worth over US$88 million in 24 LDCs (UNDP 2011). By 2018, 343 adaptation projects, had over US$ 1.6 billion grant financing provided through the LDCF, SCCF and SPA programme (UNFCCC 2018) with adaptation financing accounting for about 25 % of overall climate finance flows (UNFCCC 2019b). About 28 African countries accessed funding for formulating NAPs as of October 2018 (LDC Expert Group 2018).

**Activity 1.6 Group discussion (15 Minutes)**

- How are the international initiatives for climate change adaptation supported in your country?

The discussion below highlights specific adaptation aspects in NDCs, NAPAs, NAPs, early warning systems and disaster management.

## 1.4.1 Nationally Determined Contributions (NDCs)

Decisions 1/CP.19 and 1/CP.20 of the COP, expected all Parties to communicate their INDCs before COP 21 clearly displaying transparency, understanding and clarity of their INDCs. The INDCs set out the steps that governments proposed to undertake to tackle climate change. They were expected to publicly outline each country's post-2020 climate actions following a new international agreement. When countries adhere to the INDCs, global success of the ambitious 2015 agreement for a low-carbon, climate-resilient future is guaranteed (UNFCCC 2016).

The INDC is scaled into NDC after formally joining the Paris Agreement (PA) by submitting an instrument of ratification, acceptance, approval or accession. The PA of 2015 (Article 4, paragraph 2) requires every Party to formulate, communicate and sustain consecutive NDCs for reducing national emissions and adapting to climate change impacts. Parties should monitor domestic mitigation and adaptation actions, aiming to achieve objectives of their contributions. Submission of NDCs to the UNFCCC secretariat is every five years. Sequential NDCs should signify a progress linked to the preceding NDCs and reflecting maximum potential ambitions. The next new or updated NDCs were required by 2020 and every five years thereafter for all Parties, irrespective of their particular implementation stages. Governments are required to assess the implementation towards achievement of the purpose of the Paris Agreement and its long-term objectives (UNFCCC 2015a).

The PA adopted at COP21 of UNFCCC encouraged Parties to program, including implementation of REDD+ and joint mitigation/adaptation activities, taking into consideration the non-carbon benefits. Forests are important for both mitigation and adaptation options, as reflected by their inclusion in INDCs. About 190 Parties had communicated their INDCs by April 2018, of which 48 were African nations. The adaptation components given in the NDCs showed some methodological uncertainties associated with the evaluation. However, a package was designed to give guidance on NDCs and this describes the climate goals and activities for each country (UNFCCC 2018).

The NDCs identified several vulnerable sectors, including agriculture, energy, water resources, health, forestry, biodiversity, energy, human settlements, tourism and infrastructure. A few parties (only three) acknowledged wildlife as one of the vulnerable sectors. NDCs also identified major climate hazards particularly those with the greatest impact such as floods, saltwater intrusion, erosion of coastal areas, acidification of oceans, desertification/land degradation, increased intensity of precipitation vector-/water-borne diseases, changes in precipitation patterns, decreases in precipitation, storms, rising sea level, increasing temperatures and drought (United Nations Climate Change Secretariat 2019).

**Further reading:**

https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Mozambique%20First/MOZ_INDC_Final_Version.pdf

## 1.4.2 National Adaptation Programmes of Action (NAPAs)

Least developed countries (LDCs) are more vulnerable to climate impacts and therefore, are assisted

through their NAPAs as submitted to the UNFCCC. NAPAs were initiated by UNFCCC in 2001 to assist LDCs identifying their most critical and priority actions in the absence of which vulnerability and/or costs associated with climate change impacts are increased. Parties in LDCs prepared the documents (NAPAs) outlining urgent or priority activities and responses to their specific needs for coping with climate change. Developing countries have made substantial progress in preparing their national communication systems and developing NAPAs, following UNFCCC reporting guidelines. The NAPAs are usually presented to the global donors for funding through GEF or GCF (UNFCCC 2019b).

Important information and procedures for climate change mainstreaming in development planning are provided in the NAPAs, recognising the importance of community-level involvement as a key information source and that communities are the key stakeholders. Existing information is used by considering existing grassroots coping strategies, and building on the information to identify important strategies instead of focusing on scenario-based models for evaluating long term vulnerability and national policies. The focus of NAPAs is generally not to mainstream climate change adaptation into development planning but can help to incline and often suggest mainstreaming as a significant intervention (UNDP –UNEP 2011).

Funding for NAPAs is given to countries so that they produce country-driven strategies that are flexible, action oriented and nationally appropriate. Adaptation projects in Africa vary depending on existing adaptation needs. Financial constraints, and inadequate human and institutional capacities however, limit implementation of most NAPAs. Nevertheless, 33 African countries, who submitted NAPAs to the UNFCCC, have taken steps to fulfil such commitments. African countries such as the Gambia, Ghana, Ivory Coast, Sierra Leone and Senegal prioritized forestry in their NAPAs (Kojwang and Larwanou 2017) while others included afforestation and sustainable forest management in their NAPAs and NAMAs (Box 3).

**Box 3: Forests for climate change adaptation in African NAPAs**

In Africa, the inclusion of forestry in adaptation is not well defined and mainstreamed into policy. However, some NAPAs proposed adaptation actions that are related to forestry because they focus on conservation, reforestation and restoration as viable tools that could help achieve sustainability of local livelihoods and preservation or restoration of ecosystem services. The forestry strategies in NAPAs aim to achieve sustainable forest management (SFM) instead of climate change adaptation, and these include:

- Afforestation/reforestation, and forest restoration using species suitable for future climate and fast-growing tree species resistant to possible disturbances, such as insect pests, diseases, and fire (e.g., Burundi, Eritrea, Samoa and Tanzania);
- Prioritizing the transfer of forest management to local level in Madagascar;
- Community-Based Forest Management (CBFM), afforestation and agroforestry (e.g. Uganda, Gambia, and Sudan, Ethiopia, Tanzania and Zambia).
- SFM and protected areas to promote forest conservation (e.g., Djibouti, Democratic Republic of Congo, Guinea, Guinea-Bissau, Mali, Senegal and Tanzania).
- Rwanda NAPA project recognizes the need of forests to maintain hydrological regimes, explaining why activities are centred on conservation and protection of lands against erosion and floods; and
- In Mozambique, the NAPA includes coastal protection and mangrove restoration (CIRAD.org, Thompson et al. 2009).

The NAPAs are prepared and presented in a simple format, easily understood by stakeholders at all levels in order to facilitate effective achievement of urgent and immediate adaptation actions. African countries, like other Parties to the UNFCCC, are expected to provide national communications on climate change impacts and vulnerabilities, principles and process for preparation and the structure of NAPAs. The NAPAs are used to formulate and achieve their NAPs.

**Further reading**

1. Kojwang HO and Larwanou M. 2017. An overview of nationally appropriate mitigation actions (NAMAs) and national adaptation programmes of action (NAPAs) in Africa. The International Forestry Review. 17(3):103-113. https://www.jstor.org/stable/pdf/26431611.pdf
2. UNDP-UNEP. 2015. Gambia National Adaptation Plan Process Stocktaking report and a road map for advancing Gambia's NAP process Draft final report.
3. Adaptation Fund. Accessing resources from the Adaptation Fund. The Handbook.. Available at: https://www.preventionweb.net/files/13786_Handbook.English1.pdf

## 1.4.3 National Adaptation Plans (NAPs)

NAPs have emerged as an important mechanism for bringing together several adaptation efforts into logical and coordinated national development. The procedures for formulating and implementing NAPs aim at reducing vulnerability, mainstreaming adaptation and providing an opportunity to enhance synergies between adaptation and development. Given their success as planning instruments, the resources available for their implementation, their iterative nature and flexibility, NAPs are excellent options used to support the implementation of enhanced adaptation action (LDC Expert Group 2012, UNFCCC 2018). The UNFCCC guidelines show the NAP process with four elements and 17 steps (Figure 4). Box 4 gives examples of adaptation projects in West Africa.

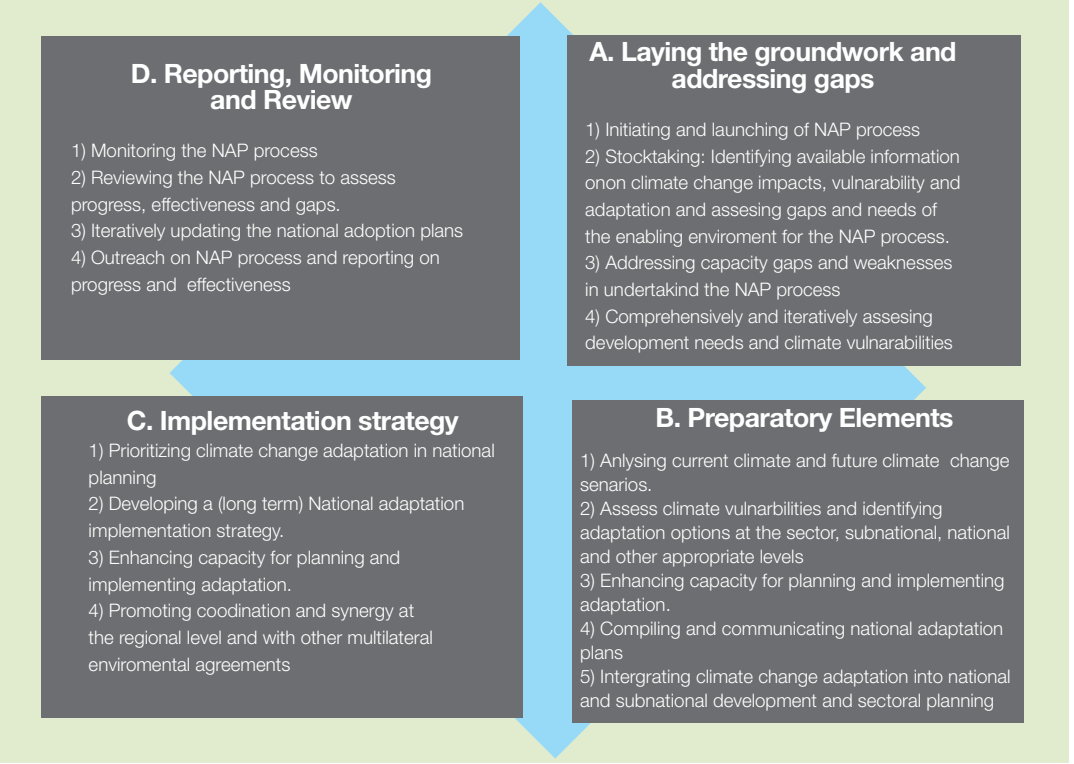


**Figure 5: Elements and steps in technical guidelines for NAP process under UNFCCC (UNFCCC 2018)**

**Box 4: Examples of adaptation projects from West Africa:**

The government of Burkina Faso's NAP includes large-scale reforestation programs using fast growing, drought tolerant tree species to reduce the impacts of desertification. The Netherlands Government's Eco-Regional Grants Programme under the International Union of Conservation of Nature National Committee of the Netherlands (IUCN NL) supports the Cambridge Programme for Sustainability Leadership (CPSL) in West Africa, focusing on climate change adaptation and resilience, as well as opportunities for development and economic growth. The programme worked with 15 members of the Economic Community of West African States (ECOWAS) undertaking research in partnerships with Green Actors of West Africa (GAWA) in countries such as Benin, Côte d'Ivoire, Gambia, Guinea, Guinea-Bissau, Mali, Niger, Sierra Leone and Togo. The Ministry of Environment, Water Resources and Forests in Côte d'Ivoire adopted a policy to establish a supervisory forestry organisation and a national forest fund, develop a programme that strengthens capability forestry, revision of the forest code, establishment of a national centre for seeds and forest plants and development of a framework controlling deforestation. The Togo government implemented strategies to generate and disseminate agro-meteorological information, promote peri-urban market gardening and livestock farming and environmental impact assessments.: (Robinson and Brooks 2010).

The NAP process should follow a country-driven, participatory, gender-sensitive, and fully transparent approach, considering vulnerable groups, communities and ecosystems. It should not be prescriptive, nor result in the repetition of efforts implemented in-country, but facilitate country-owned, country-driven actions. The objectives of the NAP process are to:

- Develop adaptation capacities and increase resilience in order to reduce vulnerability to climate change.
- Facilitate the coherent integration of climate change adaptation into appropriate new and existing policies, programmes and activities, in particular, development planning processes and strategies, within all sectors and at different levels (UNFCCC 2018).

There are several challenges faced by developing countries' when developing and implementing NAPs. These include: capacity-building, finance and technology development and transfer. In particular, the establishment of institutional framework of climate change adaptation remains a key challenge for most developed and developing nations. Nevertheless, the process of formulating and implementing NAPs can successfully support the enhanced adaptation action, development of integrated approaches to adaptation, sustainable development and disaster risk reduction. NAPs have the potential to become key instruments for facilitating the integration of adaptation into sustainable development (UNDP-UNEP 2011).

**Further reading**

www.undp.org/climatechange/adapt/apf.html
http://www.undp.org/climatestrategies/docs/lecrds/toolkit.pdf

**Activity 1.7 Group discussion (10 Minutes)**

- What are some of the challenges faced by developing countries in implementing some of the international agreements?

## 1.4.4 Provisions for Adapting to climate change under UNFCCC and National Communication

### 1.4.4.1 Provisions for adapting to climate change

National communication regarding climate change impacts and vulnerabilities is sent to UNFCCC by developing nations and adaptation is one of the key areas of action for Parties. Despite its importance, adaptation received less attention than mitigation up to the Third IPCC assessment report that acknowledged adaptation as a means of reducing vulnerability to climate change (IPCC 2001b).

In order to deal with climate change, Article 4 (UNFCCC 2015b) gives a complementary approach between adaptation and mitigation, where Parties are expected to:

- commit to the "formulation, implementation, publishing and regular updating of national and, where appropriate, regional programmes containing measures to facilitate adequate adaptation to climate change" based on the principle of common but differentiated responsibilities and certain national and regional development objectives, priorities and conditions;
- cooperate in preparation for adaptation to climate change impacts;
- build and advance suitable, integrated plans for agriculture, forests, water resources and coastal zone management, and to protect and rehabilitate areas impacted by drought, desertification, and floods, mostly in Africa;
- consider extent of feasibility and relevance to social, economic and environmental policies and actions to climate change; and
- developed country Parties are required to help developing country Parties that are most vulnerable to the destructive impacts of climate change by funding some of the adaptation costs; activities under adaptation including:
    i. collection, compilation, synthesis and dissemination of facts and figures on impacts, vulnerability and adaptation, as well as information on methods, technologies and strategies stated in national communications and NAPAs;
    ii. liaison/cooperation with international and other UN agents;
    iii. facilitation and support for capacity-building and other supporting activities;
    iv. development of tools for disseminating information and increasing community awareness through platforms such as information systems, clearing houses and workshops; and
    v. facilitation of information exchange and communication of experiences and opinions among Parties on practical ways of implementing the plans.

Furthermore, the Paris Agreement established adaptation communication process where each Party should submit periodic updates, which may include information on its priorities, implementation and support needs, plans and actions (UNFCCC.int 2020c).

### 1.4.4.2 Communication under UNFCCC

National Communications (NCs) are the reports submitted by Parties to the UNFCCC presenting their actions for implementing the Convention. Constantly reviewed and amended guidelines for reporting are provided by the COP. National Communications by developing countries must include information on actions for mitigating GHG emissions, GHG inventories, and attempts made to facilitate acceptable adaptation to climate change. Within three years after entering the Convention, developing country Parties are expected to submit their first NC followed by one every four years thereafter (UNFCCC.int 2020c).

Communication can be done through Biennial Reports (BRs) or Biennial Update Report (BURs). The BRs show progress made by Annex I Parties in achieving their emission reduction targets and support given to non- Annex I Parties in terms of technological, financial or capacity-building support. Developing country Parties submit BURs to give updates on the information supplied in their NCs, especially, mitigation actions, national GHG inventories, challenges and gaps, plus the additional support that is required and has been received. The initial BURs were submitted in December 2014 and are expected every two years thereafter. LDCs and Small Island Developing States (SIDS) submit their BURs when convenient (UNFCCC.int 2020c).

**Activity 1.8 Revision (15 minutes)**

1. W Discuss adaptation at global, regional and national levels.
2. hat are the roles of NDCs and NAPs in climate change adaptation?
3. What negative consequences result when adaptation planning and financing do not take into
4. account gender differences and women's specific needs and capacities?
5. List some funding mechanisms for climate change adaptation.

**Summary**

We have learnt that the African continent is expected to suffer from climate effects such as floods, rising sea level, drought and other extreme events. Funding of NDCs, and NAPs can be through the Green Climate Fund (GCF), Global Environment Facility (GEF), the Least Developed Countries Fund (LDCF), the Special Climate Change Fund (SCCF) and the Strategic Priority for Adaptation (SPA) programmes. At national level, the mechanisms linked to climate change adaptation include National Adaptation Programmes of Action (NAPAs), National Adaptation Plans (NAPs), Intended Nationally Determined Contributions (INDCs) and Nationally Determined Contributions (NDCs). Furthermore, disaster and risk reduction are important tools for adaptation. LDCs are expected to prepare NDCs, NAPAs and NAPs to bring together various adaptation efforts into coherent and sustainable national strategies following guidelines of UNFCCC. The NDCs identify vulnerable sectors and major climate hazards. NAPAs identify the most critical and priority actions in the absence of which vulnerability and/ or costs associated with climate change impacts escalate. The NAPAs are used to formulate and achieve NAPs. NDCs and NAPs are important mechanism for bringing together several adaptation efforts into logical and coordinated national development. The NAP process should follow a country-driven, participatory, gender-sensitive, and fully transparent approach, considering vulnerable groups, communities and ecosystems. Parties are also required to provide national communications on climate change impacts and vulnerabilities at periodic intervals following UNFCCC reporting guidelines.

# 1.5 Early Warning Systems

Early Warning Systems (EWS) are among climate change adaptation instruments integrating communication systems in order to assist community preparation for risky climate-linked events.

**Learning outcomes**

By the end of this session, the learner should be able to:

i. Describe requirements for an effective early warning system.
ii. Identify challenges of early warning systems in Africa.
iii. dentify traditional knowledge systems related to early warning systems

**Activity 1. 9 Brainstorming (10 minutes)**

- What are the early warning systems that you are familiar with and how have they helped adaptation to climate change?

