African Forest Forum

A platform for stakeholders in African forestry



Forests and Climate Change Mitigation

A COMPENDIUM FOR TECHNICAL TRAINING IN AFRICAN FORESTRY

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Back cover photo: Aerial panoramlc view of Mago National Park, Omo Valley, Omorati Ethiopia, Africa nature and wilderness. Credit: Artush

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Contents

Abbreviations and acronyms

AD	Activity Data
AF	Adaptation Fund
AFF	African Forest Forum
AFOLU	Agriculture, Forestry and Other Land Uses
AFR100	African Forest Landscape Restoration Initiative of 100 million ha
AMCEN	African Ministerial Conference on Environment
BURs	Biennial Update Reports
CA	Conservation Agriculture
CDM	Clean Development Mechanism
CH_4	Methane
Ci-Dev	Carbon Initiative for Development
CMA	Conference of Partiesserving as the meeting of the Parties to the Paris Agreement
CO_2	Carbon dioxide
COP	Conference of Parties
CPF	Collaborative Partnership on Forests
CSO	Civil Society Organisation
EAC	East African Community
EF	Emission Factor
EIA	Environmental Impact Assessment
ENSO	El Niño-Southern Oscillation
ESF	Environmental and Social Framework
ESIA	Environmental, Social Impact Assessment
ESMF	Environmental and Social Management Framework
ETF	Enhanced Transparency Framework
FAO	Food and Agricultural Organisation of the United Nations
FIP	Forest Investment Programme
FPIC	Free Prior Informed Consent
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
ILO	International Labour Organisation

IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPP	Indigenous People Plan
ITMO	Internationally Transferred Mitigation Outcomes
IUCN	International Union for Conservation of Nature
JI	Joint Implementation
KP	Kyoto Protocol
LMIC	Low and Medium Income Country
LT-LEDS	Long-Term Low GHG Emission Development Strategies
LULUCF	Land Use, Land Use Change and Forestry
M & E	Monitoring & Evaluation
MEAs	Multilateral Environmental Agreements
MERVC	Monitoring, Evaluation, Reporting, Verification, and Certification
N_2O	Nitrous Oxide
NAMAs	Nationally Appropriate Mitigation Actions
NDC	Nationally Determined Contributions
NFMS	National Forest Monitoring Systems
NGOs	Non-governmental Organisations
NTFPs	Non Timber Forest products
OECD	Organization for Economic Cooperation and Development
PDD	Project Design Document
PES	Payment for Ecosystem Services
PFCs	Perfluorocarbons
PIN	Project Idea Note
ppm	Parts Per Million
RED	Reducing Emissions from Deforestation
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	Reducing Emissions from Deforestation, forest Degradation, Conservation of Forests, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks
REL	Reference Emission Level
RMU	Removal Unit?
R-PP	Readiness Preparation Proposal
SADC	Southern African Development Community
SBSTA	Subsidiary Body for Scientific and Technological Advice
SCCF	Special Climate Change Fund
SCF	Standardised Crediting Framework
SDM	Sustainable Development Mechanism

SDG	Sustainable Development Goals
SESA	Strategic Environmental and Social Assessment
SF_6	Sulphur Hexafluoride
SIS	Safeguard Information System
UN	United Nations
UNDP	United Nations Development Programme
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFI	United Nations Forest Instrument
UNSPF	United Nations Strategic Plan on Forests
VCS	Verified Carbon Standards
WMO	World Meteorological Organisation

Preface

We 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

Executive Summary

Climate change and climate variability remain a global concern to many stakeholders. This is because of significant rise of temperature resulting to global warming due to increase of anthropogenic greenhouse gases (GHGs). Some of the important GHGs include; Water vapour (H2O), Carbon dioxide (CO2), Methane (CH4), Nitric oxide (NO2), Ozone (O3), Hydrocarbons and Chlorofluorocarbons. These gases naturally blanket the earth and keep it at about 33° C warmer than it would be without these gases in the atmosphere. They have different capacity to trap heat in the atmosphere, what is normally called global warming potential (GWP) because they are chemically stable and persist in the atmosphere over time scales ranging from decades to centuries or longer so that their emission has a long-term influence on climate. One of the long lived GHGs in the atmosphere is carbon dioxide, laying the foundation of removal by forest and trees through the process of photosynthesis. It is in this regard that in order to keep the temperature goal of 1.5 ° C, sector specific efforts towards reducing GHGs emissions are on the rise. This compendium therefore addresses the role of forests and tree resources in mitigating climate change through the process of carbon sequestration or removal carbon dioxide from the atmosphere. This is achieved through afforestation, reforestation, forest restoration and forest management practices.