EWS improve the vigilance for climate-related hazards among both individuals and decision-makers and also strengthens the capacity to optimise use of positive weather conditions. EWS for natural risks require a comprehensive, scientific and technical foundation, with a strong emphasis on communities exposed to these threats, using a systems approach to incorporate all relevant issues associated with risk, either emanating from the natural hazards or social susceptibilities, or from long or short-term processes (Luther et al. 2017). However, proper communication and reliable institutions are fundamental pre-requisites for effective early warning systems. There is also the need to consider and accommodate indigenous knowledge related to Early Warning.

The elements of EWS follow a logical sequence having direct mutual linkages and interactions with each other. There are four interacting elements necessary for effective and complete EWS (UNISDR 2016):

1. information about risk;
2. provision for monitoring and warning services;
3. communication and dissemination protocols; and
4. capacity to respond.

Early Warning Systems can address climate impacts on human health, for instance, those related to drought and heat waves. Heat waves emanating from climate warming cause death and injury, risking human health. Given these consequences, timely notification to vulnerable people using EWS can be an adaptive option for reducing human health disasters. A wide range of systems have been used ranging from traditional passive announcements (e.g. media releases), to active communication with vulnerable individuals. For example, mobile phone message alerts sent to the target groups have been used in a few cases. Promoting the development and operationalization of people-centred, multi-hazard EWS has been prioritised at the global level (UNISDR 2015). The correct use of an early warning system results in significant reduction of damages resulting from extreme climate change events. Examples of EWS applied globally are shown in Box 5.

**Box 5: Examples of EWS that have been used globally**

- The United Nations Development Programme on "Strengthening Climate Information and Early Warning Systems (SCIEWS) for climate resilient development and adaptation to climate change" is implemented in Africa, Asia and the Pacific. The model integrates components of risk knowledge, monitoring and prediction, dissemination of information and response to warning systems. It is used at sub-regional and regional levels to guarantee readiness and rapid responses to natural disasters. In Uganda, SCIEWS was implemented by changing obsolete and deficient meteorological stations with 43 modernized systems, this has reduced disaster risk impacts through more effective ways of generating and disseminating information. The information is essential for strengthening climate change resilience and food security with 64 % of the Ugandan population depending on subsistence agriculture (http://ews-undp.blogspot.com/).
- The UNEP's Climate Risk and Early Warning Systems (CREWS), is an initiative that was launched at the UN Climate Change Conference in Paris in 2015 to increase capacity of Multi-Hazard Early Warning Systems. The initiative operates in areas most susceptible to tropical cyclones and floods in 19 countries of Africa and the Pacific, including LDCs and SIDS. Progresses made by different initiatives were reported by CREWS (2019).
- The Gambia, has an integrated project for advancing national planning, raising awareness and increasing knowledge sharing, building capacity and creating national rapid response and early recovery mechanisms through their Disaster Risk Reduction (DRR) and Climate Change Adaptation programme (UNDP-UNEP 2015).
- The Climate Information for Resilient Development in Africa (CIRDA) created a model to deliver effective weather and climate services in sub-Saharan Africa. This was funded by GEF and implemented by UNDP. The end product is a communications toolkit for communicating early warning systems (http://undp-cirda.blogspot.com/)
- Outside Africa, climate change stimulated the early rehabilitation and advanced improvement of EWS. In Europe, they have had considerable experience with early warning systems, especially concerning flood and flash-flood risk, but also heat waves. For example, the availability of several global collaborative weather prediction systems through the "THORPEX Interactive Grand Global Ensemble" (TIGGE) archive that offers prospects of new dimensions in early flood forecasting and warning where the data have been used as meteorological input to the European Flood Alert System (EFAS) applied in a case study of a flood event in Romania in October 2007. It was possible to raise awareness for the flooding event eight days before the event and the other forecasts provided greater understanding of a range of potential flood conditions (Bougeault et al. 2010).

**Activity 1. 10 (Group discussion) (20 minutes)**

- Identify some of the traditional early warning systems in your country.

## 1.5.1 Challenges affecting effective implementation of EWS

Several technological and social barriers prevent effective implementation of EWS. The UNDP (2016) identified twelve major challenges limiting effectiveness of early warnings in Africa:

i. **Absence of reliable data:** Most National Hydro Meteorological System (NHMS) in sub-Saharan Africa provide incomplete information, though there has been some improvement over time. Furthermore, reliability of data is constrained by issues such as limited technical capacity of staff, limited resources and defective monitoring systems.

ii. **Lack of credibility:** Although information generated by NHMS have improved because of investments in climate observation and communication services, the information generated by most NHMS in sub-Saharan Africa are unreliable and inconsistent. This has damaged the reputation of most NHMS because of their failure to give reliable information to prepare for the response to disasters and risks associated with climate change.

iii. **Lack of protocols:** The packaging, diffusion and preventative response actions of most African nations are limited with only a few who are able to gather weather and climate data for early planning for appropriate responses.

iv. **Poor information packaging and sharing:** Weather information should be packaged to give early alerts and action-oriented weather information (e.g. Public Service Announcements (PSAs) and reports on seasonal cropping calendars, including how people should react when there is bad weather. Other information packages could be tailored for private sectors for wide sharing. Innovative information packaging, gives NHMS opportunity to overcome credibility problems and creates new effective relationships with consumers of the information.

v. **Limited engagement with traditional media and other actors:** Early warning messages generated by NHMS are often passed onto other actors such as extension agencies, the media, government partners and private companies for dissemination and action. There is a great opportunity for success when these actors (potential brand ambassadors and messengers) are effectively engaged.

vi. **Lack of clear information dissemination systems:** It is necessary to find appropriate ways of disseminating the information to all farmers, including those living in remote areas. Good and well packaged information is likely to be more trusted as users are enlightened on what to do in the event of bad weather and this saves lives and property.

vii. **Limited business-development capacity and necessary frameworks:** Skills required to develop business proposals and information systems, or for the development of favourable legal and policy frameworks are different from traditional skills of gathering, examining and sharing/disseminating information. With the development of business skills, NHMS should manage credibility snags, create income streams and connect with new groups of potential partners, that currently exist in some countries.

viii. **Poor coordination skills and capacities among concerned actors:** because EWS is a mechanism that involves a harmonised, organised structure and means of information exchange.

ix. **Cultural challenges:** Some of the challenges associated with the use and/or understanding of early warnings are linked to cultural beliefs, gender, age, language, education and literacy levels. There should be ways of reaching out to the diverse groups which speak different languages, have peculiar cultural beliefs about weather information and mostly less educated.

x. **Political challenges:** The credibility deficit among NHMS has resulted in limited political support for NHMS budgets or institutions. Hence there is a need to break the status quo by reconnecting in the political space and creating clear communication strategies where relevant actors at the policy and public levels are actively involved.

xi. **Economic challenges:** In poor nations, circumstances often lead to diversion of funds intended for weather and climate services to other services. In addition, the communication systems used in developed countries are not very suitable for the unique social, cultural, political and economic settings of the African continent.

xii. **Climatic challenges:** The changing climate and associated weather patterns and conditions such as droughts, heat, floods, torrential rainfall, lightning, and other extreme weather events present new challenges for NHMS and their advancement. Resilience can be strengthened at all levels by addressing the climate challenges and establishing integrated adaptation systems.

Early Warning Systems can be strengthened when political commitments are complemented by robust institutional capacities, which continually depends on appreciation by the public. In most cases, community awareness and support are usually higher soon after a serious disaster incident than at other times. The awareness and support can be used sustainably to strengthen and secure EWS. Some other challenges of EWS include absence of well-defined institutional structures and inadequate capacities at local and national levels for supporting development of public and institutional capacities. Users who are knowledgeable and fully aware of the system are convinced and will trust in the system.

**Activity 1. 11 Revision (10 minutes)**

- Explain your understanding of early warning systems.
- What are the challenges of early warning systems in Africa?

**Summary**

In this section we learnt that Early Warning Systems are important in climate change adaptation. Early Warning Systems enhance the preparedness of decision-makers and individuals for climate-related natural hazards and their readiness to harness favourable weather conditions. For Early Warning Systems to be effective, there is need for strong political commitments complemented by robust institutional capacities, which sequentially depends on appreciation by the public. In developing countries, the use of Early Warning Systems has had several challenges linked to technological and capacity constraints.

**Further reading**

1. https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_TAR_full_report.pdf
2. www.adaptation-undp.org/strengthening-climate-information-and-early-warning-systems-climate-resilient-development
3. http://www.fao.org/forestry/climatechange/53459/en/
4. https://unfccc.int/resource/docs/publications/adaptation_eng.pdf

# 1.6 Disaster management

In the previous section we learnt that early warning systems are important in reducing the impacts of climate change disasters. A Disaster is a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's capacity to cope using its own resources thus, prompting the need for external support (Lavell et al. 2012). In this chapter we learn about types of disasters and the disaster management cycle.

**Learning outcomes**

By the end of this session, the learner should be able to:

1. Relate concept of disaster management to climate change adaptation.
2. Explain components of the disaster management cycle.
3. Explain relevance of internationalizing the framework for disaster management.

**Activity 1. 12 Revision (10 minutes)**

- What do you think are the elements of disaster management?

Climate-linked risk occurs when physically defined exposures interact with the exposed systems' assets i.e. their social vulnerability or sensitivity. Risk can also be considered as a combination of an incident, its probability, and associated consequences – i.e., Disaster risk = probability of climate hazard x the system's vulnerability/ Coping capacity (Usman et al. 2013). Lavell et al. (2012) defined disaster risk as the likelihood of severe alterations in normal functioning of a community or a society over a specified time period due to hazardous physical events interacting with vulnerable social conditions. This leads to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

> Disaster management refers to social processes used for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organizational and societal levels before, during and after a disaster (Lavell et al. 2012).

The Sendai Framework for Disaster Risk Reduction (DRR) 2015–2030 highlighted that there is increase in frequency and intensity of disasters linked to climate change. These climate-related disasters are significantly slowing down the progress for achieving Sustainable Development Goals (SDGs) (United Nations Climate Change Secretariat, 2017). The activities of DRR emphasise the management of present and future risks, with a focus on building resilience by 2030 (UNISDR 2015). In this regard, four priorities of action should be pursued by all countries:

- understanding disaster risk;
- supporting governance of disaster risk;
- investing in resilience; and
- enhancing and guiding disaster preparedness.

Climate change is one of the main drivers of disaster risk and therefore there is need for action on adaptation and building of resilience, to lessen disasters and threats linked to climate change categorised into: natural, technical/human induced or emerging complex emergencies (Table 2).

**Activity 1.13 (Group discussion) (10 minutes)**

- Give examples of the types of climate related disasters that have occurred in your country.

**Table 2: Types of disasters**

| Natural Disasters | Technological/Human Induced | Complex Emergencies |
|---|---|---|
| • Drought<br>• Earthquakes<br>• Extreme temperatures<br>• Floods<br>• Disease epidemics<br>• Insect and animal plagues<br>• Landslides<br>• Tornadoes<br>• Tropical cyclones<br>• Tsunamis<br>• Volcanoes<br>• Wildfires<br>• Winter weather<br>• Storms and wave surges | • Accidental discharge of hazardous chemicals<br>• Bioterrorism<br>• Nuclear reactor bombing or destruction<br>• Oil spills<br>• Radiation disasters from nuclear blasts, nuclear reactors, or accidental spills of radioactive material | • Conflict<br>• Wars<br>• Famine<br>• Displaced populations |

Source: Wood et al. 2013

Consequently, the disaster management cycle follows a series of steps from preparedness, response, recovery and mitigation (Figure 6).


**Figure 6: Disaster management cycle (After Wood et al. 2013)**

**Preparedness**: This is can be used as the starting point in disaster management planning and is demonstrated by willingness to react to any crisis situation using programs that support technical and administrative capacities of governments, organizations, and groups of people. In the preparedness phase, individuals, communities and organisations prepare for the next possible event through actions such as the deployment of early warning systems and development of community recovery plans (Wood et al. 2013). Other forms of preparedness include strategic reserves of food, water, medicines, equipment, and other basic needs preserved and used after a national or local disaster. Preparedness actions are influenced by the integration of appropriate measures into national and regional development plans. The measures include:

- preparedness plans;
- early warning systems;
- crisis training/ exercises;
- evacuation planning and training;
- disaster communications systems;
- stock inventories;
- standby employees contact lists;
- mutual relief arrangements, and
- public information and education.

**Response:** Begins after a disaster and is about the support that is directly given to preserve life, improve health or give assurance to affected people. The response phase attempts to meet people's basic needs before a more stable and sustainable solution is established. Examples of such assistance are temporary shelter, transport, water, food, and creation of semi-permanent settlements e.g. in camps. Response may also encompass some early repairs to damaged infrastructure (Lavell et al. 2012).

**Recovery:** Includes activities that are done in anticipation of the systems returning to normalcy or becoming better. This entails a situation when the affected population is able to assume responsibility for supporting their welfare and the infrastructure that supports them. Recovery actions can be both short and long term, as well as restoration of vital life-support systems to encompassing, basic functional standards, reconstruction, public information, health and safety education, temporary housing, psychotherapy procedures and economic impact analysis.

**Mitigation or reconstruction:** Entails current assistance for maintaining life, improving health and giving assurance to the affected communities. The support can be in the form of limited aid.

There is a strong relationship between climate change adaptation, development and disaster risk reduction (Figure 7). Adequate planning can help to build resilience where systems are able to survive after an incident and are able to adapt and/or improve (Usman et al. 2013).

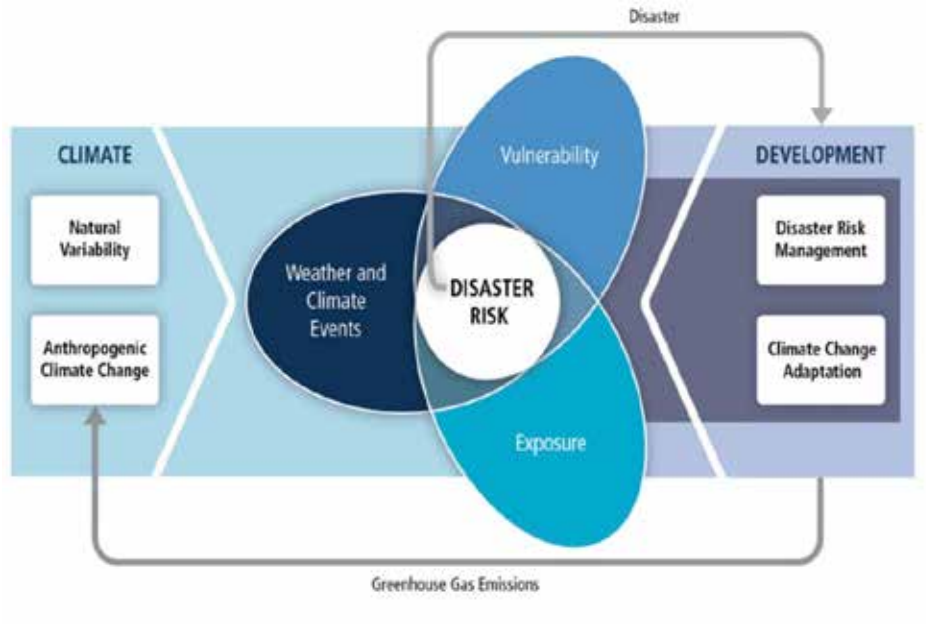


**Figure 7: Linkages between climate, disaster risk and development (IPCC 2012)**

## 1.6.1 Forests and the Sendai Framework for Disaster Risk Reduction

There is growing demand for nature-based solutions to better manage exposure to natural hazards and climate change while supporting efforts to build resilience in a sustainable manner in vulnerable developing countries. Forests play a critical role in this, not only in mitigating risks but also in providing other benefits for communities in terms of income and resilience during recovery phase.

**Activity 1. 14 (Group discussion) (10 minutes)**

- Explain the role of forests in disaster reduction.

The Heads of State and Government, ministers and delegates who participated in the Third United Nations World Conference on Disaster Risk Reduction made a declaration recognising the increasing impact of disasters and their complexity in many parts of the world and called for action by all stakeholders as the new framework depends on unceasing and tireless collective efforts by all. The Sendai Framework for Disaster Risk Reduction (2015–2030) underscores ecosystem-based solutions for reducing disaster risk. Furthermore, Sustainable Development Goals (SDGs) confirm that ecosystem services are essential and effective as disaster risk tools (PROFOR 2019). This is because ecosystem-based solutions are relevant to various dimensions of Disaster Risk Reduction (DRR). They can help reduce social vulnerability by providing food, income and ensuring water supply (Renaud et al. 2013). For example, when ecosystems are protected or restored along coastlines or riverbanks, they act as natural buffers for hazardous events and reduce exposure to hazards (Tanaka 2012). Sebesvari et al. (2019) recommended that the Sendai Monitoring Framework should include an enhanced integration of available data collected for international frameworks such as SDGs, Convention on Biological Diversity (CBD) Aichi targets, Ramsar Convention, including data from national forestry inventories, earth observation data, etc. to boost data availability.

**Further reading**

Living with Risk: A global review of disaster reduction initiatives: http://www.unisdr.org/unisdr

**Activity 1. 15 Revision (10 minutes)**

1. What is disaster management?
2. Explain the disaster management cycle.
3. What do you understand by the "Sendai Framework" of disaster reduction?
4. What is the role of forest ecosystems in disaster management?
5. Explain importance of ecosystem based solutions in disaster risk reduction.

**Summary**

Climate change is one of the key drivers of disaster risk, and provides a platform for adaptation and resilience-building to reduce associated disaster risk. Disasters can either be natural, technical/human induced or emerging complex emergencies. Disaster management follows a cycle with four elements: preparedness, mitigation, response and recovery. There are strong linkages among, adaptation to climate change, disaster risk reduction and development.

# 1.7 Maladaptation

Maladaptation was defined in section 1.2.12 as an action, or inaction that may increase the risk of adverse climate-related outcomes, increase vulnerability to climate change, or diminish welfare, now or in the future (Mimura et al. 2014). Adaptation projects involve several regions and levels, ranging from local level projects to national and regional policies and initiatives (East Africa, Europe, Pacific, Sub-Saharan Africa, South America etc.). Procedures and specific mechanisms for adaptation implementation should be informed by sound scientific, technical, and socio-economic data (Mimura et al. 2014). In this section we learn more about maladaptation, frameworks for assessment and examples of maladaptation.

**Learning outcomes**

By the end of this session, the learner should be able to:

1. List examples of maladaptation; and
2. Describe frameworks for assessing maladaptation.

**Activity 1. 16 (Group discussion)(10 minutes)**

- Identify climate adaptation projects that did not bring the desired outcomes in your country.

The actions can increase vulnerability of people or ecosystems to climate change impacts, directly or indirectly, significantly weakening capacities or opportunities for both present and future adaptation (Magnan et al. 2014) (Box 6).

Therefore, there is need for efforts to support socio-ecological systems that are vulnerable to climate change, although implementation of adaptation remains vague in some cases. Climate funding may cause a risk by supporting initiatives that damage the socio-ecological systems, i.e. by promoting short-term adaptation that consequently affects vulnerability and/or adaptive capacity to climate change in the long-term (Schneider and Sarukhan 2001). For example, the design of agricultural policies promoting high-yielding crop varieties through subsidies may increase production and boost revenues in the short-term, but will also reduce agro-biodiversity and increase exposure and vulnerability of mono-crops to climate change and eventually undermining the long-term adaptive capacity of the smallholder farmers (World Bank 2010). In such scenarios, maladaptation becomes inevitable and therefore, should be avoided as an important step towards comprehensive adaptation actions through evaluation of all costs and benefits, including co-benefits to all groups in the society and being explicit on the sharing of burdens and costs (UNEP 2019).

**Box 6: Examples of maladaptation (Magnan (2014, 2016, Chi et al. (2021)**

Most initiatives branded as "climate change adaptation" in the developed and developing countries have failed to adequately or correctly adjust to their environment or circumstances resulting in maladaptation. Examples of maladaptation include:

- Adoption of actions ignoring local relationships, traditions, traditional knowledge, or property rights, causing an ultimate failure;
- Adaptation actions that do not take into account the wider impacts;
- Adaptation actions of benefit in the short term but failing in the long-term causing risks that go with various low-regrets activities;
- Neglecting direct and/or indirect drivers of vulnerability;
- Adaptation that may address one sector and fails to account for negative flow-on effects in other sectors or to other people's values;
- Reducing incentives to adapt; and
- Holding on to irrelevant customary responses

(Magnan 2014; WIREs Clim Change 2016).

**Activity 1.17 Group Discussion (10 Minutes)**

- How can communities and nations avoid maladaptation in their attempt to cope with the effects of climate change?.

Climate change causes disturbances that affect structure, species composition, natural regeneration and populations in forest ecosystems and the long-term response of forest productivity to climate change (Morin et al. 2018). The species population becomes locally maladapted and declines in fitness, having potentially detrimental effects on forest ecosystem processes and functions (Seidl et al. 2019, Thom et al. 2017).

## 1.7.1 Frameworks for understanding maladaptation

Adaptation activities become maladaptive when they increase the vulnerability of those who are at the highest risk, such as minority groups or low-income households, in the process of meeting the needs of one sector or group. There are frameworks that help to identify various forms of maladaptation to improve on the understanding (WRIs Clim Change 2016). Two frameworks known as Pathways framework and Precautionary framework provide a basic understanding of risks and forms of maladaptation. Because of the limitations associated with the two frameworks, a complementary framework called the Assessment framework was developed. The frameworks are discussed below:

The Pathways framework is illustrated by maladaptation characteristics developed in (i) engineering responses to water stress in Australia (Barnett and O'Neill 2010); (ii) adaptation activities aimed at livelihood diversification, intensification, extensification and irrigation in Ghana (Antwi-Agyei et al. 2018); (iii) building of a dam for irrigation which contributed to flooding of grazing lands and settlements in Ethiopia; and (iv) coastal protection from storm surges using sandbags that caused loss of beach area, loss of tourism and tourism revenue and reduced recreational value at the bay scale in Cape Town, South Africa (Magnan et al. 2016). The characteristics which were identified as critical in the South African example were further analysed and turned into principles by Magnan (2014) (Table 3).

**Table 3: Pathway Framework characteristics and associated principles**

| Characteristic (Barnett and O'Neill 2010) | Associated Principle (Magnan 2014) |
|---|---|
| Increasing GHG emissions | Make sure that the initiative does not increase emission of GHGs |
| Disproportionately burdening the most vulnerable | Ensure that initiatives are economically and socially equitable |
| High opportunity cost | Avoid initiatives that have high costs |
| Reduced adaptation incentive | Increase adaptation incentives |
| Path dependency | Initiatives should have built in flexibility |

The Precautionary framework which was proposed by Hallegatte (2009), focuses on avoiding irreversibility and strengthening flexibility of socio-ecological systems. The framework supports the pathways framework by considering uncertainty and potentially harmful effects of current or planned initiatives to climate change. In this regard, reducing the risk of increasing system vulnerability becomes important. A wide range of impacts should be taken into account to select the most robust and insensitive option for future climate conditions in planning for adaptation rather than choosing the best option from one scenario.

The precautionary framework is based on six criteria/strategies:

- No-regret approaches are able to yield benefits even without climate change.
- Reversible strategies to support reversible and flexible options instead of irreversible choices in order to reduce the cost of incorrect assumptions about future climate change.
- Safety margin strategies help prevent maladaptation naturally because they represent an acceptable extra cost (e.g. social, environmental and economic) at the stage when an option is considered and implemented.
- Soft strategies are non-technical and non-engineering choices which represent a particularly extensive range of potential maladaptation in social, cultural, and political aspects. In this regard, technical solutions are not considered as the only way of adapting to changing climate but institutional and financial tools can also be used.
- Strategies that minimise time horizons for decision-making and reduce uncertainty and associated expenditures. For example, the use of short rotation species in forestry can be an option although this is also controversial when considering the reduced timescales for decision-making that could be a primary source of maladaptation; and
- Considering conflicts and synergies among strategies allows appraisal of maladaptation, directed at negative impacts of an adaptation initiative. The negative effects are analysed based on the overall effects of the particular initiative (balancing the positive and negative) and the implementation of alternative initiatives (covering both adaptation and mitigation). In this regard, maladaptation becomes relative.

**The Assessment Framework.** The two frameworks described above are certainly useful in moving from the maladaptation concept to more practically-oriented guidelines. However, their usefulness in coastal areas is limited, because their main focus is infrastructure, ignoring other drivers of vulnerability and adaptation. Due to the limitations in the Pathways and the Precautionary frameworks, the Assessment framework was developed to accommodate other forces driving vulnerability and adaptation in coastal regions, such as ecosystem roles and risk perception by local communities. The Assessment framework is an ex-ante framework designed to inform preparation of adaptation strategies before implementation, instead of ex-post evaluation of the benefits and shortcomings of the initiatives carried out to achieve

adaptation. Assessment framework for dealing with climate change maladaptation at a local level focuses on avoiding three areas of environmental, social and economic maladaptation (Box 7) (Magnan 2014).

**Box 7: Characteristics of the Assessment framework**

| 1. Avoiding environmental maladaptation | 2. Avoiding social maladaptation | 3. Avoiding economic maladaptation |
|---|---|---|
| » Shun degradation that causes adverse effects in situ.<br>» Shun displacement forces moving to other environments (adjacent areas or areas ecologically or socio-economically connected).<br>» Support protection of ecosystems functions against existing and future climate-related threats.<br>» Integrating uncertainties of impacts of climate change and the ecosystems responses.<br>» Primary purpose should focus on promoting adaptation to climate-related changes rather than to reducing GHG emissions. | » Begin with local social features and cultural values that might influence risks and environmental dynamics.<br>» Consider and build on local/indigenous knowledge and skills related to climate change hazards and the environment.<br>» Gather new skills that can be acquired by the community. | » Reduce socio-economic inequalities.<br>» Diversify economic and/or subsistence activities.<br>» Integrate potential changes in economic and subsistence activities caused by climate change. |

**In text question (5 minutes))**
How can we avoid environmental, social and economic maladaptation?

When a country's development choice deteriorates, there will be a corresponding increase in susceptibility to the impacts of climate change eventually becoming maladaptation. Development approaches that increase people's dependency on climate sensitive assets (e.g. certain crops), provide a disparity amongst adaptation activities especially when externally funded, the result is maladaptation. However, the country's stage of development determines their vulnerability to the adverse effects of climatic fluctuations and capacity to adjust (Barnett and O'Neill 2013).

**Activity 1.18 Group Discussion (5 Minutes)**

- Mitigation is necessary and adaptation is unavoidable. Discuss in the context of climate change..

**Summary**

In this section we learnt that maladaptation occurs when an adaptation action increases vulnerability to climate variability and change, either directly or indirectly, and/or significantly undermines capacities or opportunities for present and future adaptation to climate change impacts. Frameworks for avoiding maladaptation include Pathways framework, Precautionary framework and Assessment Framework. The assessment framework focusses on avoiding social, economic and environmental maladaptations. A country's development stage can determine its susceptibility to climate impacts and its capacity to adapt.

# 1.8 Temporal and spatial scales of adaptation

Global climate has progressively been warming over the past century resulting in variations in climate, over an extensive range of temporal and spatial scales. Spatial climate gradients have resulted in a number of ecological changes. The spatial scales for adaptation range from global, regional, national, and sub- national to urban and rural communities (Landauer et al. 2015).

**Learning outcomes**

By the end of this session, the learner should be able to:

- Clarify temporal and spatial scales of adaptation

**Activity 1. 19 (Group discussion)(10 minutes)**

- How does climate change affect different ecosystems in your country?

Spatial scales of variation can include altitudinal and latitudinal climate-related gradients such as the unusual variations in soil fertility, composition and structure of habitats, growth rates, and programming of reproductive cycles. Warming may force species to migrate to higher latitudes or higher elevations where temperatures will be more favourable for their survival (EPA 2017). Furthermore, at low latitudes (less than 45°) species demographic responses are positively related to precipitation, suggesting that in low latitude biomes, drought is the most commonly limiting factor of populations growth/composition across a range of taxa (Pearce-Higgins et al. 2015).

The temporal scales include past changes in global, regional and local temperatures, precipitation and extreme events in a particular area and their effects on other ecosystem components (Ummenhofer and Meehl 2017). Temporal changes can affect population in terms of species-range, habitat invasions and extinctions because of spatial heterogeneity. Consequently, these affect regional and local ecosystem functions and human well-being (Kosanic et al. 2019). The environmental effects of the daily and seasonal climate variations are well documented and can fairly be predicted to reflect the temporal scales. The temperatures during the day/night and those during winter or summer can limit ecological processes and dynamics of population in different ecosystems (IPCC 2014). For example, extremely cold winters/ nights or extremely warm days or summers control geographical distribution and regenerative capacities e.g. for insects and microbial activities in soil and water. Some plants and animals have adapted to daily and seasonal climatic variability through adjustment of reproductive cycles, migration, hibernation, nocturnality, seed dormancy and leaf shedding. The restraining consequences of daily and seasonal climate variability at the geographical scales are entwined with the reproductive and growth rates of living organisms as the hot extremes come in summer days whilst the cold extremes come during winter nights (National Research Council 2001).

Climate variability occurs from inter annual to decadal time scales and is a product of combined atmosphere-ocean processes, sunspot sequences and other unexplained drivers. However, these variations can have significant ecological and health consequences. For example, variations in climate related to the El Niño-Southern Oscillation (ENSO), such as continuous drought years, and continuous decadal monsoon and hurricane cycles are associated with differences in vegetation structure, productivity, insect abundance, success of bird-nesting, and several other ecological processes. Large range shifts or even extinction of species are likely to occur over much longer time scales.

Increases in temperature are likely to result in changes to tree lines and phenology for certain species in the SADC region (Lesolle 2012). Extended warming trends that have been experienced over the last

century are associated with numerous ecological trends such as early spring (manifested by biological events such as flowering of vegetation or egg laying) decline in population of birds, mammals and amphibians; and shifting ranges for species of birds, butterflies, and some marine invertebrates. There is compelling evidence to support the observation that the shifts/changes are a result of climatic trends in some cases (e.g., trends in plant-flowering phenology), and at least indicative of such trends in other cases. Organisms are usually more susceptible to temperature extremes than to average temperature, and such extremes can cause geographical range shifts, and population density alterations for some species (Chen et al. 2011, Sintayehu 2018).

The changes in temporal and spatial temperature and precipitation patterns make Africa's smallholder farmers and major agricultural production systems more vulnerable climate risks, associated with crop failure, and dips in livelihood and health. In sub-Sahara Africa, Schlenker and Lobell (2010) and Thornton et al. (2011) observed that the expected climate change makes smallholder farmers highly vulnerable with over 20% decrease in staple crop production.

**Activity 1. 20 (Group discussion)(10 minutes)**

- Explain how temporal and spatial scales of climate variability affect ecosystem components.

**Summary**

Climate varies naturally on a wide range of temporal and spatial scales, and in the past century, the global climate has been gradually warming. Spatial scales can include altitudinal and latitudinal climate related gradients while temporal scales include past changes in global, regional and local temperatures, precipitation and extreme events in a particular area and their effects on other ecosystem components. In natural ecosystems, temporal changes can affect population species-range, habitat invasions and species extinction.

# 1.9 Mainstreaming climate change adaptation into development policy plans and actions

In the previous chapter we learnt about temporal and spatial factors affecting adaptation of ecosystem components and that climate change is a threat to the development process, affecting human and natural systems as well as the achievement of the SDGs. The cross- cutting nature of climate change results in economic, geographic, administrative and temporal scale effects. Consequently, adaptation programmes or strategies need to be prepared as a component of wider development plans (UNDP-UNEP 2011). In this section we will learn about factors that determine the capacity of one to adapt to climate change and the importance of mainstreaming climate change adaptation into development policies and plans.

**Learning outcomes**

By the end of this session, the learner should be able to:

1. Describe the forms of capital that are important in the determination of the vulnerability of individuals, communities or nations to the impacts of climate change.
2. Analyse how adaptation can be mainstreamed into development processes.
3. iExplain characteristics of adaptation policy approaches; and
4. Describe the framework for mainstreaming climate change adaptation

**Activity 1. 21 (Group discussion)(10 minutes)**

- Why do you think it is important to mainstream climate change adaptation into development policies and planning?

Engagement and harmonization of activities across various levels of authority (regional, national, sub-national and local levels), becomes crucial for improving adaptation actions and providing opportunities for catalysing transformation. Although all societies are to some extent adapting or have adapted to climate change impacts, the ability to adapt to different variabilities and accelerated alterations varies significantly, calling for a need for policy support. Emerging international policy responses, and funding mechanisms of the UNFCCC and Kyoto Protocol were a product of the recognition of the inability and vulnerability of the developing world (IPCC 2007b).

Mainstreaming climate change adaptation is an iterative multi-stakeholder and multi-year process for integrating climate change adaptation into all processes of development at national, sectoral and sub-national levels. This involves coordinating with both governmental and non-governmental agencies in the definition of the impacts of adapting to climate change on livelihoods and development (UNDP-UNEP 2011). Such engagement and coordination can be achieved using several approaches, including financial support, mainstreaming climate change adaptation in the development process and sharing of multidisciplinary information.

Successful adaptation is however, determined by the agility of individuals to react to internal stresses, external forces and variabilities. In this regard, the sustainability concept, can encompass all activities that allow the individual's agility to remain. Sustainagility supplements sustainability concerns because the two concepts are determinants for the survival of current systems. Sustainability at some level, e.g. cropping systems or livelihoods, can be linked to sustainability of specific constituents, or the agility to find and fit in the new constituents. Carney (1998) identified five important elements (capital/assets) supporting the resource base for sustainability that have limited and incomplete possibilities for exchanges among the capital types: human capital, natural resource capital, social capital, physical capital and financial capital (Figure. 8).

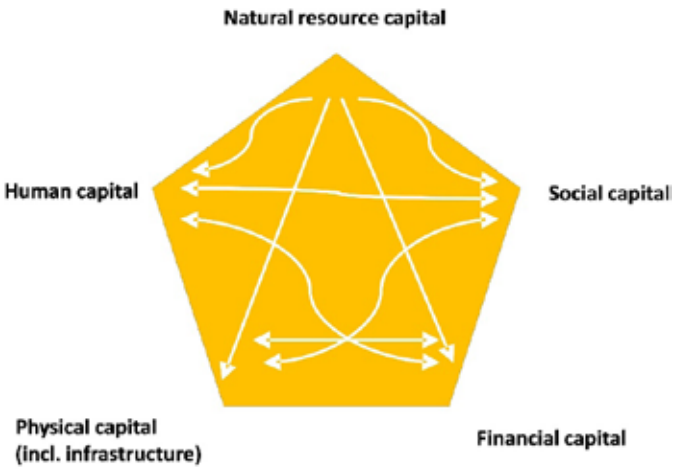


**Figure 8: Types of capital affecting development and capacity to adapt**

These capital types act as assets that are important in the determination of the vulnerability of individuals, communities or nations to the impacts of climate change. All forms of capital are either directly or indirectly affected by climate change. Internal and external mechanisms related to the forms of capital affect the adaptation of agroecosystems and thus, their sustainagility and sustainability.

> Sustainagility is "the properties and assets of a system that sustain the ability (agility) of agents to adapt and meet their needs in new ways" (Jackson et al. 2010).

"Agro-ecosystems, particularly the ones rich in agro-diversity and biological capitals (Natural resource capital), can adapt (depending on their Human and Social capital) by way of increasing the use of their under-exploited local resources, or on the basis of (locally or globally) new technology (new crops, new cultivars, new management practices, new external inputs), depending on their Financial, Human and Social capital" (Verchot et al. 2007).

Performance of specific adaptation activities (for specific problems, sectors or groups) varies with situations, but a project-based approach for formulating and financing adaptation may not yield desired outcomes needed in the long term. Therefore, a cross-cutting, integrated policy approach is needed to support formulation of national adaptation policies or strategies. While working with communities in Asia, Vij et al. (2017) identified five approaches and four key adaptation policy characteristics (Table 4).

**Activity 1.21 In text question (5 minutes)**

- A project-based approach to adaptation planning and financing may not yield desired outcomes needed in the long term. Discuss this statement in the context of climate change in your country.