The development of this compendium was therefore motivated by the fact that forest and tree resources have been globally recognised more so in the Kyoto Protocol (KP) and Paris Agreement (PA) that they play a significant role in climate change mitigation. Specifically, Article 5 of the Paris Agreement entrenched policy approaches and positive incentives for activities relating to reducing emissions from deforestation and forest degradation (REDD+), and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries. It also emphasised on the alternative policy approaches, such as joint mitigation and adaptation approaches for the integral and sustainable management of forests. Article 5 also reaffirms the importance of incentivising, as appropriate, non-carbon benefits associated with integration of mitigation and adaptation actions.

It is within this background that this compendium was developed to equip learners in technical training colleges with the knowledge and understanding on forest and climate change mitigation. The compendium is pedagogically structured into the following key chapters each with learning objectives, outcomes and activities:

i. Concepts of climate change mitigation;
ii. Forest and tree-based mitigation initiatives;
iii. The Clean Development Mechanism (CDM), REDD+ and other forest based approaches for mitigating climate change;
iv. Non forest climate change mitigation initiatives and other approaches; and
v. Monitoring, reporting and evaluation of climate change mitigation initiatives and other approaches.

The overall aim of this compendium is to build an understanding of the principles of climate change mitigation and forest and non-forest tree-based climate change mitigation strategies with robust monitoring, reporting and evaluation. This will be achieved through the following compendium objectives that the learners are expected to achieve:

i. Defining climate change mitigation;
ii. Describing concepts of forest based climate change mitigation measures;
iii. Distinguishing between forest and non-forest based climate change mitigation initiatives; and
iv. Identifying and applying appropriate monitoring and evaluation tools for climate change mitigation projects and practices.

Chapter 1: Concept Of Climate Change Mitigation

1.1 Chapter Overview

This chapter introduces the concept of climate change mitigation and explains national policies, strategies and actions aimed at climate change mitigation and the relationship between adaptation and mitigation. The discussions include highlights of some good greenhouse gases (GHGs) reduction practices and practices that reduce GHG from the atmosphere through carbon sequestration.

Learning outcomes

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

Define climate change mitigation and forest-based climate change mitigation;

i. Explain the concept of climate change mitigation and the relationship between adaptation and mitigation;
ii. Describe national policies and strategies or actions in climate change mitigation;
iii. Identify good GHGs emission reduction practices; and
iv. Identify good practices of carbon sequestration

1.2 Definition of mitigation in the context of climate change and forestry

Climate change mitigation includes all efforts to reduce or prevent emission of GHGs into the atmosphere. Mitigation measures are in different forms. These include; increased use of renewable energy, use of new technologies such as electric cars, or changes in behaviour or practices such as change of diet. This can be in any of the following forms or their combination including the following:

i. afforestation and reforestation for CO2 removal;
ii. avoided deforestation and forest degradation for carbon stock enhancement and sink;
iii. new technologies for carbon capture and storage (CCS);
iv. improving efficiency of old equipment and machinery;
v. modifying buildings so that they become more energy efficient;
vi. use of renewable energy sources (wind, solar, and small hydropower);
vii. developing more sustainable transport systems in cities (e.g. electric vehicles, rapid bus transit, and biofuels);
viii. promotion of more sustainable land uses and sustainable forest management; and
ix. changing management practices or consumer behaviour (GEF 2022).

According to the UNEP and IUCN (2021), afforestation, reforestation, avoided deforestation, sustainable forest management and promotion of green based options in Agriculture, Forestry and other Land Uses (AFOLU) are among the important nature based solutions to climate change mitigation. This section therefore introduces learners to various key and important concepts in climate change mitigation with view of developing better understanding on how they apply in different sectors. Some of these key concepts will be highlighted in subsequent sub sections.

Activity 1. 1 (Brainstorming)(20 minutes)

i. In a group of 3-5 discuss concepts related to climate change mitigation.
ii. Identify those concepts that are forest and non-forest based mitigation.