**Table 4: Policy approaches to adaptation**

| **Approach** (Characteristics) | **Description** |
|---|---|
| **Scenarios** (Inflexible; local and national scale) | • Mainly focusing on a single scenario of a system<br>• Lacking focus on actors or agencies<br>• Process is systematically set<br>• Availability of substantial empirical evidence |
| **Strategic (spatial) planning** (Inflexible; local, national and global scale; case focused) | • Main focus is on physical solutions<br>• Based on land-use planning<br>• Pre-set time-periods<br>• Used by both developed and developing countries. |
| **Robust Decision Making (RDM)** (Flexible; uncertainty) | • Quantitative decision<br>• Analytical approach supports choices under circumstances of deep uncertainty. |
| **Adaptation pathways** (Flexible; time-oriented; reflexive experimental; Local and national scale; focuses on gradual/ incremental change;) | • Focus on policy reflexivity and its adaptive nature<br>• Emphasis on policy and transformational change<br>• Considerations for power and politics<br>• Some empirical evidence at local scale available although still conceptually and theoretically in experimental phase |
| **Adaptive Governance** (Flexible; uncertainty; incremental change; local and national scale) | • Adaptive management<br>• Anticipatory governance<br>• Assumption based planning- Flexible decision framework that uses a wide range of possible futures to prepare for change and to guide current decisions toward maximizing future alternatives or minimizing future threats.<br>• Explore implications of uncertainty for current and future choices |

(Source: Vij et al 2017)

Frameworks available for developing countries to plan and implement responsive adaptation processes and policies include: National Adaptation Programme of Action (NAPA), Adaptation Policy Framework (APF), Community Based Adaptation (CBA) (Cannon 2013) and Ecosystem-Based Adaptation (EbA). The UNFCCC follows a defined framework (Box 8). Adaptation policy approaches should have the following characteristics:

- flexible;
- scalable;
- considers uncertainties;
- resilient;
- incremental/gradual change;
- time oriented;
- global, national or local scale; and
- experimental and responsive.

**Box 8: Framework for mainstreaming climate change adaptation**

Setting the stage for mainstreaming by understanding the linkages between climate change and national development priorities and understanding the governmental, institutional and political contexts that inform efforts to define pro-poor adaptation outcomes. Find entry points into development planning, and make the case for adaptation mainstreaming.

Mainstreaming adaptation into policy processes through integration of climate change adaptation matters into ongoing policy processes, e.g. national development plan or sectoral strategy, centred on particular evidence from the country (i.e., vulnerability, impact, and adaptation assessments, socio-economic analysis and demonstration projects).

Ensuring that climate change adaptation is mainstreamed into budgeting and financing, implementation and monitoring, in order to meet the implementation challenge and making mainstreaming a standard practice.
(UNDP-UNEP 2011)

Successful adaptation to changes in climate, therefore, involves integration of potential climate change impacts into existing approaches and plans at sectoral and national levels (Smit and Pilifosova 2001, Huq et al. 2003). Once the relevant planners and managers have been provided with the appropriate methodologies and tools, they should be able to incorporate climate change issues into their normal planning (at relatively low costs). Mainstreaming adaptation involves actors engaged in development work including government, international development agencies, non-governmental organisations (NGOs), local communities and the private sector. These actors should be well coordinated in order to improve understanding of impacts of climate change before mainstreaming the issues into their regular activities. Stakeholders are important throughout the process of mainstreaming climate change adaptation issues into the development process. The benefits of mainstreaming climate change adaptation into development activities include avoiding policy conflicts, reducing risks and vulnerability, improved efficiency by not managing adaptation as a separate activity, and leveraging the much financial flows in the sectors affected by climate change (Lebel et al. 2012).

**Activity 1.22 In text question (5 minutes)**

- A project-based approach to adaptation planning and financing may not yield desired outcomes needed in the long term. Discuss the statement in context of climate change in your country

**Summary**

Engagement and coordination across, multiple levels of governance, including regional, national, subnational and local levels, is critical to enhancing adaptation efforts and can provide opportunities that will catalyse transformational change. Adaptation policy approach should be flexible, scalable, reflexive to reduce uncertainty, resilient, show incremental/gradual change, time oriented, at local, national or global scale, experimental and responsive. Issues of climate change are supported by principles aligned to environmental justice and human rights..

# 1.10 Rural sociology

Rural sociology is a component of sociology that focusses on the social life in rural areas (Lichter 2015). Actions related to climate change adaptation usually focus on either protection of the climate from society (mitigation) or protection of the society from climate impacts (adaptation). In rural sociology all activities related to analysis of potential impacts of climate change, possible mitigation and coping/adaptive measures for all sectors of rural communities, are analysed.

**Learning outcomes**

By the end of this section the learners should be able to:

Explain the relevance of rural sociology to climate change adaptation

The connection between social contexts and natural resource use and management exists as supported by Grundmann et al. (2012) who highlighted that social behaviour can alter natural process and natural process can also alter social relations. Social and community vulnerability perspectives have been the focus of climate change adaptation after realising that local level characteristics can impact adaptation actions. Drivers of climate change include population growth, economic systems, urbanization, poverty, land use change including deforestation, form of government and a country's development stage. Qualitative and quantitative analyses demonstrate how cultural and social practices shape attitudes, discourses and conceptual dimensions of climate change in community deliberations and strategic development processes, thus associating rural sociology to climate change actions.

The use of forests in climate change adaptation is appropriate because forest resources require limited quantities of physical, financial, or human investment and hence are perceived as cheap. Forests provide environmental services and non-timber forest products (NTFPs), that have been extensively used as safety nets or "natural insurance" to assist the poor and vulnerable groups to cope with economic and environmental disasters (Paumgarten 2005, Agrawal et al. 2013, Cheng et al. 2017). Forest resources are important for responsive coping as they provide food and income during shortages/crop failures after climatic instability. Issues of climate change are also supported by principles aligned to human rights and environmental justice. These also support climate change adaptation and are explained by Stillings (2014) in four ways:

- Developed countries in the north contributed immensely and excessively to global environmental pollution;
- climate change effects will have more adverse impacts on the poor nations located in the Southern hemisphere because of their location and low coping capacities (e.g. being non-Annex I parties);
- global climate agreements are in favour of developed nations relative to processes and impacts; and
- those living in the present day are adversely modifying the atmospheric and climatic conditions of the earth, reducing its capacity to sustain life over many generations to come and resulting in an imbalance in intergenerational equity.

**Activity 1.23 In text question (5 minutes)**

- What is the role of forests in socio-ecological climate change adaptation?

**Further reading**

Dasgupta et al. 2014. Rural areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
https://gala.gre.ac.uk/id/eprint/14369/4/14369_MORTON_Rural_Areas_2014.pdf

**Chapter Summary**

CIn this chapter we learnt about several terms related to climate change adaptation such as climate change, extreme events, uncertainty and vulnerability. Vulnerability to climate change is shown by the degree, extent or magnitude to which a system is susceptible to harm/adverse effects of climate change including climate variability and extreme events. However, the extent of damage depends on sensitivity and adaptive capacity of a particular system. It is a function of the character, magnitude and rate of climate change and variation to which a system is subjected. The potential impact is determined by exposure and sensitivity, but the overall vulnerability may be moderated by adaptive capacity. Adaptation measures vary according to the way climate change is described or experienced, the sector or exposure unit that is adapting, the manner and timing of adaptation, and the adaptation capacity. LDCs, are expected to prepare NAPAs and NAPs to bring together various adaptation efforts into coherent and sustainable national strategies following guidelines of UNFCCC. LDCs, as all Parties to UNFCCC are, however, also required to provide NDCs and National Communications on climate change impacts and vulnerabilities at regular intervals. Early Warning Systems enhance the preparedness of decision-makers and individuals for climate-related natural hazards and their readiness to harness favourable weather conditions. For Early Warning Systems to be effective, there is need for strong political commitments complemented by robust institutional capacities, which sequentially depend on appreciation by the public. Climate change is one of the key drivers of disaster risk, and provides a platform for adaptation and resilience-building to reduce associated disaster risk. Disasters can either be natural, technical/human induced or emerging complex emergencies. There are strong linkages among, adaptation to climate change, disaster risk reduction and development. Maladaptation occurs when an adaptation action increases vulnerability to climate variability and change, either directly or indirectly, and/or significantly undermines capacities or opportunities for present and future adaptation to climate change impacts. Climate varies naturally on a wide range of temporal and spatial scales, and in the past century, the global climate has been gradually warming. Engagement and coordination across, multiple levels of governance, including regional, national, subnational and local levels, is critical to enhancing adaptation efforts and can provide opportunities that will catalyse transformational change. Adaptation policy approach should be flexible, scalable, reflexive to reduce uncertainty, resilient, show incremental/gradual change, time oriented, at local, national or global scale, experimental and responsive. Issues of climate change are supported by principles aligned to environmental justice and human rights.

**Further Reading**

1. African Forest Forum 2019. Basic Science of Climate Change: A Compendium for Short Courses in African Forestry 03. Available at: https://afforum.org/publication/basic-science-of-climate-change-a-compendium-for-short-courses-in-african-forestry/
2. IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. In Field, C.B., V. Barros V, Stocker TF, et al (eds.). Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp. https://www.ipcc.ch/site/assets/uploads/2018/03/SREX_Full_Report-1.pdf

# Chapter 2: Forest-Based Climate Change Adaptation Strategies and Actions

## 2.1 Chapter overview

Climate change affects forests, but the forests also have an important role in making ecosystems and communities adapt to climate change. Forests can support species adaptation to climate change and unexpected climate events through provision of refuge and migration corridors. In times of extreme weather events such as droughts and floods, forest ecosystems provide goods and services that help reduce vulnerability of socio-ecological systems. Adaptation measures in forestry are influenced by a variety of related factors, including climatic threats, management goals, forest type, and the non-climatic pressures. Vulnerability of forests and people to climate change can be reduced through application of several forest-based actions, which can increase resilience to the impacts of climate change. This session explores the importance of forests in climate change adaptation and outlines some forest-based adaptation strategies and measures, including forest resilience and socio-economic adaptation. The chapter concludes by exploring the relationships between forest-based adaptation and mitigation and some case studies from the African continent.

**Learning outcomes**

By the end of this chapter, the learners should be able to:

i. Describe how forest and tree resources respond to climate change.
ii. Explain the contribution of forests to adaptation of societies and ecosystems.
iii. Analyse aspects of forest resilience.
iv. Discuss forest management activities that reduce vulnerability of forests and people to climate change; and
v. Explain components of socio-economic adaptation.

**Activity 2.1 In text question (5 minutes)**

Share your views on forest-based climate change adaptation strategies

# 2.2 Forest and tree responses to climate change

Forests and trees are affected by changing climatic factors such as changing temperature and precipitation as well as extreme events, which can negatively affect biotic and abiotic components of the forest ecosystem. Climate change directly affects the physiology of trees and alters the biogeochemical processes that drive forest ecosystems, thus indirectly altering the structure, composition and diversity of plant communities (Morin et al. 2018).

**Learning outcomes**

By the end of this session, the learners should be able to:

i.) Describe how forest and tree resources respond to climate change;
ii.) Explain forest resilience in the context of climate change; and
iii.) Describe the relationship between forest resilience and adaptation to climate change

**Activity 2.2 (Group work) (15 Minutes))**

1.) How do forests and trees respond to climate change?
2.) What is the relationship between forest resilience and adaptation to climate change in Africa?

On the African continent, climate change is an additional challenge to the already stressed and threatened habitats, ecosystems and species. Climate change has been suggested as a trigger for habitat reduction, leading to the migration of species. Climate change impacts on forests and trees will certainly have far-reaching consequences on the forestry industry (Seppälä et al. 2009). Some forest pest occurrences have been linked to climate change (Box 9, Figure 9).

**Box 9: Climate change effects in forest ecosystems**

Southern Africa, has experienced increased arrival/emergence of pathogens/pests over the past two decades due to climate change. Outbreaks of previously unknown forest pests and diseases such as the red gum lerp psyllid (Glycaspis brimblecombei), the blue gum chalcid (Leptocybe invasa), and the disease Teratosphaeria gauchensis in Eucalyptus stands (Jimu et al. 2015).

A great storm occurred in 2005, 2007 and 2009 causing severe wind throw affecting Swedish forests, mainly the middle-aged and old spruce stands resulting in increased populations of insects, notably the European spruce bark beetle, (Ips typographus). In other areas of Europe e.g. Slovakia, severe storms of 2004/2005 affected a forest in the Tatra National Park, resulting in a severe bark beetle outbreak over an area of 12 000 hectares (FAO 2010).

**Figure 9: Invasion of Eucalyptus spp. by Leptocybe invasa in Zimbabwe**

Climate change results in changes in the timing of seasonal life cycle events in ecosystems. Climatic variability could influence mortality, growth, reproduction, physiology and interactions between trees and pests or pathogens (Trumbore et al. 2015). Wildfires, winds and insect/pathogenic attacks could also stimulate disruptions and disturbances. Increased fragmentation of forests, habitat reduction and other human-induced pressures have placed 50% of Africa's biodiversity at risk (Harvey 2018). This is exacerbated by human population increases, abuse of land resources (including forests), land degradation and desertification. Given the importance of forests to ecosystems and people, there is need to consider them when designing landscape adaptation policies and practices. Adaptation is also needed to minimize the impacts of climate change on forests, taking into account the fact that climate change is one of the key drivers of forest development (IUCN 2017).

The impacts of climate change on forests are, however, a product of multiple internal and external factors, including how the forests at a particular site respond to such changes, coupled with the magnitude of the unit under consideration i.e. individual trees, forests or landscapes. Although forests are exposed to long term climate impacts, disturbances such as drought, cyclones, insects and fire may have serious short term effects if they cross critical thresholds (Seidl et al. 2017). However, the magnitude and form of disturbances depend on the type of climatic factor. For instance, in Southern Africa, cyclone Idai of 2019 had negative impacts on productive functions of forest ecosystems, particularly in mountain ecosystems, which in turn affected local economies.

Land use changes exacerbate effects of droughts and other disturbances on forest ecosystems although climate change is expected to affect susceptibility of forests to the disturbances. Susceptibility of forests depends on frequency, duration, intensity and time of disturbance occurrence. For example, more extreme weather conditions or a combination of increased rainfall and warmer temperatures cause increased fuel loads and extend fire seasons (FAO 2006). Disturbances such as fire, landslides, drought, insect and disease outbreaks, species invasions, and climatic events such as cyclones, hurricanes, ice storms and windstorms modify the structure, composition and functions of forests. A changing climate will also alter the disturbance dynamics in natural forest pathogens and insect pests, in addition to enabling the establishment and distribution of invasive pest species. Direct impacts of climate change on trees and forest ecosystems coupled with altered disturbance dynamics, can have harmful impacts that can increase the susceptibility of forests. Prediction of future impacts of climate change on forests is complicated by these interactions (Seidl et al. 2017).

Forest ecosystems are affected by changing climatic conditions in many ways including the alteration of habitats and interactions, and the timing of biological events including pollination, herbivory and seed dispersal (Thompson et al. 2009). These alterations are likely to transform existing ecosystems and food webs. For instance, increased temperatures (warming) can affect a particular food web, consequently affecting various other organisms. This may cause the removal of prey or predators that are key in existing food chains. Hence, climate change and associated shifts in environmental conditions can facilitate the spread of pests and diseases, with potentially severe effects on humans, agriculture, forestry and fisheries (National Research Council 2001).

Both native and introduced pest species, and invasive alien plant species, present a threat to natural and planted forests (Wingfield et al. 2010). The availability of complete data at various levels enables the analysis of risks through prediction of future pest eruptions and designing and application of cost-effective protection strategies. This also calls for establishment of effective phytosanitary procedures to reduce cross-border pests and invasive plant species movement (International Trade and Invasive Alien Species 2013) and being vigilant in biosecurity (Burgess and Wingfield 2016).

The mismatches in the timing of food availability, migration, breeding and pest invasion are issues that affect/reduce growth and survival when migrants reach a place before or after presence of a food source. When warming occurs, the habitat ranges change, resulting in expansion or shrinkage of ranges for some species, while others shift to less hospitable habitats with increased competition. Some species may have no option because they have reached the limits e.g., already at the top of a mountain. Consequently, some plants and animals can become locally extinct in some areas. In this regard, habitat destruction and pollution are additional stressors to climate change in contributing to species extinction (Thompson et al. 2009).

## 2.2.1 Forest resilience

In chapter one we learnt about the different terms related to adaptation, and resilience was one of them. In forest ecosystems, resilience can be shown by the ability of the forest ecosystem to absorb climate disturbances and retain the same basic structure, ways of functioning, and the capacity to adapt to stress and change. Forests respond to climate change in various ways depending on local site conditions and the adaptive potential of trees. A forest ecosystem that is vulnerable, has lower resilience when there is a major disturbance linked to climate change. In this section we learn about forest resilience and application of the resilience thinking approach in managing forest resources.

**Learning outcomes**

By the end of this session, the learners should be able to:

i. Explain forest resilience in the context of climate change.
ii. Describe the relationship between forest resilience and adaptation to climate change; and
iii. Explain the principles critical for fostering forest resilience

**Activity 2.3: (Brain storming) (20 minutes)**

- What do you understand by forest resilience?

The United Nations office for Disaster Risk Reduction (DRR) defines resilience as: "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management."

A resilience approach to sustainable development places emphasis on building capacities to tackle unexpected events. The approach considers how people interact with the biosphere (sphere of air, water, and land) as one of its components rather than as external drivers of ecosystem dynamics. As people use various ecosystem services such as food, water, spiritual or cultural values, they demonstrate their dependence and interaction with the biosphere. People also transform the biosphere in numerous ways through activities such as timber harvesting/poaching, expansion of agriculture, settlements, infrastructural development (e.g. roads) and urbanisation. A resilience thinking approach attempts to explore best management options for these interrelating systems of people and nature (social-ecological production systems) to guarantee sustainable and resilient provision of necessary ecosystem services to sustain human existence (Simonsen et al. 2015). Biggs et al. (2015) identified seven principles critical for fostering resilience in social-ecological systems. These include:

i. Maintenance of diversity and redundancy;
ii. management of connectivity;
iii. management of slow variables and feedbacks;
iv. fostering complex adaptive systems thinking;
v. encourage learning;
vi. broaden participation; and
vii. promotion of polycentric governance systems.

Apart from human activities, global climatic changes can also alter forest ecosystems as the biophysical rates and physiological tolerances of species may likely be exceeded. The need to restore or maintain the resilience of the forests as an important societal climate change adaptation measure becomes critical. In forest ecosystems, the biological resources and ecological formations/characteristics determine the system's resilience to changing environmental conditions especially:

- species diversity, including that of micro-organisms;
- the genetic variability in each species; and
- species and ecosystem pools at regional level.

The size of forest ecosystems, and the condition and character of the surrounding landscape contributes to the resilience of a forest ecosystem.