1.3 Basic concepts of climate change mitigation

The UNFCCC requires all Parties to formulate and implement programmes containing measures to mitigate climate change based their responsibilities and capabilities. The programmes focus on economic activities that can provide an incentive for actions that are cleaner or that can cause big reductions in the amounts of GHG emissions. Some of these activities include incentive schemes and investment programmes as well as policies covering all sectors of GHG emissions. These most dominant of these sector are: energy; transport; industry; construction; agriculture; forestry and other land use (AFOLU); and waste management. This section therefore discusses the following in line with climate change mitigation:

- Kyoto Protocol
- Paris Agreement
- Parties to the United Nations Framework Convention on Climate Change
- Market and non-market approaches
- Carbon sequestration
- Mitigation approaches
- Greenhouse gases

1.3.1 The Kyoto protocol and the Paris agreement

a) The Kyoto Protocol

The UNFCCC was signed and came into effect in 1995. The convention formed the basis for negotiations on combating the impacts of climate change and climate variability. This resulted to the development of a protocol or other legal instruments containing stronger commitments for developed countries identified as top emitters of GHG emissions and those in developing nations that are most vulnerable to the impacts of climate change..

The Kyoto Protocol to the UNFCCC became an important climate change action adopted in Japan in December 1997, serving as a pillar for the global climate change response. The protocol contains a number of specific GHG reduction pledges from developed nations, together with their programs to promote increased removals through sinks and the transfer of cleaner technologies from developed nations to both developed (Joint Implementation-JI) and developing nations (Clean Development Mechanism or CDM). This means that investments resulting in properly verified emission reductions in industrialised (through JI) or developing (via CDM) nations have the same effect as if the investor had reduced emissions in his own nation. The primary goal is global reduction of emissions.

Other international agreements (UNFCCC) supporting forest based mitigation activities can be traced back to the Warsaw Framework for REDD+ that was adopted at COP 19 in 2013 where REDD+ framework was created by the UNFCCC Conference of the Parties (COP) to guide activities that reduced emissions from deforestation and forest degradation, in the forest sector as well as the sustainable management of forests and the conservation and enhancement of forest carbon stocks in developing countries.

b). The Paris Agreement

The Paris Agreement (PA) was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and became a legally binding climate change international treaty with a goal to limit global warming to below 2 degrees, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. It entered into force on 4 November 2016 and became the first binding agreement to bring all nations to a common cause of undertaking ambitious resolutions of climate change mitigation and adaptation, effectively replacing the Kyoto Protocol. To achieve a climate neutral world by mid-century, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century (UNFCCC 2022a). It is in this context that the PA is viewed as a landmark in the multilateral climate

change process.

During COP 21 that was held in Paris, France in 2015, there were agreements to limit the rise in the global average temperature to no more than 2 °C (3.6 °F) above preindustrial levels; while also attempting to keep this increase to 1.5 °C (2.7 °F) above preindustrial levels. The Paris Agreement requires a review of progress every five years and the creation of a $100 billion fund by 2020 that would be renewed annually to aid developing nations in implementing non-GHG gas emission technologies.

1.3.2 Main Parties to the UNFCCC

Parties to the UNFCCC, according to Kyoto Protocol are either Annex I Parties (developed countries) to the Convention or non-Annex I Parties (developing countries) and they report their GHG mitigation and emissions expressed as tonnes of carbon (tonnes C) or as tonnes of CO2 equivalent (t CO2 eq). Main groups of Parties to UNFCCC are shown in box 1.1.

Box 1.1 Three main groups of Parties to UNFCCC

Annex I Parties - include industrialised countries that were members of the Organisation for Economic Co-operation and Development (OECD) in 1992, including countries with economies in transition (EIT), the Russian Federation, the Baltic States, and several states in Central and Eastern Europe.

Annex II Parties – these are OECD members in Annex I, but are not EIT Parties. They are required to provide financial resources to enable developing countries to undertake emissions reduction activities under the Convention and to help them adapt to adverse effects of climate change. Funding provided by Annex II Parties is channelled mostly through the financial mechanism of the convention.

Non-Annex I Parties include developing countries recognised by the Convention as being particularly vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. They need investment, insurance and technology transfer (unfccc.int).

The implementation of the Climate change initiatives is based on the principle of common but differentiated responsibilities (CBDR) that acknowledges that all countries have an obligation to address climate change, but the individual capabilities of each country should guide the extent of such efforts and therefore, simultaneously address inequalities.