Tree species adapt to rapid changes in climate and have done so repeatedly over geological time through dispersal and genetic changes based on their genetic diversity within local or regional gene pools, suggesting long-term genetic based resilience to change (Thompson et al. 2009). The impact of water stress depends on water conservative traits protecting vulnerable xylem transport system and these dictate patterns of leaf display in seasonally dry tropical forests (Vinya et al. 2019).

> Species that have broad physiological niche requirements are likely to be highly resilient to even significant global climate change. Similarly, species that have a narrow ecological niche may be more resilient than they appear, if altered conditions provide them with an advantage over their competitors (Thompson et al. 2009)

**Activity 2.4 Revision (10 Minutes)**

1.) How does climate change affect resilience of forest ecosystems?
2.) List the principles critical for fostering resilience.
3.) What are the characteristics that determine a forest ecosystem's resilience?

**Summary**

The impacts of climate change on forests are a product of multiple internal and external factors, including how the forests at a particular site respond to such changes coupled with magnitude of consideration. Climate change can alter habitats and associated interactions, and affect the timing of biological events such as pollination, herbivory and seed dispersal. In addition to climate events, disturbances such as fire, landslides, drought, insect and disease outbreaks, species invasions modify the structure, composition and functions of forests. This will also affect their capacity to provide ecosystem services. Forest ecosystem resilience can be shown by the ability of the forest ecosystem to absorb climate disturbances and retain the same basic structure, ways of functioning, and the capacity to adapt to stress and change. .

# 2.3 Forest and tree-based adaptation options in different landscapes

Forests help in maintaining natural ecosystems and protecting the earth against major catastrophes, which are expected to escalate with changing climatic conditions. They also support the maintenance of societal needs providing valuable goods and services for forest dependent communities and urban households. Forests supply wood and non-wood forest products to satisfy people's needs and help them in times of crisis (Shackleton and Shackleton 2012, Dewees 2013). Furthermore, forests promote environmental health that enhances integrity of over- and under-storey layers of the forest system. Hence, forest management can guide the direction and timing of adaptation in different areas. In this session we will discuss how forest and tree resources contribute to climate change adaptation.

**Learning outcomes**

By the end of this session, the learners should be able to:

i ) Explain how forest and tree resources contribute to climate change adaptation in different landscapes in Africa; and

ii ) Discuss the relationship between forest and climate change adaptation and mitigation.

**Activity 2.5 (Group discussion) (20 minutes)**

Discuss how forest and tree resources contribute to climate change adaptation. Cite relevant examples from your country/sub-region/region

Consequently, the provision of ecosystem services and products from forests (such as timber production, protection against natural hazards, water, and biodiversity) may be critically diminished (Jandl et al. 2019) under a changing climate. Forest and tree-based adaptation options are linked to activities that conserve and protect forest ecosystem components, mainly through the reduction of deforestation and forest degradation, soil protection and water conservation in agroecosystems. Forest-based adaptation options in different landscapes need to consider the following:

- Information needed for options of management practices under different settings equilibrium and non-equilibrium environment especially for the countries in semi-arid areas due to high levels of variability, sharp seasonality and temporal and spatial heterogeneity;
- adoption of ecosystem based forest management to encompass structured interdisciplinary approaches that involve concerned stakeholders;
- the role of different partners as this is important in making them understand their role and ensure coordination among stakeholders, and
- sensitisation of decision makers in order to influence decision making processes towards support for conducive policies mainly at the agenda setting stage of policy formulation and decision making.

The ability of forests to cope with, and adapt to disturbances should be prioritised under a changing climate in order to maintain genetic diversity and forest ecosystems resilience. Healthy forest ecosystems provide vital goods and ecosystem services for people, such as clean drinking water and spiritual well-being (Swiderska et al. 2018). For example, countries like Ethiopia, Rwanda and Zimbabwe have used forest-based adaptation measures under watershed management and forest restoration through tree planting, to restore watershed integrity (UNDP 2018). Agroforestry is one of the key adaptive measures that has been implemented in Benin Republic, Mali, and the Democratic Republic of Congo, to improve soil fertility and control soil erosion. An adaptive measure that has been shown to have great potential is

the use of improved fallows among other climate smart options in agro-ecosystems (Partey et al. 2017). Although agroforestry is considered an effective adaptive measure, it has had a number of challenges in some countries as communities usually expect to plant areas for longer periods exceeding the time when tree cover is well established.

**Activity 2.6 Revision (5 Minutes)**

1. Explain important considerations in designing forest-based adaptation options?
2. Give examples of forest-based adaptation measures in Africa

**Summary**

Forests help to maintain natural ecosystems; they protect the earth against major catastrophes; they also support the maintenance of societal needs by providing valuable goods and services to forest dependent communities and urban households. Therefore, forest and tree-based adaptation options are linked to activities that conserve and protect forest ecosystem components, mainly through the reduction of deforestation and forest degradation, soil protection and water conservation. We also learnt about considerations for enhancing forest-based adaptation in different landscapes. We concluded with a few examples of forest-based options in Africa.

# 2.4 Adaptation actions in forest management

There are several adaptation actions that can be implemented to promote resilience and sustainability in forestry. The strategies are aimed at reducing deforestation and forest degradation, enhancing tree planting and promoting best forest management practices, thus maintaining biodiversity and supply of ecosystem services. In this session we will learn about adaptations linked to forest management focusing on adaptive management and forest-based socio-economic adaptation.

**Learning outcomes**

By the end of this session, the learners should be able to:

i) Explain forest related adaptation strategies to reduce the impacts of climate change,
ii) Describe how adaptive management can help in climate change adaptation.
iii) Explain forest-based socio-economic adaptation.

**Activity 2.7: (Brain storming) (10 minutes)**

Share your experiences on adaptation actions linked to forest management.

Table 5 gives an outline of some adaptation strategies related to forestry for selected climate change impacts.

**Table 5: Forest related adaptation strategies for combating climate change impacts**

| Climate change impact | Adaptation strategy |
|---|---|
| Increased fire risk linked to increased incidences of heat waves and increasing areas affected by drought. | » Protecting forests from fire – e.g. fire awareness, fire guards, forest for micro-climate moderation (shading effect) etc.<br>» Reducing deforestation and forest degradation. |
| Erratic rainfall | » Protecting land from soil erosion and floods<br>» Water conservation measures e.g., rainwater harvesting<br>» Using hydrogel during planting in dry season. |
| Severe weather events e.g., droughts/floods | » Tree planting, Watershed management, Advance warning system, Risk management plans. |
| Regulation of water flow and water quality | » Protecting stream banks and catchment areas<br>» Watershed/catchment area management – water storage, regulation and erosion control.<br>» Forest land restoration- forest ecosystems reduce sedimentation and can mitigate floods. |
| Declining agricultural productivity | » Sustainable forest management – NTFP utilization<br>» Agroforestry. |
| Pests and diseases outbreaks | » Selection of resistant species, breeding for resistance, biological control, train extension officers on various pests. |

The Global EbA in Mountains Programme in Uganda, used the Vulnerability and Impact Assessments (VIAs) to enable a more integrated landscape level planning process, building on prior participatory assessments. The gravity flow scheme was embedded in a broader catchment and riverbank management plan, and tree planting was integrated into broader landscape restoration. Information from the VIA was used as the basis for developing new catchment management and district development plans for Mount Elgon, helping to ensure the sustainability of EbA measures (Swiderska et al. 2018).

Due to the uncertainties surrounding the the timing of climate change impacts, options such as Ecosystem-based adaptation (EbA) are emerging to support biodiversity conservation in the face of climate change. EbA includes sustainable management, conservation and restoration of biodiversity and ecosystems to provide services that help people adapt to the adverse effects of climate change (Swiderska et al. 2018). EbA encompasses adaptation policies or procedures that take into account ecosystem services and their role in reducing society's vulnerability to climate change in a multi-sectoral and multi-scale approach (Vignola et al. 2009; UNEP 2012). EbA will be discussed in detail in chapter 4.

Apart from adapting to climate change impacts, adaptation strategies and actions should also reduce the vulnerability of forest ecosystems and their services to other threats, such as pollution and land-use change. Particular ecosystem services that are critical for adaptation in a particular region can be conserved or restored through EbA. For example, forests being managed to provide reliable clean water, may need their management plans and priorities revised and improved to suit a future under a changing climate. In adapting forests to climate change, three possible options were suggested by Bernier and Schoene (2009):

i. no intervention;
ii. reactive adaptation; or
iii. planned adaptation.

Under no intervention, business as usual, approach is taken with the objectives based on the assumption that the forests will adapt as they did in the past. Reactive adaptation takes place after the climate change event and is mainly corrective. In doing the corrections, responses to similar events will be improved bearing in mind that extreme events will be a regular feature of climate change in the future (Bernier and Schoene 2009). Bernier and Schoene (2009) indicated that this decreases vulnerability, improves resilience, and increases adaptive capacity. Reactive adaptation activities include the following:

- revision of harvesting schedules;
- salvage harvesting;
- recalculation of allowable cuts;
- post-disturbance modifications of industrial processes to process the salvaged timber; and
- developing socio-economic support for affected areas.

### 2.4.1 Adaptive forest management

Sustainable and diverse forest and tree-based livelihoods entail continuous provision of important goods and services from forests to local communities at risk of threats related to climate. In this regard, sustainable forest management (SFM) becomes key to achievement of continuous supply of forest goods and services. Sustainable forest management entails a system of practices aimed at the maintaining and enhancing economic, social and environmental values of forest ecosystems. The principles of SFM can be used to reduce the sensitivity and exposure while enhancing the adaptive capacity of forests. In this regard, SFM becomes important in climate change adaptation (Seppälä et al. 2009). For instance, there may be need to formulate fire management policies and plans as well as build human capacity to cope with longer and more severe fire seasons, increasing fire frequency, and larger areas exposed to fire risk (Keenan 2015).

Ethiopia is implementing a 10-year Oromia Forested Landscape Program to reduce deforestation and greenhouse gas emissions from land use in all of the forested areas in the regional state of Oromia through an integrated landscape approach, by addressing trade-offs and synergies among forest, livestock, crops, water, and household energy needs. The activities include payments for ecosystem services, where farmers or landowners are given incentives to manage their lands in ways that provide an ecological service, such as climate regulation, fresh water or cleaner air. Similarly, Mozambique is implementing the Zambezia REDD+ Integrated Landscape Management Program (World Bank 2015).

Adaptive forest management includes several silvicultural measures such as changing species composition by converting monocultures to mixed forests, manipulating forest structure (e.g., shifting from even-aged to uneven-aged or coppice to high forest), intensification of thinning, or the reducing of rotation age (Yousefpour et al. 2017, Cosofret and Bouriaud 2019). Thinning is a silvicultural operation that focuses on the stimulating growth of large residual trees, improves drought resistance, and provides greater resilience to future climate-related stress (Kerhoulas et al. 2013). Reducing of the rotation period of tree crops can decrease their exposure time to risk and also reduces the risk of wind throws by limiting the height to be reached (Schelhaas 2008). These adaptive management techniques generally reduce uncertainty and allow better adapted species to be replanted (Cosofret and Bouriaud 2019).

In adaptive forest management, responsive adaptation activity, adjustments or interventions are processes that create or enhance the following;

- resilience and improved livelihoods;
- resilience and improved productivity in ecosystems; and
- sustainable governance - e.g. regulatory, institutional, educational (Lim et al. 2004).

For example, after a cyclone had destroyed housing infrastructure, all new houses that are to be constructed will have new building standards to enable them to be much stronger. In forestry, post cyclone salvage harvesting by the forest industries can be done. African nations' responsive adaptive actions have been linked to activities such as subscribing and being signatories to international initiatives such as UNFCCC, UNCCD, CBD and SDGs. Initiatives include rehabilitation of degraded lands, participatory and sustainable forest management, afforestation and reforestation programmes, REDD+ based activities and the Bonn challenge (to bring 150 million hectares of degraded and deforested landscapes into restoration by 2020 and 350 million hectares by 2030). The initiatives are aimed at reducing atmospheric carbon emission and managing the impacts of climate change by increasing resilience of communities and ecosystems (Rizvi et al. 2015).

**Activity 2.8 Revision (10 minutes)**

Describe the forest-based adaptation activities that can improve or create the following outcomes:

i.) resilience;
ii.) livelihoods; and
iii.) productivity in ecosystems.

On the other hand, planned adaptation, includes the redefinition of forestry objectives and procedures in anticipation of climate change-related risks and uncertainties. Deliberate, anticipatory interventions are defined at various levels and across the sectors. For communities, planned adaptation can consist of broadening/diversifying forest-based and non-forest-based income sources, improving local forest resource governance and building capacity for monitoring and coping with potential threats. Within the forest industry sector, planned adaptation may involve use of bioenergy for promoting low carbon wood products. At national and global levels, planned adaptation can include appropriate tools for monitoring and reporting, vulnerability assessments and adaptation planning (Bernier and Schoene 2009).

Planned adaptation in forest management can be used as an adaptation strategy that can be included in monitoring forest resources. Multiscale and risk assessments can be used for early detection of the status and health of the forest. Furthermore, the development of planting stock with desirable genetic traits for productivity, drought tolerance and pests/diseases resistance may be a promising strategy to counter changes in the local climate (Bernier and Schoene 2009). Sustainable management of forests reduces or reverses forest losses and degradation while increasing resilience of forest to climate change. In the developing world, technical capacity building and concerns about equity and social justice are also important for the forest sector's adaptation to climate change (Keenan 2015).

The forest-based activities that support the sustainable provision of goods and services even under a changing climate include; participatory forest management; fire management in natural environments; rehabilitation of degraded lands; environmental awareness/training; promotion of sustainable and diverse tree based livelihoods, agroforestry and other tree planting activities; regulation of water and protection of soils to reduce climate impacts; protection of coastal areas from climate-related threats; promotion of urban forests and trees to regulate temperature and water and support for resilient cities; building social systems and promoting gender in forestry.

Further reading at https://www.bonnchallenge.org/about.

## 2.4.2 Forest-based socio-economic adaptation

Globally, more than 1.6 billion people depend on forests for subsistence, livelihoods, employment and income generation, and the wide range of forest-based goods and services create opportunities to address sustainable development challenges (UNFF 2015). Forests and trees are basis of life and are critically important for human and societal development (Arce 2019), because they provide wood and non-wood/non-timber forest products, buffering communities during periods of scarcity, and are a source of nutrition for the poor (Agrawal et al. 2013). Globally, communities in rural areas depend on forest products when reacting to stresses (coping tactics) especially after crop failure resulting from drought, or when they want to overcome post disaster stress.

Sustainable livelihood comprises the capabilities, assets, and activities required for a means of living that is able to cope with and recover from stresses and shocks, maintain or enhance its capabilities, assets, and activities now and in the future, while not undermining the natural resource base (Serrati 2017). Social vulnerability considers the condition of human systems that can be manipulated by economic, political, cultural and social factors that are likely to put communities at risk, apart from reducing their capacity for climate change adaptation. Climate change adaptation can be supported by forests and trees through:

- provision of important goods to local communities at risk of climatic threats;
- regulation of soil, water, and microclimate for more resilient growing of crops and trees in agricultural fields and trees in forested watersheds;
- regulating water and protecting soils to reduce climate impacts;
- protecting coastal areas from climate-related threats;
- urban forests and trees regulating temperature and water to support resilient cities; and
- provision of timber and non- timber forest products (NTFPs) including charcoal, mushrooms, firewood, medicines, wild fruits, roots, fibre and fodder that provide safety nets and alternative sources of income from diversified options for most rural communities in developing countries especially after climate hazards or climate variability (Pramova et al. 2012).

The forest-based activities that support the sustainable provision of goods and services under a changing climate should strengthen indigenous knowledge based coping and adaptation options. Although these activities have promoted livelihoods diversification, they tend to reduce sensitivity and exposure to climate change as they are mainly ecosystem-based (UNDP 2018).

Nevertheless, for sustainable livelihoods to be realised, an understanding of poverty reduction is essential because poverty is both a condition and one of the determinants of vulnerability. Poverty reduction requires an understanding of how local livelihoods are conducted and sustained, because the assets and capabilities that comprise peoples' livelihoods often shape poverty and the ability to reduce it (IUCN et al. 2004).

**Activity 2.9 Revision (10 minutes)**

1. Explain adaptation strategies linked to different types of climate impacts.
2. List some reactive adaptation strategies linked to forest management.
3. Explain the relevance of adaptive forest management in climate change adaptation.
4. How does forest management strengthen social systems adaptation.

**Summary**

In this section we learnt that there are several adaptation actions that can be implemented to promote resilience and sustainability in forestry. The strategies target reduction of deforestation and forest degradation, enhancing tree planting and promoting best bet forest management practices to promote and maintain biodiversity and the supply of ecosystem services. Approaches include adaptive management, Sustainable Forest Management and forest-based socio-economic adaptation options. Apart from adapting to climate change impacts, adaptation strategies and actions should also reduce the vulnerability of forest ecosystems and their services to other threats, such as pollution and land-use change. Reactive adaptation activities include revising harvesting schedules, salvage harvesting, recalculation of allowable cut, post-disturbance modifications of industrial processes to process the salvaged timber and developing socio-economic support for affected areas. Forests help people and ecosystems to adapt to climate change and can exacerbate climate change when destroyed or degraded

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## 2.5 Nexus between forest and climate change adaptation and mitigation

There is an intricate relationship between forests, climate change adaptation and mitigation. As earlier mentioned, forests provide goods and services for people and serve as important safety nets for communities who are forest dependent. The existence of forests helps people and ecosystems to adapt to climate change. Different forest ecosystems are major reservoirs of varying quantities of carbon; so, forests can also mitigate climate change through absorption of atmospheric carbon dioxide ($CO_2$), although, in consequence, therefore, forests can also exacerbate climate change when destroyed or degraded. The linkage between adaptation and mitigation is demonstrated by the fact that adaptation is often about responses to local circumstances and therefore becomes a local concern benefiting local populations, while mitigation is a response to a global concern and is usually dealt with at the national, regional and global scales. Forest investment for wood production through improved silviculture or plantation forests represents a joint mitigation and adaptation measure (IPCC 2007b). Adaptation and mitigation can also be achieved through international initiatives such as REDD+, which is mainly considered as reduction of global emissions of $CO_2$ to the atmosphere but also represents adaptation because it explores novel opportunities created by climate change in the form of carbon credit sales, incentive payments, and forest investments (Bernier and Schoene 2009).