1.3.3 Market and non-market based approaches in the Paris Agreement

a). Market based approaches

The Kyoto Protocol created three carbon market mechanisms namely: i) emissions trading with emissions markets in countries around the world. The most common is the European Union Emissions Trading System (EUETS); ii) The project-based the Clean Development Mechanism (CDM); and iii) Joint Implementation (JI) done when countries set a limit, or cap, on GHG emissions. Projects under CDM and JI don't earn units by reducing emissions below a set cap but by reducing emissions below "business-as-usual. The units are called certified emission reductions (CERs) in CDM and emission reduction units (ERUs) in JI. Companies under the EUETS could use CERs and JI units to cover a part of their obligations. The countries or companies that reduce emissions below their cap have something to sell, an unused right to emit, measured in tonnes of CO2 equivalent.

Countries and companies that don't meet their target can buy these one-tonne units to make up the shortfall. This is called emissions trading, or cap and trade. The net effect on the atmosphere is the same, provided measurements are done accurately (UNFCCC).

Under the Paris Agreement, Art 6.2 provides mechanism of carbon trading through cooperative approaches whereas Art. 6.4 provides avenues for common market approaches of transiting the carbon credits in CDM to the new market instruments.

b). Non-market approaches

The non-market based approaches in the Paris Agreement are a result of Parties recognising other ways to cooperate on climate action, and approaches apart from market-based approaches to reduce emissions. For example, recognising the role of sustainable development and broad participation in climate action by private and public sectors. The other actions include promotion of nature based solutions with adaptation and mitigation co-benefits aiming at addressing climate change challenges and promoting sustainable development goals (SDGs).

Further reading: What are Market and Non-Market Mechanisms? | UNFCCC

1.3.4 Carbon sequestration

As stated earlier, the release of CO2 is one of the major contributors to global climate change, emitted through human activities. To reduce CO2 emissions into the atmosphere, while helping to meet present and future energy demands, strategies that capture and/or store carbon are needed. Carbon sequestration is about increasing the storage of carbon from the atmosphere as well as directly from the source of emission in a reservoir other than the atmosphere. One of the most obvious methods for carbon sequestration is the removal of CO2 from the atmosphere using biological means, where land use changes and forestry have great potential to remove large quantities of CO2 from the atmosphere through photosynthesis.

This carbon is stored as biomass, although the CO2 can be released when biomass decomposes or through burning. Strategies to increase the uptake of CO2 from the atmosphere through plants include afforestation, reforestation, improved agriculture, agroforestry and some revegetation practices. Figure 1 illustrates the sources of carbon sequestration and emissions.

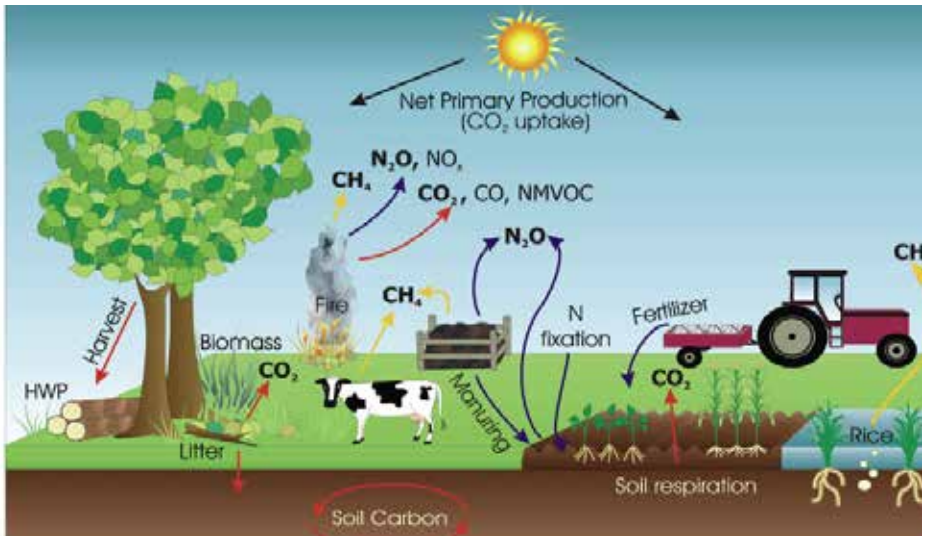

Figure 1: GHG emissions and carbon sequestration in agro-ecosystems (IPCC 2006)

Oceans take up about 30% of carbon emissions through phytoplankton (marine algae). The phytoplankton also removes CO_2 from the atmosphere through photosynthesis. The rate of photosynthesis and the uptake of CO_2 from the atmosphere can be increased through ocean fertilisation and intensification of phytoplankton populations.

However, when the phytoplankton die, the photosynthesised CO_2 is taken to the bottom of the ocean floor in their tissue. Although some CO_2 would be released from the decomposition of these organisms, a huge portion would remain on the ocean floor and is turned into sedimentary rock (Agaliotis 2020).

Carbon dioxide can also be sequestered through non- biological means such as scrubbing towers and artificial trees. Scrubbing towers are used as air is funnelled in the inside by wind turbines and sprayed with either sodium oxide or calcium oxide to form carbon precipitates and water, which can be piped to safe locations for storage. Artificial trees include a series of sticky, resin-covered filters capable of converting CO_2 into a carbonate called soda ash. The soda ash could be washed off the filters and collected for storage. The two methods are however expensive and may not be feasible (ibid).

It is however, easier to collect the carbon at source and store it safely somewhere through a process of carbon capture. The technologies involve either pre-combustion capture, oxyfuel combustion, or post combustion capture (Kheirinik et al. 2021).

1.3.5 Mitigation approaches and actions for climate change

Mitigation approaches and actions for climate change vary with sector and environmental conditions. There are several approaches that can be taken by different sectors and figure 2 shows maximum climate mitigation potential with safeguards for reference year 2030 for three groups of ecosystems (Griscom et al. 2017).

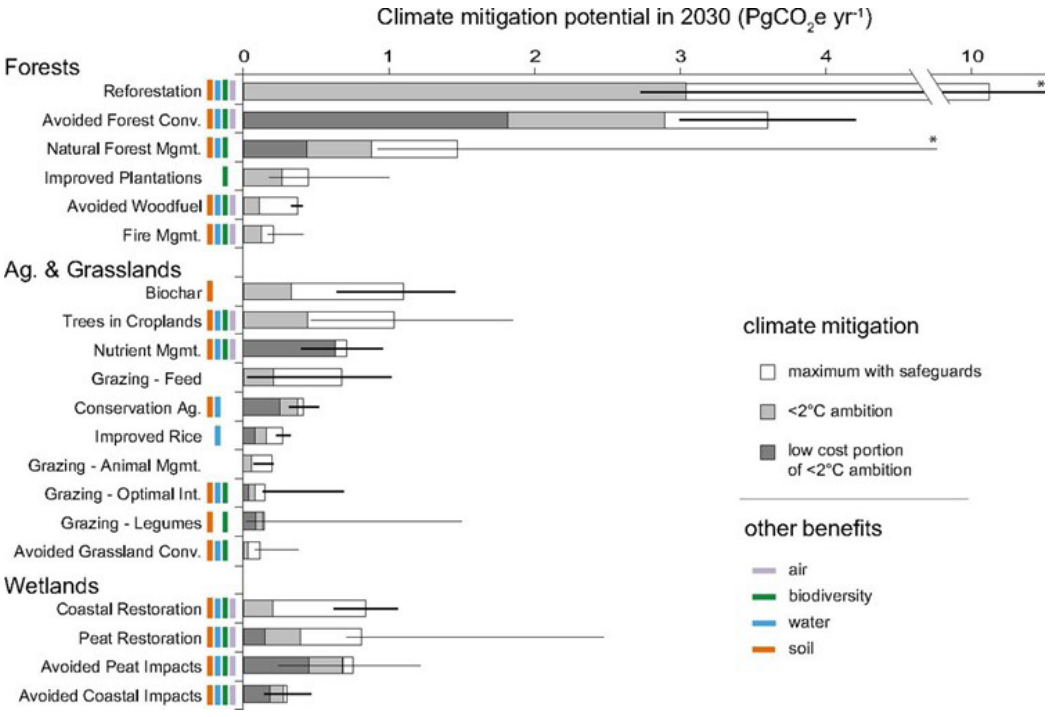

Figure 2: Climate change mitigation potential of 20 natural pathways

Light gray portions of bars represent cost-effective mitigation levels assuming a global ambition to hold warming to <2°C (<100 US$ $MgCO_2e^{-1}$ y^{-1}). Dark gray portions of bars indicate low cost (<10 US$ $MgCO_2e^{-1}$ y^{-1}) portions of <2°C levels. Wider error bars indicate empirical estimates of 95% confidence intervals, while narrower error bars indicate estimates derived from expert elicitation. Ecosystem service benefits linked with each pathway are indicated by coloured bars for biodiversity, water (filtration and flood control), soil (enrichment), and air (filtration). Asterisks indicate truncated error bars (Griscom et al. 2017).