The storage of carbon in soil and biomass entails climate change mitigation. FAO (2012) demonstrated that forest have four major roles in climate change:

- contributing about one sixth of global carbon emissions when cleared, overused or degraded;
- reacting sensitively to the changing climate;
- when managed sustainably, they produce wood fuels as a benign alternative to fossil fuels;
- have the potential to absorb about one-tenth of global carbon emissions projected for the first half of this century into their biomass, soils and products and store them - in principle in perpetuity.

Source: http://www.fao.org/forestry/climatechange/53459/en/

# 2.6 Case Studies

### 1. Forest Investment Programme in Burkina Faso and Ghana

There are several projects implemented in Africa dealing with all sectors (e.g. agriculture, forestry, energy and fisheries) affected by climate change. The Forest Investment Program (FIP), through the African Development Bank has sponsored projects in Ghana and Burkina Faso, focusing on sustainable forest management, through actions of reducing deforestation and forest degradation and instituting sustainable forest management (REDD+), and engaging in agroforestry and sustainable agriculture. Burkina Faso was specifically, allocated US $30 million whilst Ghana got US $50 million for the activities. In Burkina Faso, they manage the state-owned forests, emphasising on participatory methodologies and sustainable governance, whereas in Ghana, they are dealing with national primary drivers of deforestation and catalysing transformational adjustments through design of new models of managing forests, access and benefit sharing mechanisms, new economic instruments and incentives, private sector engagement in REDD+, and enhancing coordination and knowledge sharing. Source: https://www.afdb.org/en

### 2. Foresting watersheds, regulating water and protecting soils for reduced climate impacts

Heavy rains in Cameroon resulted in massive landslides with flows of debris from mountainous areas, accompanied by river overflows, dam breaks, and flooding. The impacts were worsened by the lack of forest cover on mountain slopes and watersheds to protect the soil and reduce peak flood flows. Another factor contributing to severity of the disaster impact was land-use change. No tree cover = vulnerability to climate related disasters (Bele et al. 2011).

### 3. Forests as safety nets after climate related disasters

Forests help to sustain natural ecosystems, contributing to natural protection against key catastrophes, which are expected to increase with climate change. During the 2005-2006 drought period, forest products were consumed directly by communities in Tanzania as part of daily food intake, and 42% of their total income was realised from the sale of firewood, wild fruits, charcoal and timber (Enfors and Gordon 2008). In another community in rural Peru, people collected palm hearts, wild fruits, and other forest products to survive after a flood (Takasaki et al. 2004). Furthermore, in Honduras, forest products helped rural communities to cope with the after effects of Hurricane Mitch by selling timber and other forest products (McSweeney 2005).

**Summary**

In this chapter we discussed how forest ecosystems are affected by climate change and how they react to impacts of climate change. We also learnt that forest ecosystems are reservoirs of organic carbon and can mitigate climate change by absorbing atmospheric (CO2). Furthermore, we looked at how people depend on forests when adapting to climate change. Forests have an important role in helping ecosystems and communities adapt to climate change. Forest and tree growth are a product of multiple internal and external factors, including changing temperature and precipitation and extreme events which can destroy the forest ecosystem components. Changing climate affects plant physiology, mortality, growth, regeneration and reproduction and indirectly affects ecosystems by changing the structure, species composition and diversity of plant communities. A changing climate will also alter the disturbance dynamics in natural forest pathogens and insect pests, in addition to enabling the establishment and distribution of invasive plant and pest species. Furthermore, climate change can trigger habitat reduction, leading to migration of species. In marine and coastal ecosystems, rising sea level can cause intrusion of saltwater into freshwater bodies, pushing/moving some important species out or making them extinct. Susceptibility of forests depends on the frequency, duration, intensity and time of disturbance occurrence. Forest and tree resources respond to climate change through alterations of their genetic diversity and dispersal within local or regional gene pools, depending on environmental factors and adaptive potential of the trees. Forest and tree-based adaptation options in different landscapes are linked to activities that sustainably conserve and protect forest ecosystem components, mainly by reducing deforestation and forest degradation, protecting the soils soil and conserving water in agroecosystems. Forest-based adaptation actions for climate change impacts include reducing deforestation and forest degradation, protecting forests from fires, tree planting, soil and water conservation, watershed management, agroforestry, restoration of degraded forest areas, streambank and catchment area protection, use of hydrogel, selection of pest and disease resistant, drought tolerant species and sustainable forest management. These can be achieved through approaches such as ecosystem-based adaptation, adaptive forest management or forest-based socio-economic adaptation (sustainable livelihoods). Forests help people and ecosystems to adapt to climate change and can exacerbate climate change when destroyed or degraded.

**Further reading:**

Arce 2019. Background Analytical Study Forests, inclusive and sustainable economic growth and employment. https://www.un.org/esa/forests/wp-content/uploads/2019/04/UNFF14-BkgdStudy-SDG8-March2019.pdf

IUCN 2016. Making the Case for Forest Restoration: A guide to engaging companies. Gland, Switzerland: IUCN. https://portals.iucn.org/library/node/45203

# Chapter 3: Non-Forest-Based Climate Change Adaptation Strategies and Actions

## 3.1 Chapter overview

We have already learnt that climate change affects all sectors through increased frequencies of floods and droughts, resulting sometimes in famine, loss of ecosystem functions and loss of biodiversity. These occurrences are likely to worsen as climate change progresses. Climatic variables such as precipitation, temperature, humidity, radiation, etc. directly affect the productivity of agriculture, fisheries and forestry systems. This is because vegetative growth, animal production and their development require optimum climatic conditions. These sectors have developed coping and adaptive strategies to ensure their survival. In the preceding chapter, we focused on adaptation strategies and actions based mainly on the forestry sector. The other sectors impacted by climate change outside the forestry sector include the agricultural sector (crops and livestock); water resources; transport and energy sectors; coastal, marine and fisheries; insurance and tourism sectors. These will be discussed in the following sections followed by discussions of adaptation in selected sectors.

**Learning outcomes**

By the end of this chapter, the learners should be able to:

i. Explain the impacts of climate change on sectors outside forestry.
ii. Identify adaptive actions for sectors outside forestry.
iii. Apply traditional coping strategies to local climate change challenges.
iv. Discuss the relationship between forests and other sectors.

**Activity 3.1 (Brainstorming) (10 minutes)**
What are some of the climate change coping mechanisms in sectors outside forestry?

# 3.2 Sectors outside forestry impacted by climate change

## 3.2.1 Agriculture.

The yield and nutritional quality of agricultural production strongly depends on a balance of appropriate biophysical resources, including water availability, soil quality, sufficient sunlight, suitable temperature, $CO_2$, and, in some instances, the abundance of pollinators (Myers et al. 2017). Agricultural activities include the cultivation of all types of plants and other life forms such as crops, livestock and all products produced for food, energy, fibre, and other purposes to fulfil human needs, sustain and enhance humanity. Climate change impacts such as increasing temperatures, increased atmospheric $CO_2$, and increased frequency and magnitude of extreme weather events such as droughts, are expected to affect crop yields and production processes (Lobell et al. 2011, IPCC 2018). Increased atmospheric $CO_2$ increases the rate of photosynthesis and water use efficiency (Long et al. 2006). Hence crops that have a $C_3$ photosynthetic pathway, such as rice, wheat, and soybean, experience greater stimulation of growth than crops with a $C_4$ photosynthetic pathway, such as sorghum, maize, and sugarcane (Leakey et al. 2009). Changing climatic conditions reduce growing seasons due to shifting climatic zones; this phenomenon, coupled with water scarcity, leads to poor crop yields.

As more and more areas in Africa are expected to become arid or semi-arid, agricultural production is projected to decrease. With more than 70% of the population dependent on agriculture and about 40% of the continent's total exports being agriculture-based, Africa will suffer more than other regions from the impacts of climate change. In spite of the impact of climate change on agriculture, agriculture is also a driver of climate change. The ways in which agriculture is impacted by climate change are explained in Table 6:

**Table 6: Effects of climate change on agriculture**

| Effect | Description |
|---|---|
| Reduced crop yields and agricultural productivity | Crop yields are expected to decrease due to temperature increases, reduced arable land, poor soil fertility and quality, drought, flood, disturbance of seasonal farming cycle |
| Increased drought periods | Natural resources dependent people migrate out after frequent droughts- this could reduce labour availability for agricultural production.<br>Soils become impoverished and yields of crops decline drastically<br>Work load of women will increase and livelihoods will be reduced |
| Limited water availability | Soil moisture and soil moisture storage capacity, which are vital for agricultural crops are reduced with increased temperatures.<br>Small quantities of rainfall reduce quantity of water in water bodies affecting capacities for irrigation<br>Women workload for fetching water increase and livelihoods will be reduced |
| Reduction in soil fertility. | Limited availability of soil nutrients and other needed soil parameters for crop production reduce crop yields. |
| Reduced livestock productivity and high cost of production | Livestock is affected by heat stress.<br>Indirectly, affects availability of feed and fodder that negatively affects animal health, dairy production, meat quality and reproduction.<br>Could impact food security leading to protein deficiency and under-nutrition. |
| Increased pest incidences | Increase in temperatures is likely to be conducive for proliferation of pests that are detrimental to crop and livestock production. A good example is the recent arrival and proliferation of the Fall armyworm Spodoptera frugiperda in West and Southern Africa in 2017 and 2018 (Nagoshi et al. 2018) and locusts in Eastern Africa in 2020 (Figure 10). |

| Effect | Description |
|---|---|
| Food and distribution costs increase | Higher temperatures increase the need for refrigeration in the food distribution network.<br>Food shortages resulting from drought, cause prices of food to increase due to shortages and changes in consumption patterns. |
| Absence of human resources | Increased temperatures and humidity create favourable conditions for infectious diseases that will directly affect the availability of agricultural labour<br>When many people are diseased, availability of on-farm labour is affected |
| Outmigration and low availability of labour for agriculture | Poor performance of the agricultural sector, causes migration of youths out of farming communities to urban areas. |
| Tensions/ conflict and displacement of people | When climate induced events affect agriculture and natural resources, people and livestock move in search of water, food/feed. This creates competition over scarce resources, which is likely to degenerate into social unrest/conflicts.<br>A good example is the movement of herdsmen and their cattle from the Sahel region of West Africa to farming communities in an effort to meet food security needs. |

**Figure 10: Locust invasion in East Africa in 2020**

Agricultural production in some parts of Africa is expected to decline by 20% in 2050, with the greatest impact on the rural poor whose livelihoods are heavily dependent on agriculture (Deloitte 2017). When temperatures and precipitation reach extreme levels, the reproductive growth of crops is affected (Fahad et al. 2017). Increases in atmospheric $CO_2$ and the warming of the earth can improve yields of some crops. Evidence shows that the increased $CO_2$ levels can promote plant growth but reduce nutritional value of most food crops. For example, increased atmospheric $CO_2$ levels, reduced protein and concentration of essential minerals in plant species, such as rice, wheat and soybeans (Ziska et al. 2016). Furthermore, weed, pest, and fungal species grow more under warm temperatures, wetter climates, and increased $CO_2$ levels (Ziska et al. 2016, Myers et al. 2017). In addition, extreme rainfall events increase runoff and flooding (IPCC 2013) resulting in degradation and crop damage.

**Activity 3.2 (5 minutes)**

- How can farmers be sensitised to recognise the importance of responding to climate change?

Livestock are affected directly by heat wave, which directly compromises their growth and survival (pigs, cattle, poultry, etc.), whilst drought indirectly affects livestock by reducing feed quality and available pastures (Bernabucci et al. 2010, Nardone et al. 2010, Lara and Rostagno 2013). Climate change could also increase the outbreak of livestock parasites and pathogens (Myers et al. 2017). To maintain livestock health, there must be potential changes to some veterinary practices to respond to climate-induced changes. Although productivity of pastures can increase with increase in atmospheric $CO_2$, their quality could also decrease. But, when higher $CO_2$ concentration reduces the quality of forage in pasturelands, the same nutritional benefits can be obtained when livestock consume more of the low quality forage (Bernabucci et al. 2010).

Pastoralism as one of the main land use practices constituting an important social, economic and environmental component of forest ecosystems, especially natural forest and woodlands in Africa's arid and semi-arid areas, including the savanna. Pastoralism is a system where pastoralists herd large numbers of livestock in planted, and/or natural forest and open woodlands. The Humanitarian Policy group (2009) stated that pastoralism had unique climate change adaptive characteristics that can be optimised by enabling policies to achieve the development agenda. Pastoralists use mobility to respond quickly to fluctuations in resource availability, dictated by the drylands' scarce and unpredictable rainfall. They also employ a number of highly specialised risk spreading strategies to safeguard their herds against drought, floods, disease and social unrest. Pastoralists employ the following strategies to adapt and cope with climate change (ibid):

- Increase herd sizes as insurance against times of hardship;
- splitting herds across different locations to spread risk;
- move to greener pastures;
- keeping different species and breeds; and
- loaning surplus animals to family and friends.

If supported by the right policies, pastoralism can become a resilient, low input land use option that can perform well under variable climatic conditions.

## 3.2.2 Water resources

Climate change affects all types of water. Scarcity of water, especially freshwater, has become a global problem, with its intensity aggravated by climate change and human activities. Freshwater is the water from precipitation and can be divided into green and blue water resources. Green water is site-specific precipitation that does not run off and can be in the form of productive green water, i.e. transpiration from biomass production in terrestrial ecosystems, or the non-productive green water, i.e. interception and soil evaporation. Blue water is surface and groundwater that is stored in aquifers, rivers, dams and lakes and can be extracted for human use (Rockström and Falkenmark 2000, Falkenmark and Rockström 2006).

Water shortage is an induced problem attributed to climate change that affects a quarter of the African population. The situation will be further exacerbated by declining precipitation, particularly in northern and southern Africa. Therefore, wide-scale adaptation measures are required to manage the situation. This is because water problems can hinder agricultural development, through variability of rainfall patterns, flooding, soil erosion and saltwater intrusion into coastal freshwater aquifers (Jiménez Cisneros et al. 2014). These serious consequences result in reduced food productivity and availability.

In this regard, water resources are affected by the amount of rainfall and the rate of ground water recharge. When there is little or excess rainfall in the wet season, other sectors are affected, through economic losses due to the vulnerability of crops/livestock to drought or flooding. Increased evaporation and variability of precipitation can result in a decrease in soil moisture available to plants, eventually affecting crop yields and hence food security. Furthermore, there will be a reduction in water yield of near-surface springs. Too much water in the form of floods makes people vulnerable to flood risks and causes pollution (Prutsch et al. 2014). Increased water shortages can affect industries specialising in soft drinks and bottled-water and this may affect their pricing.

## 3.2.3 Health

The geographical spread of perilous tropical diseases appears to be changing and Africa's vulnerability to climate sensitive diseases such as cholera, malaria, tuberculosis and diarrhoea is increasing. In areas where tropical diseases are spreading, the situation is worsened by poor hygienic conditions. Diseases such as malaria are likely to be more prevalent in certain regions, than others, depending on climatic conditions (Lindsay and Martens 1998). Some pathogens that thrive in flood conditions, become more prevalent after the occurrence of floods when the temperatures are high. Increased temperatures modify the geographical distribution of disease progression, due to disease causing vectors/pathogens migrating to new areas and higher altitudes. The malaria mosquito moves to higher altitudes (to previous malaria-free zones) exposing large numbers of previously unexposed people to infection in densely populated areas in East African highlands of Rwanda, Burundi, Kenya, and Ethiopia. The emergence of vector and vector-borne diseases, due to increased temperature and humidity creates conducive environment for infections that will directly affect human capacities (UNECA 2011). Increased incidences of other diseases such as sleeping sickness, cholera etc. will affect the health of more people in sub-Saharan Africa. Rift valley fever, which is affecting livestock and people, has been linked to rainfall episodes and its incidence is expected to continue to rise due to climate change (Caminade et al. 2011).

Climate variability coupled with other stresses and vulnerabilities such as HIV/AIDS (Department for International Development (DID) 2006), conflicts and wars (Harrus and Baneth 2005) are major drivers and contributors for the emergence and spread of infectious diseases. Increased $CO_2$ levels are a potential threat to human health and can affect affordability and availability of nutritious food (Serdeczny et al. 2016). Unfortunately, the short term solution of using pesticides and herbicides endangers people's health as pest pressure increases while pesticide efficacy reduces.

## 3.2.4 Infrastructure, settlements and industry

Besides social conflicts and pollution, increased occurrence and magnitude of weather disasters continue to pose problems in settlements, and to infrastructure and industries. Tropical cyclones and flooding events can cause severe damage or loss to property (Chinowsky et al. 2015, Pudyastuti and Nugraha 2018) Although the population in African urban areas is relatively low, droughts and other weather-induced catastrophes continue to cause migration of people from rural to urban centres, to seek alternative sources of livelihoods due to declining agricultural productivity attributed to climate change (Stapleton et al. 2017).

Climate change and variability will increase the rate at which extreme natural disasters destroy infrastructure and houses. Hence, the construction and housing sectors are highly vulnerable to increased frequency of tropical cyclones and heavy rainfall. The capacities of buildings to cope with rainwater and waste-water systems such as gutters and sewage systems will be tested (Pudyastuti, and Nugraha 2018). Another challenge is the fact that increases or reductions in temperatures affect the design of building infrastructure, with increased demand for improved energy efficient heating and cooling systems. Furthermore, there are chances of increased heat stress and deteriorating indoor conditions due to higher concentrations of pollutants inside buildings or sealing/insulation measures. Green infrastructure (e.g. green roofs, urban parks

and porous pavements) can improve storm water management and reduce flood risk in cities, and can moderate the heat-island effect, in addition to provision of some co-benefits for mitigation against climate (Noble et al. 2014). Box 10 summarises impacts of climate change on infrastructure.

At the local level, infrastructure associated with the provision of basic services, such as water, power, sanitation, solid waste disposal, storm water, road and public transport management are important for increasing adaptive capacity (Barron et al. 2012)

**Box 10: Impacts of climate change on infrastructure and housing development**

- Heat stress can increase and indoor conditions become poor
- Sealing/insulation measures can increase concentration of pollutants inside buildings
- More energy demand for cooling in summer
- Energy demand for heating can be decreased in winter or increased when winters become colder
- More frequent heavy rains can increase mass movements e.g. mudslides, landslides etc.
- Buildings and other structures can be damaged due to increased fluctuations in temperature and distinct changes in water table levels
- Increased frequency of heavy rains can overload the capacities of buildings, residential rainwater and waste-water systems (sewer systems, gutters, sewage treatment plants, etc.)
- Buildings and infrastructure can also be damaged by storms (Prutsch et al. 2014) National Park, resulting in a severe bark beetle outbreak over an area of 12 000 hectares (FAO 2010).