When dealing with the forestry sector, mitigation approaches and actions for climate change fall into three main categories (Fawzy et al. 2020).

i. Conventional mitigation efforts – These employ decarbonisation technologies and techniques that reduce CO2 emissions, and include renewable energy, nuclear power, switching fuels, improving efficiency and carbon capture storage and utilisation (Ricke et al. 2017, Bataille et al. 2018).

ii. Negative emissions technologies (carbon dioxide removal methods) – these are techniques that are potentially used to capture and sequester CO_2 from the atmosphere (Ricke et al. 2017). The techniques include; soil carbon sequestration, bioenergy carbon capture and storage, biochar, enhanced weathering, direct air carbon capture and storage, ocean fertilisation, ocean alkalinity enhancement, afforestation and reforestation, wetland construction and restoration, as well as alternative negative emissions utilisation and storage methods such as mineral carbonation and using biomass in construction. In this category are forest based activities (Lawrence et al. 2018, Lenzi 2018, Royal Society 2018, Palmer 2019, Yan et al. 2019).

iii. Radiative forcing geoengineering technologies – these follow the principle of altering the earth's radiation balance through the management of solar and terrestrial radiation to stabilise or reduce temperatures. The techniques involved are mainly theoretical or at development stage and include; stratospheric aerosol injection, cirrus cloud thinning, marine sky brightening, space-based mirrors, surface-based brightening and various radiation management techniques (Lawrence et al. 2018, Lockley et al. 2019).

Activity 1.2 (Brainstorming) (20 minutes)

Identify ways in which sources and sinks of GHGs can be manipulated to limit global increases in temperature.

1.3.6 Green House Gases (GHG) sources and sinks

The GHGs already released/emitted into the atmosphere will remain there for many years and they will take many years to remove them from the atmosphere. The change in concentration of GHGs in the atmosphere is shown by the difference between the sources (emissions to the atmosphere) and sinks (removals from the atmosphere). Stability of GHG concentrations occurs when sources and sinks are equal. The main sources of emissions are natural systems and human activities. Natural systems include forest fires, wetlands, earthquakes, oceans, permafrost, and volcanoes while human activities are predominantly related to energy production, industrial activities and land use change (agriculture forestry and other land uses (AFOLU)) (Edenhofer et al. 2014, Yue and Gao 2018). Other GHGs that are mainly defined by the Kyoto Protocol include; carbon dioxide (CO2), nitrous oxide (N2O), and methane (CH4) fluorinated gases such as hydrofluorocarbons (HFCs), sulphur hexafluoride (SF6) and perfluorocarbons (PFCs) (UNFCCC 2008).

The World Meteorological Organisation (WMO) showed that the global average concentrations of CO2 reached 405.5 parts per million (ppm) in 2017, up from 403.3 ppm in 2016 and 400.1 ppm in 2015 (WMO 2017). Nitrous oxide emissions are mainly influenced by agricultural and industrial activities, increased

by 0.8% in 2018 compared to a 1% annual increase over the past decade. A significant increase was, however, noted in the fluorinated gases during 2018 at 6.1% compared to 4.6% annual increase over the past decade (UNEP 2019).

The most abundant GHG is CO2 (Butler and Montzka 2018) (Figure 3). The CO2 emitted into the atmosphere is through the combustion of fossil fuels for energy, industrial processes, biomass burning and land use change but can also be captured through forest based mitigation actions. This makes forests and trees important in climate change actions. CO2 is the most important GHG driving climate change resulting from human activities (90%) such as burning fossil fuels; and land use changes including deforestation. About 55% of the anthropogenic CO2 emissions are removed from the atmosphere by natural sinks in the ocean and land biosphere, while 45% accumulate in the atmosphere (Thomas et al. 2016). The capacity of natural CO2 sinks is determined by ocean chemistry and ocean mixing, and by multiple factors in terrestrial ecosystems influencing photosynthesis and respiration of plants and soils, including CO2 'fertilisation' (the increase in photosynthesis and plant growth resulting from increased CO2 levels in the atmosphere) (Prentice et al. 2015).

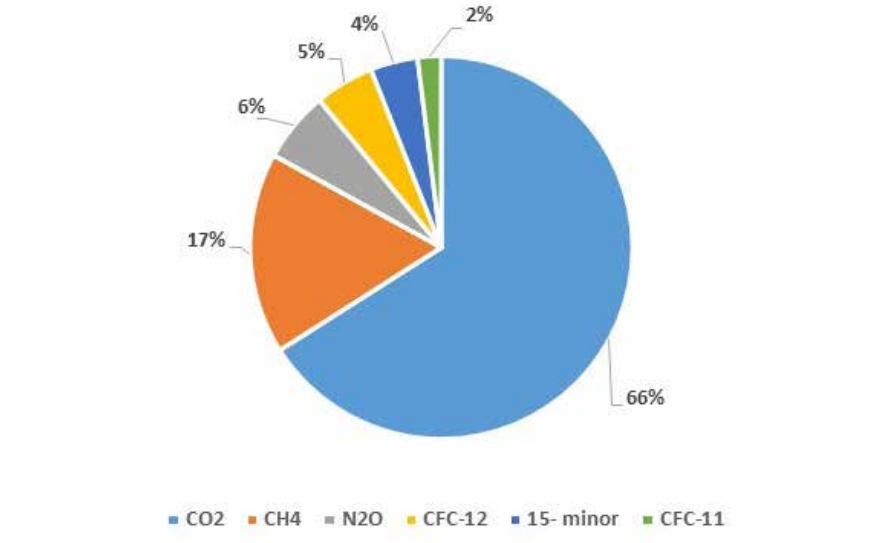

Figure 3: Proportion of GHG concentration in the atmosphere

Prior to Covid-19 related emission declines in total global GHG emissions between 2011 and 2019, fossil-based and land-use-related CO2 emissions increased by approximately 1.4 GtCO2 per year with lower atmospheric accumulation of CO2 in 2021 driven by La Niña conditions that help enhance the land carbon sink. The Pacific Ocean shifts from El Niño to La Niña every five or six years (Carbon Brief ltd 2021).

> The La Niña is a natural phenomenon that drags temperatures down whilst, the El Niño, tends to boost global temperatures when the event occurs. The warm and cold phases are referred to as El Nino Southern Oscillation (ENSO).

To put these numbers into perspective, a recent Intergovernmental Panel on Climate Change (IPCC) report demonstrated that anthropogenic activities so far have caused an estimated 1.0 °C of global warming above the pre-industrial level, specifying a likely range between 0.8 and 1.2 °C. Global warming

is likely to reach 1.5 °C between 2030 and 2052 if the current emission rates persist (IPCC 2018). Figure 4 shows GHG from all sources between 1970 and 2020 (UNEP 2021).

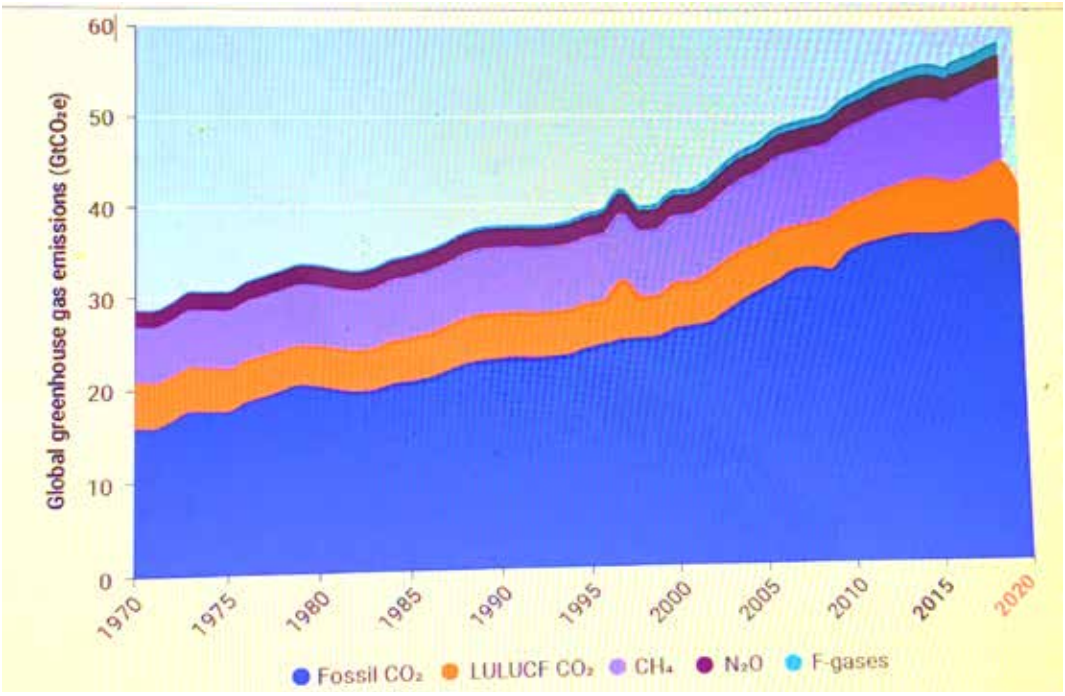

Figure 4: GHG emissions over time from 1970-2020 (UNEP 2021)

UNEP (2020) stated that emissions could be reduced by 25% from pre-COVID-19 predictions, significantly increasing the possibility of limiting warming to below 2°C above preindustrial levels, though 1.5°C would remain out of reach by 2030. Activities to achieve this include initiating global green recovery, guided by direct support for zero-emissions technologies and infrastructure, reducing fossil fuel subsidies, no new coal power plants, and nature-based-solutions, among other policies.