### 3.2.5 Transport and energy

The transport sector entails rail, road, air and marine/water transport systems. This sector is a vital enabler for most business activities as nearly all other sectors rely on transport infrastructure to move goods and services from one place to another. Climatic change events such as storms, high temperatures, cyclones, heavy rains, hurricanes etc. and rising sea level damage transport infrastructure (Chinowsky et al. 2015). This increases maintenance costs and disrupts transportation of goods and services. Lack of resilient and reliable transport infrastructure reduces and/or hampers economic growth and investment opportunities. This will have a negative overall impact on human welfare and socio-economic development (Gachassin et al. 2010). The risks associated with climate change in the transport sector include:

- extreme weather conditions directly interfere with machinery operation, creating delays and increasing operation costs;
- higher temperatures soften pavements causing them to expand, forming potholes as well as distortion of rail tracks;
- flooding, when exacerbated by periodic torrential rainfall, creates a risk to road, sea, rail and air network (Figure 9);
- port facilities are damaged by severe storms and sea level rise; and
- destruction of road infrastructure especially bridges.

**Figure 11: Road destruction after cyclone Idai in Zimbabwe in 2019 (a) bridge swept away (b) road destruction and (c) softening of road surface**

On the other hand, the transport sector presents its own challenges associated with GHG emissions. The sector is also constrained by insufficient data about transport policies and the complications of the transport system. No doubt, the transport sector, in many countries contributes significantly to national GHG emissions. The transport sector needs to be effective, efficient and climate-resilient in order to lower operational costs and improve on competitiveness (Twerefou et al. 2015).

The energy sector is affected by climate factors such as temperature increase, extreme weather events (storms, cyclones), fluctuation in precipitation and rising sea-level (European Union Energy Initiative 2017). The energy sector is important because it needs to improve its efficiency by using improved technologies that reduce energy costs as well as GHG emissions. Under a warming climate, heating energy needs will decline whilst cold climatic conditions increase the need for heating energy with the magnitude depending on the socio-economic, geographical, and technological circumstances. Efficiency of thermal conversion will decrease as a result of rising temperature in thermal power stations. Additionally, the use of fossil fuels can emit GHGs and environmental pollutants into the atmosphere (IPCC 2011, Abdollahi et al. 2019). Furthermore, the lucrative oil, gas and coal industries are likely to be threatened by international regulations on use of fossil fuels in efforts to reduce GHG emissions (Caldecott et al. 2013).

Efficiency of existing steam power plants can, however, be improved to reduce emissions. Furthermore, the volume of thermal power generation in many regions will decrease and increase in their use of cooling water, leading to reduced generation of power, reduced capacity, and some temporary shutdowns. Many countries in Africa have considerable fossil energy resources (African Climate Policy Centre (ACPC) 2013). Moreover, most rural areas in Africa have no electricity supply, and use biomass as the most important primary source of energy (Bildiricia and Özaksoy 2016). As exploitation of fossil fuels and bioenergy sources become less attractive due to climate change and dwindling reserves and stock, there will be a gradual shift to renewable energies and new technologies, providing opportunities for countries to quickly exploit their potential and invest in the necessary expertise and infrastructure.

The use of biofuels has been advocated to ease the fossil fuel burden in most developing countries. Examples of biofuel use in Africa include bioethanol generation from sugarcane in Malawi and Zimbabwe, Jatropha electrification in Mali, the use of sisal waste for biogas production in Tanzania and the production of ethanol from cassava in Benin (Smeets et al. 2009, Watson 2009, Smeets et al. 2020). Some African countries (Botswana, Burkina Faso, Cameroon, Gambia, Ghana, Zambia, Kenya, Liberia, Sierra Leone, South Africa, and Tanzania) developed, formalised and implemented policies on the use of bioenergy (COMPETE project 2009).

**Activity 3.3 (Group discussion) (20 minutes)**

- Discuss the role of biofuels in responding to climate change in the transport and energy sectors in your country or region.

## 3.2.6 Coastal and marine systems and fisheries

Adaptive options in marine and coastal areas include structural and non-structural protection, accommodation (land use change), and retreat or resettlement. Low-lying coastal areas are threatened by rising sea-levels which are disrupting groundwater levels and leading to reduced availability of fresh water. Oceans are predicted to be deoxygenated, warmed and acidified by impacts of climate change (Gattuso et al. 2015) thus modifying net primary production (Boyce et al. 2010) and generally displacing habitats (Garcia et al. 2015). The fishing industry is affected by ocean acidification because certain species of shellfish cannot thrive in more acidic environments (Speers et al. 2016, Myers et al. 2017). Sea level rise will therefore, affect the fishing industry which is facing problems such as water pollution and overfishing. For example, salmon and trout, grow well in cold, free-flowing water but they are threatened by habitat loss if emissions of heat-trapping pollutants are not reduced. These pollutants are estimated to be as high as 17 % and 34% by 2030 and 2060 respectively (Kinsella et al. 2008).

Furthermore, the timing of reproduction and migration of aquatic organisms, which is typically controlled by temperature, is susceptible to climate change. Marine disease outbreaks have also been linked to changing climatic conditions. This is because higher estuarine salinities and increased water temperatures have enabled the spread of parasites and diseases of oyster and salmon, respectively. In addition, disease outbreaks in coral, eelgrass, and abalone have also been linked to warmer temperatures (Khan et al. 2020). Heat waves and sea level rise have been implicated in degradation of mangrove forests while gas flaring continues to pollute water bodies. Similarly, saltwater can intrude into some freshwater systems due to rising sea levels and this can either push/move some important species out of their habitat or cause them to become extinct. This affects fishing and farming activities; hence, exacerbating poverty for communities whose livelihoods are directly dependent on agriculture and fisheries (Omeire et al. 2014).

## 3.2.7 Climate change and the Insurance sector

Insurance is associated with reduction of disaster risk and adaptation to climate change, because it allows recovery, reduces vulnerability, and offers information and incentives for decreasing risks (IPCC 2012). Hazards, including tropical cyclones; hail storms; pests; diseases; storms; river, maritime and flash floods from rainfall and melting snow including winter storms, are expected to intensify and be more frequent with climate change. It is estimated that climate change and variability will increase losses and loss variability in several regions of the world due to these increased, recurrent and/or severe weather catastrophes.

The insurance industry is likely to be strained by climate change events such as rising sea levels and the possibility for increases in catastrophic flood incidences that may increase both the premiums and pay-outs. Not everyone will require disaster insurance because disasters such as floods only impact on certain low-lying areas while property owners in highland/raised areas have no justification to purchase flood insurance. Flood insurance is therefore more expensive because there are few purchasers who are usually not included in most insurance schemes. Insurer Climate Risk Disclosure Survey Report and Scorecard (2016) revealed that only a third of global losses from weather-related disasters were covered by insurance. Adaptation in the insurance sector can be improved using risk-commensurate insurance premiums while financial resilience can be improved through risk management.

### 3.2.8 Climate change and the Tourism sector

Climate and weather are important factors affecting tourism because they influence decisions on the choice of destination. Recreation and tourism are weather-dependent. The tourism sector is vulnerable to risky weather. For instance, if winters get shorter and warmer and the precipitation turns to rain, areas that are more dependent on cold-weather tourism will lose considerable revenue. In most cases, holidays are planned in advance, and tourism activities depend on expected weather which will increasingly become erratic due to climate change and may affect demand for recreation and tourism services (Rotich et al. 2020).

However, tourists can adapt to climate change by adjusting timing, regions to visit and their holiday activities. Those dealing with recreation can also adjust the timing of their activities while seasons and schedules for tourist activities may be adjusted in other regions of the world depending on the climate forecast (Becken 2010).

# 3.3 Sectoral adaptation strategies

Generally, all sectors are working towards managing risks to reduce vulnerability using the following measures:

- Agroforestry and integrated agricultural systems: integrating trees and/or animals in farming systems, managed together with other farming system components.
- Alternative eco-friendly energy uses: bioenergy, solar energy, geothermal energy, hydro power, ocean power and wind energy.
- Climate smart agricultural production e.g., conservation tillage, use of organic manure, water harvesting and efficient use of irrigation, integrated soil fertility management.
- Diversification of livelihood strategies/alternatives e.g., through rural non-farm economy (RNFE)/off-farm employment/ income-generating activities, etc.
- Local governance of resource decentralization: rules, regulations and policies promoting equity, transparency and accountability.
- Use of climate information systems and Early Warning Systems.
- Infrastructure development: climate proof buildings and following climate resilient standards.
- Promoting insurance schemes.
- Effective use of genetic material: drought tolerant and pest/disease resistant varieties, gene banks etc.
- Analysis and promotion of suitable crop varieties adapted to local areas: good extension services important,
- Use of local/indigenous knowledge systems and gender mainstreaming -: promotes sustainability and empowerment.
- Improve infrastructure for small scale irrigation, water harvesting and water storage: to reduce crop failure and increase agricultural production in the face of climate change.
- Improve soil and water management: to increase production; and
- Adjust farming systems and livelihood options: to promote resilient communities.

Examples of adaptation actions that have been implemented in different sectors are given below.

## 3.3.1 Adaptation in the agricultural sector

The agricultural sector has used several practices and techniques to adapt to impacts of climate change. Among these are crop rotation and diversification, agroforestry, conservation farming e.g. minimum tillage, switching to resilient crops, rainwater harvesting and drip irrigation (Mendelsohn et al. 1994, Myers et al. 2017). Practices such as agroforestry, mulching, manuring/compositing, and water harvesting improve soil nutrients, soil moisture and other conditions required for crop growth.

Changes in climate heavily affects rural livelihoods, prompting people to develop various means for coping and adapting to the effects of climate change. Several traditional adaptation and coping strategies, such as rotation of crops and early planting, have been implemented to adapt and cope with the changing climate. Smallholder farmers are not exposed to modern scientific techniques but have been cultivating crops on the basis of existing local/indigenous knowledge regarding ecological conditions. Hence, their adaptation approaches are a product of their priorities, capacities and knowledge, shaping how they plan and cope with climate change issues (Reid et al. 2009).

**Box 11: Livelihood resilience for smallholder agriculture in Namibia**

A smallholder farmer in Oshikoto region, used conservation tillage techniques where a ripper and furrower prepared the land. The ripper cracks the hard pan and opens it – allowing for deep root development – and forms ridges of 30 centimetres between the ripped planting lines, which create an in-field water harvesting effect that guides rainwater to the plants. The farmer realised a bumper harvest of 4,660 kilograms of pearl millet 'mahangu' per hectare, in 2013 when there was a drought. This was far above less than 300 kilograms per hectare by approximately 160,000 subsistence farmers. The farmer's key to the success was based on early land preparation, planting with the first rain, thinning seedlings and applying a mixture of manure and fertilizer (UNDP 2018).

Depending on the forms of livelihood ventures in a community, unique methods are used to ensure their survival in the face of climate change (Box 11). For example, in Tanzanian communities' techniques such as tree planting, terracing, mixed cropping, crop diversification and water harvesting are used locally to adapt and cope with climate change. In Tanzania, farmers' adaptive strategies also include rainwater harvesting and on a much smaller scale, bottles are used for drip irrigation of local plants (Kihila 2018). In South Africa, farmers improved soil fertility through application of manure and kitchen garbage in the fields whilst others switched to more drought tolerant livestock systems from vulnerable cropping systems. Cotton farmers in Zimbabwe used irrigation and diversified to more drought-tolerant crop varieties to cope with climate change. The farmers also adjusted the periods of planting to match with the beginning of the rain season. In other parts of Africa, farmers have adopted and used conservation farming methods such as minimum-tillage to improve soil fertility, trap moisture and minimize soil erosion, subsequently decreasing dependency on rainfall while increasing crop yields (UNDP 2018).

In places outside Africa, farmers in Pakistan changed from growing traditional cotton varieties to genetically modified cotton varieties. They managed to avoid losses arising from pest attacks which were common in traditional cotton varieties. Furthermore, they planted wheat varieties that tolerated high heat stress as their response to increasing frequency of extreme maximum temperature events (Abid et al. 2016). Similarly, some early maturing, drought resistant, high yield maize varieties have been introduced in Southern Africa (Fisher et al. 2015, Katengeza et al. 2019). Other smallholder farmers in drought prone areas of Zimbabwe switched from maize to traditional sorghum and millet resulting in improved food security (FAO 2017, Mugambiwa 2018).

Adaptation strategies for livestock farmers and pastoralists in sub-Saharan Africa date back to times when farmers used to migrate with their animals to better pastures. Pastoralists migrating with their livestock in search of pasture makes them resilient to drought. Sometimes the pastoralists react to drought by timely marketing of their livestock and destocking without altering the breeding herd. Farmers have also been breeding livestock for drought tolerance and pest and disease resistance, varying breeds or altering production to low input systems such as ostrich or game farming. For improving water supplies, livestock farmers harvested rainwater, constructed stock dams/water pans for water storage and used windmills to pump water from boreholes to drinking troughs. In Tanzania, farmers' adaptive strategies include rainwater harvesting in ditches, construction of check dams and engaging in alternative income generating activities to supplement income from livestock (Kihila 2018). Other measures include improved livestock management by storing forage through silage and hay management, daily rationing in right quantity and quality of feed; integrated pest management in livestock and crops; and improved livestock/animal shelter.

**Activity 3.4 (5 minutes)**

- Explain how climate change adaptation is achieved through agroforestry and integrated agricultural farming systems.

## 3.3.2 Adaptation in water and fisheries sectors

Climate change has resulted in water scarcity and decline in fisheries (Myers et al. 2017). For the water sector, farmers are coping with drought through mulching, irrigation, rainwater harvesting, weirs and drip irrigation. The capacity of existing water resource facilities should be enhanced, e.g. by increasing dam height, through recharging of groundwater, by infiltration and storage of rainwater, or building new dams and reservoirs to increase water storage. Water harvesting and mulching conserve soil moisture in croplands. In developed countries, seawater and saline groundwater (brackish water) are desalinised while wastewater is recycled. Similarly, fishermen are adapting by varying fishing times, fishing in deep waters, scheduling fishing times and engaging in alternative income generating activities (Young et al. 2019). In Ghana, fishermen are adapting to climate change by changing fishing times, increasing daily fishing time and fishing efforts, engaging in aquaculture production, fishing further away or deep inside the waters, migrating to other fishing areas, catching smaller fish, participating in alternative non-fishing livelihoods and taking a moratorium in fishing (Mabe and Asase 2020).

African countries in coastal regions, such as Madagascar, Mozambique, Kenya, Tanzania and South Africa, are equally vulnerable to the impacts of climate change. In coastal areas, a combination of EbA and harder engineering solutions are used; the latter being constructions such as offshore living breakwater structures and artificial reefs, used as barriers between the sea and land, providing habitats for species and aiding the restoration of coral reefs. The success of these depends on the successful removal of barriers such as policy development and alignment; access to finance; regional cooperation; capacity building; peer learning; promotion of partnerships, especially with coastal communities and marginalised groupings such as women and children (Chevallier et al. 2019).

## 3.3.3 Adaptation in the health sector

Health sector affects all the other sectors, as such adaptation practices in the sector may include:

- Enhancement of epidemiological surveillance action targeted to specific areas, spraying insecticides, distribution of mosquito nets, drugs etc.;
- Focus on specific vector and disease control programmes including entomological surveillance;
- Management of domestic waste.
- Development of Early Warning Systems for epidemics especially after extreme events such as floods; and
- Facilitation of access to health care services.

## 3.3.4 Disaster risks management

Disaster management was covered in detail in section 1.6 of this Compendium. Disaster risk management is an important adaptation strategy that can help to reduce the negative impacts of extreme climate events. Risk encompasses the possibility of consequences where something significantly important is at stake and where the result is not clear, bearing in mind the diversity of values. Simply put, risk is a product of the interaction between vulnerability and hazard. Climate change risk assessments are an important element of adaptation.

**Risk assessment** involves thorough analysis of phenomena likely to cause harm to people in order to assess if adequate precautions have been taken or additional things need to be done to prevent the harm. Risk assessment can either be qualitative (relying on descriptive statistics and professional understanding and qualitative ranking into classes for example, low, medium and high) or quantitative (using available methodologies and appropriate models).) The steps include identifying the hazards (i.e. everything that can cause harm), determination of target group, and how they are likely to be affected by assessing the risks and taking action, documenting the results, and revising the risk assessment. The management of risk can be done through tenure security, insurance, local norms and traditions.

# 3.4 Nexus between forest and non-forest-based adaptation options

Forests assist in conserving ecosystems, providing habitat, shelter, raw materials, food, medicine, genetic materials, a barrier against disasters, a stable source of resources and many other ecosystem goods and services which help species, people and countries to adapt to climate change. In order for forests to continue serving as a natural storehouse of goods and services into the future, they should be delivered from all destructive human activities that do not safeguard biodiversity and ecological processes (Dudley et al. 2009, Mansourian et al. 2009).

The agricultural sector is the greatest contributor to deforestation through expansion of cropland, expansion and utilisation of wood fuel for industrial production processing of agricultural products such as tea and tobacco. Agriculture, infrastructure development, urban expansion and mining contribute 73, 10, 10 and 7%, of the total global deforestation, respectively (Hosonuma et al. 2012). Therefore, adaptation activities that enhance forest and tree cover and promote green growth and clean energy become important in the fight against climate change as they help reduce atmospheric carbon.

**Activity 3.5 (10 minutes)**

Explain forest-based adaptation in the following sectors:

i. Agriculture
ii. Marine and coastal resources
iii. Tourism sector
iv. Health

**Summary**

In this chapter, we have learnt that forestry is not the only sector affected by climate change, as other sectors in development are also affected. Climate change affects agriculture (crops and livestock), coastal and marine resources, water and fisheries, transport and energy, insurance, health and tourism and recreation industries. In some areas/communities traditional adaptation and coping strategies have been promoted. The capability to adapt or cope with effects of climate change can be improved through sector specific risk assessment, focusing on activities that reduce vulnerability such as appropriate social safety nets, diversification, management of soil and water resources, use of fuel efficient stoves or LP gas, building settlements in safe zones, appropriate timing of activities, early warning systems, improved building designs and insurance cover. To maintain their ability to continue serving as a natural storehouse of goods and services into the future, forests should be delivered from all destructive human activities that do not safeguard biodiversity and ecological processes.

**Further readings**

African strategy on climate change 2014. Draft African Union strategy on climate change. AMCEN-15-REF-11. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/20579/AMCEN_15_REF_11_Draft_African_Union_strategy_on_climate_change_English.pdf?sequence=1&amp%3BisAllowed=

# Chapter 4: Barriers, Challenges and Gaps To Climate Change Adaptation

## 4.1 Chapter overview

There are several challenges, gaps or barriers that reduce adaptive capacities of socio-ecological production systems. Barriers are obstacles that can be overcome with well-co-ordinated concerted effort, change of attitudes, creative management, prioritization, and related alterations in land use, resources and institutions. This chapter discusses the challenges to adaptation with emphasis on adaptation gaps and barriers. These are usually in the form of technical/technological, financial/economic, political/ institutional or social spheres of influence. Knowing barriers and challenges will inform successful and effective adaptation action.

**Objectives**

By the end of this chapter, learners should be able to:

i. Identify barriers to adaptation.
ii. Explain the challenges to effective climate change adaptation.
iii. Describe ways of overcoming some of the barriers to climate change adaptation.
iv. Explain briefly means and roles of main actors in addressing barriers to climate change.

**Activity 4.1 (Brainstorming) (10 Minutes)**

Explain forest-based adaptation in the following sectors:

i. Agriculture
ii. Marine and coastal resources
iii. Tourism sector
iv. Health

Whenever changes are made in one system on the earth, other systems are likely to be affected as well. Actions considered for limiting or adapting to climate change may result in either positive or negative unintended consequences.

# 4.2 Barriers to climate change adaptation

Due to high levels of poverty, Africa's vulnerability to climate change is higher than in other continents. Some of the barriers to climate change adaptation are internal while others are external to a system. These barriers are basically in the form of impediments which can delay, stop, or divert the adaptation process (Moser and Ekstrom 2010). These include technical, institutional/political, cultural, social, biophysical, behavioural, cognitive and gender-related barriers (Niang et al. 2014).

**Learning outcomes**
By the end of this section, learners should be able to:
i. Identify technical/technological barriers to climate change adaptation.
ii. Explain financial, economic and social barriers to adaptation.
iii. Explain governance, policy and institutional barriers to climate change adaptation.
iv. Identify informational and cognitive barriers to climate change adaptation; and
v. Identify biophysical and infrastructural barriers

**Activity 4.2 (Brainstorming) (10 Minutes)**
What do you think are categories of climate change adaptation barriers? Give examples.

There is a complex web of interacting barriers to local-level adaptation that is revealed from national to local scales. Throughout the adaptation process, resources are important at every stage, especially during implementation and monitoring. The adaptation resources include financial, technical/information, technology, time and staff expertise. Any lack of these affects success of management options (Moser and Ekstrom 2010). The following discussion provides key highlights on each of the barriers as outlined by Niang et al. (2014), Hallmeyer and Tonkonogy (2018) and other authors.

## 4.2.1 Technical and technological barriers

These are conditions that limit ability to access relevant and useful information including software and hardware (IT) for technological tasks. Insufficient resources, poor technical infrastructure and other practical technology issues are barriers to adaptation. Some of these are outlined below:

- Lack of technical capacity within an organization is shown when prospective users of the technology do not have the technical capacity that is needed to implement or use the technology;
- lack of internal capacity –inadequate internal management and operational capacity of the adaptation product or service provider;
- lack of access to new information and technologies, e.g. barriers to uptake of fuel-efficient technologies. For example, in the Seychelles, lack of communication among government agencies was identified as a key barrier to knowledge related to sea-level rise and storm surges (UNFCCC 2019a);
- lack of proper settings of information handling and poor means of exchanging and processing information for decision making; and
- difficulty of having more accessible and reliable climate information although the provision of information does not guarantee adaptation unless it is accompanied by behavioural change.

## 4.2.2 Social barriers

Social barriers affect perceptions, capacity to act, freedom and, often. the available resources, authorisation, permits, political climate, or social norms. Social barriers include poverty, religion, gender, traditional systems and norms. Nielsen and Reenberg (2010) showed that communities in northern Burkina Faso, reacted differently to adaptation initiatives due to their cultural differences. One group

adopted new livelihood strategies to reduce their vulnerability to climate change, while the other cultural group did not. Some specific social barriers are as follows:

- Poverty, lack of access to inputs and shortage of labour;
- characteristics such as religion, wealth, social class, gender, caste, ethnicity, or profession;
- if the dominant culture disapproves of the departure from "normal way of doing things", innovations may be suppressed (Ludi et al. 2012); and
- where erosion of traditional systems makes it difficult for people to respond to climate change.

### 4.2.3 Economic/financial barriers

These include issues that have to do with market environment, where there is unsupportive market environment for investment in different sectors. These economic and financial barriers may emanate from the economy, weak historical track records, poor value chains and human capital. The barriers that follow include:

- Lack of required capacities for initiating and establishing successful investment (e.g., no local sectoral expertise or sector-specific value chain);
- the value added to products may be uncertain or unknown and users may not be aware of the value or benefit of the technology or its uncertainty;
- users of introduced technologies may not consider climate risk in their decision-making;
- these barriers are further compounded by high operational cost of the technologies;
- poverty and lack of cash or credit that can limit adaptive capacity e.g., Ghana, Ethiopia, Kenya, Malawi, Mozambique, South Africa, Zimbabwe and Zambia cases (Niang et al. 2014).;
- difficulties associated with justifying high costs for hard adaptation solutions;
- low returns on investments for adaptation; and
- lack of funding mechanisms at varying scales for adaptation.

Financial barriers also include lack of funding from central government, limited access to financial resources, lack of institutions that facilitate adaptation financing, lack of resources to monitor progress, or lack of political will to mobilise financial resources (Biesbroek et al. 2013).

### 4.2.4 Governance, Policy and Institutional barriers

Governance and policy barriers that can inhibit the process of developing and implementing adaptation governance and policy processes may include:

- Lack of clarity surrounding roles and responsibilities for each level of governance;
- lack of clarity surrounding public/private sector policy regulation and control;
- competing demands across governance portfolios/sectors;
- focus on disaster recovery rather than on prevention;
- mismatch between adaptation timelines and political terms (short policy cycles);
- politicised nature of climate change policy;
- public mistrust in climate change experts, politicians and government groups.

In Africa, there are some legislative frameworks that do not allow for the use of ecosystems, causing conflicts in some areas; yet ecosystems can have an important role in making communities to adapt beyond short-term coping (Robledo et al. 2012). Institutional barriers result from the existing structures and frameworks associated with responses to climate change (Casey and Becker 2019). The lack of institutional support creates a major barrier to climate change adaptation at all levels. The barriers are as highlighted below:

- Impeded adaptation through hijacking by influential and corrupt persons/groupings;
- institutional and coordination relations as in many African political settlements and compromises results in setting of inappropriate formation of institutions and deformed coordination mechanisms that negatively affect adoption of proper adaptation action;

- lack of social roots to sustain institutions;
- no attention given to institutional specifications of latest technological interventions (Ludi et al. 2012);
- institutions that are restrictive can block efforts to develop local adaptive capacity by upholding underlying inequities linked to gender and ethnic minorities. Furthermore, tenure security over land and critical assets enables people to make long-term and future decisions amidst uncertainty (Romero González et al. 2011);
- lack of community cohesion where individual benefits are emphasised;
- lack of clear roles and responsibilities for actors;
- inadequate leadership or political willingness to prioritise action, and
- conflict of interests - difficulties in getting all involved actors to move in unison or agreement resulting in stalling or shift of priorities.

## 4.2.5 Informational barriers and Cognitive barriers

Effective communication of climate change information is needed to increase awareness and understanding, provide continuity, and constructively engage policy-makers, the public and all other stakeholders. Information barriers are linked to the type of information, how it is created and communicated, the channel and the receiver.

If the information is not understood, there is wrong interpretation and this severely interrupts or derails social interactions among those involved in the process of adaptation (Moser and Dilling 2007). Examples include lack of information on climate change predictions and weather, agroforestry and/or afforestation, different crop varieties and adaptation strategies

These include alternative explanations about extreme events and weather. These alternative views may emanate from religion (God's will), the ancestral beliefs, and witchcraft, or seeing these changes as out of people's own control. Deeply held values and spiritual beliefs affect perception of people and how they interpret situations, and think about climate related risks and their management, including information and knowledge that they consider as important. These highlighted points provide a basis for the decisions and choices of people during the adaptation process (Moser and Ekstrom 2010, Niang et al. 2014).

## 4.2.6 Biophysical and infrastructural barriers

Biophysical and infrastructural barriers are reflected by limited access to infrastructure and basic resources such as water and land, road infrastructure, fertile soils, and properly managed ecosystems. Biophysical factors constraining climate change adaptation may be internal or external. The internal biophysical factors are internal to the system of interest e.g., topography, environmental conditions, and land cover; while external biophysical factors are external to the system of interest, but provide the biophysical context in which the system exists e.g., severe storms, earthquakes, and sea-level change (Rothman et al. 2014).

**Activity 4.3 (Group Discussion) (10 minutes)**

1. Identify ways to overcome some of the barriers to climate change adaptation?
2. Explain briefly means and roles of actors in addressing the main barriers and challenges to adaptation

**Summary**

In this section we learnt that barriers to climate change are impediments that can delay, stop, or divert the adaptation process, and these can be in the form of technical/ technological capacities, financial and economic capacities, governance or institutional barriers, social barriers, informational and cognitive barriers and biophysical barriers.

# 4.3 Challenges to climate change adaptation

In the previous section we learnt about several barriers to climate change adaptation. Similarly, challenges to climate change adaptation include the societal or environmental conditions that make adaptation more difficult by increasing the risks associated with any given level of climate change (O'Neill et al. 2014). As the African continent strives to promote different sectoral reforms and capacity building, challenges remain in the areas of governance, environmental protection, forest livelihoods (including poverty) and the need to expand market mechanisms that help to secure environmental goods and services, and improving dry forests management (World Bank 2008). The challenges to adaptation are a function of the socio-economic determinants of exposure to climate change hazards, sensitivity to these hazards, and the adaptive capacity to deploy coping measures. The challenges include the limits of autonomous adaptation (i.e. the range of adaptive measures that are readily accessible to individuals and organizations) and the obstacles and constraints to adaptation policies, such as ineffective institutions and governance that impede policy implementation (O'Neill et al. 2014). Like the barriers, climate change adaptation challenges are also linked to technical capacity, financial/economic conditions, political/institutional commitments and social environments as described in this section.

Objectives
By the end of this section, learners should be able to:
i. Identify technical challenges to climate change adaptation;
ii. explain social challenges to climate change adaptation;
iii. explain financial and economic challenges to adaptation; and
iv. explain political and institutional challenges to climate change adaptation.

**Activity 4.4 (Brainstorming) (10 Minutes)**
Looking at the forestry sector, identify some of the challenges to climate change adaptation?.

## 4.3.1 Technical Challenges

Environmental management challenges have continuously been connected to unstable levels of uncertainty, inadequate data, and risk, causing a need for rethinking and reforming conservation and management approaches under a changing climate (Locatelli et al. 2008). Climate change is putting additional challenges, which are linked to uncertainties, possible scope and seriousness of the impacts, as well as remarkable frequency and type of events that threaten ecosystem resilience. Deforestation and forest degradation are hindrances to implementation of sustainable forest management and conservation actions. Technological and technical challenges affect planning and implementation of adaptation initiatives and are linked to technical capacity of governments, communities or animals to adapt to climate change, and include the following:

- Securing involvement of suitable experts to drive adaptation activities, and difficulties of organising work in remote locations and timing it with seasonal conditions (World Bank 2008).
- Lack of understanding of ecosystem behaviour when adapting to a changing climate and how ecosystem vulnerability might change based on existing ecological information. Although models indicate that climate change is expected to affect the distribution of ecosystems and species, there is need to understand ecosystem behaviour and how it affects the flow of ecosystem services. Maladaptation and short-term coping strategies present a challenge by creating additional pressures on ecosystems; for example, when NTFPs, used as safety nets, are collected from forests that are not sustainably managed (IUCN 2008, Apeaning 2019). To overcome such adaptation challenges,

planning should be linked across sectors and scales.

- Lack of quality controls by governments, corrupt business practices by traders, poor market access and insecure tenure.
- Lower technical knowledge or capacities in developing countries than in developed countries: for example, issues about trees and forest management options suitable under future climates and how best to minimize negative impacts of climate change.
- Implementation of NDCs and NAPAs suffer from lack of capacity to use specific policy tools and actions for forestry projects.
- Inability to carefully consider and factor in the potential of trees in providing ecosystem services under changing climate
- Challenges related to scientific methods and tools required for assessing useful trees in various socio-ecological perspectives and unavailability of data and information for use by all stakeholders.
- As adaptation actions can have direct and measurable outcomes, while, at the same time, the impacts of climate change on vulnerability are usually not directly visible in the short term but can only become evident over a long period (e.g. many decades), interpretation of the characteristics of climate change adaptation success can be a challenge (Ford et al. 2013).
- Disentangling the role played by adaptation is further complicated by the fact that baseline climatic and socio-economic conditions that determine adaptation effectiveness also change over time, potentially rendering interventions ineffective (Ford et al. 2013).
- Success of short-term adaptation actions may be maladaptive in the long term, worsening vulnerability due to alteration of behaviour, changing patterns of development, displacement of risks to other groups, and creation of path dependency, and these challenges limit the maintenance of interventions (Barnett and O'Neill 2010, Fazey et al. 2010, Schirmer and Yabsley 2018).
- High variability of adaptation needs, risks and decisions about potential climate risk depending on economic/resource sectors and regions.
- Level and speed of adaptation in developing countries is affected by their slow technological progress/advancement.
- Poor understanding and development of reliable EWS in developing nations. Climate uncertainty, high levels of variability, lack of access to appropriate real-time and future climate information, and poor predictive capacity at a local scale are common barriers to adaptation from the individual to national level. Poorly resourced meteorological agencies with no in-country expertise to interpret and use climate information for planning and decision making (Dinku et al. 2011, Okpara et al. 2017, Myeni et al. 2019).
- In Africa, monitoring networks are not sufficient; they are therefore difficult to model because of the sparse coverage as well as short and fragmented digitised records (Boko 2007).

### 4.3.2 Financial and economic challenges

Finances drive the process of adaptation initiatives and the benefits obtained from such actions are important as motivation for sustainability. Savvidou et al. (2021) stated that about half of the adaptation finance in Africa is targeted to the sectors of agriculture and water supply and sanitation. Financial challenges are driven by lack of financial capacity to deal with climate change impacts and this can be for both internal or external funding while economic challenges are linked to access to markets and market information and the associated value chains. Financial and economic challenges include the following:

- Lack of sufficient finance to adequately prepare for and to respond to climate change disasters (Chaudhry 2021);
- adoption of some adaptation strategies can be hampered by discouraging results e.g. possible reduction in short-term crop yields;
- high costs of adaptation actions may require external inputs for poor communities (Potdar 2019);
- intangible advantages of taking specific actions (adapting or limiting emissions) are usually not clear to the lay person (Ajiboye et al. 2018);
- lack of capacity for valuation of ecosystem services and no ready markets for the ecosystem goods and services;
- lack of access to market information (Chaudhry 2021); and
- complicated and lengthy processes to get global environmental/adaptation funds.

**Further reading**

Savvidou G, Atteridge A, Omari-Motsumi K, Trisos CH. 2021. Quantifying international public finance for climate change adaptation in Africa, Climate Policy, 21(8): 1020-1036, DOI: 10.1080/14693062.2021.1978053

## 4.3.3 Political/ institutional challenges

Climate change is a global phenomenon that requires efforts of both developed and developing countries to combat it. In most African states, development of policies is done by central government agencies, with other actors insufficiently involved while local communities are in most cases excluded. Absence of practical implementation strategies, political interference, and the different levels of implementation (village, ward, district, provincial, national etc.), constrain adaptation efforts. There are four commonly encountered capacity inputs into effective institutions and these include institutional arrangements, leadership, knowledge and accountability (UNDP 2018). Given these inputs, challenges that arise include the following:

- Cross-sectoral and inter -ministerial collaboration not always clear on how the complex set of actors and their activities can be consolidated in a coordinated manner.
- Political and institutional inefficiencies, where prioritising climate change adaptation initiatives for example, in Southern Africa is blocked by other issues such as mitigation, disaster and risk management (Chevallier 2012).
- Overlapping and conflicting laws regulations and mandates, cause inadequate understanding of the limits and responsibilities of individual agencies (UNDP 2018).
- Limited collaboration among relevant ministries, contributing to weak coordination among actors in the development space, is a challenge to adaptive actions.

## 4.3.4 Social challenges

Social challenges are linked to socio-cultural values, methods, cultural practices, beliefs and norms that may drive an individual or people/community to conform to certain behaviours or ways of doing things. Social challenges may prevent individuals from adopting certain initiatives for fear of being regarded as an outcast. Among these factors are poverty, lack of employment, heavy reliance on natural resources to support livelihoods, culture population increase and religion (Nielsen and Reenberg 2010, Ramyar and Zarghami 2017). Poverty limits the means to cope with and adapt to climate change effects (Dungumaro and Hyden 2010, Adhikari and Baral 2018). Examples of social challenges are outlined below:

- Farmers who become reluctant due to their own perceptions, views and beliefs about climate change;
- inadequate, economic capacity to adapt for most of the rural poor;
- public understanding on climate change is disturbed by inadequate support for initiation, and implementation of adaptation measures.

**Further reading**

https://climatepolicyinfohub.eu/climate-change-adaptation-needs-barriers-and-limits

**Activity 4.5 Revision (10 minutes)**

1. What is the difference between barriers and challenges of climate change adaptation?
2. Explain barriers to adaptation.
3. Discuss the challenges to climate change adaptation in Africa.

**Summary**

In this chapter, we have learnt that some barriers to climate change adaptation are related to technical, institutional/political, cultural, social, biophysical, behavioural, cognitive and gender-related issues. Moreover, making choices for adaptation and their implementation to address climate change involves complex processes that can encounter challenges across technological, political/institutional, social, financial and economic, scientific and psychological dimensions. Therefore, recognising and understanding the barriers and challenges can facilitate crafting of practical and sound adaptation responses to climate change.

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# African Forest Forum

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ISBN 978-9966-7465-2-8