In forested ecosystems, the net flux of carbon to the atmosphere from land-use change (mainly through deforestation) depends on the size of converted area, carbon density per ha, the fate of the altered land and the ecosystem processes that control fluxes of carbon (Watson et al. 1992). The UNFCCC (2011) encouraged developing country Parties to contribute to mitigation actions in the forest sector by undertaking appropriate activities, in accordance with their respective capabilities and national circumstances and include the following activities that basically defines REDD+:

a. reducing emissions from deforestation;
b. reducing emissions from forest degradation;
c. conservation of forest carbon stocks;
d. sustainable management of forests; and
e. enhancement of forest carbon stocks.

Drivers of climate change include substances and processes that alter the earth's energy budget as sources of GHGs. The GHGs sources are broadly classified into two, namely: Natural sources of GHGs -; and anthropogenic sources of GHGs. These two categories form the major causes of climate change and climate variability as highlighted below.

1.3.6.1 Natural sources of GHGs

Natural sources of GHGs include respiration and decomposition of plants and release of GHGs from oceans into the atmosphere. Many natural GHGs such as water vapour, carbon dioxide, nitrous oxide and methane occur naturally in the atmosphere. Natural sources of GHGs include climate forcing mechanisms which can be separated into internal and external types. External forcing operates from outside the Earth's climate system, and includes changes in the global energy balance due to variations in the Earth's orbit around the Sun, and changes in the amount of energy coming from the Sun.

Internal forcing (Fahey et al. 2017) operates from within the climate system, for example, the changes in the global energy balance due to changes in the composition of the atmosphere and include the following:

Volcanic eruptions – are an example of internal climate forcing. Explosive volcanic eruptions can inject large quantities of dust and sulphur dioxide, in gaseous form, and CH4 and CO2, directly into the upper atmosphere, the stratosphere, where the sulphur dioxide is rapidly converted into sulphuric acid aerosols. Dormant volcanoes also release large amounts of GHGs through volcanic hot springs into the atmosphere having total intermittent GHG emissions far greater than those from volcanic eruptions (Guo et al. 2015).

Ocean currents - The ocean covers 71% of Earth's surface and is always in motion as masses of water move together as ocean currents, transporting heat, marine organisms, pollutants, nutrients, and dissolved gasses such as carbon dioxide and oxygen.

Earth orbital changes - are an example of external climate forcing. On timescales of a millennium and longer, changes in the character of the Earth's orbit around the Sun can significantly affect the seasonal and latitudinal distribution of incoming solar energy. These are known as the "Milankovitch Cycles".

Solar variations- are an external climate forcing where physical changes within the Sun may alter the intensity or character of the incoming solar energy.

Atmospheric composition- The changing composition of the atmosphere, particularly its greenhouse gas content, is a well-known example of internal climate forcing. Greenhouse gases (GHGs) absorb terrestrial, long-wave radiation from the Earth and re-emit this radiation up to space and down to the surface. A change in the GHG content of the atmosphere will affect the energy balance of the climate system.

Natural sources of GHG emissions also include those from forest fires, wetlands, permafrost, and earthquakes (Cui et al. 2012).

Cui et al. (2012) assessed emissions from Wenchuan earthquake and found that the level of CO2 emission was almost equivalent to 2% of the global CO2 emissions from combustion of fossil fuel. Other natural sources of emissions are high altitude permafrost (CH4), freshwater ecosystems (CH4), seas and oceans (CO2), forest fires and wetlands (Seiler and Crutzen 1980, Elliott and Angell 1987, Bastviken et al. 2011, Koven et al. 2011).

1.3.6.2 Anthropogenic sources of GHGs

These are the gases generated as a result of human activities in different sectors of social and economic development. Some of the gases include carbon dioxide from the Land Use Land Use Change and Forestry (LULUCF), nitrous oxide from agriculture, methane from livestock management and Hydrofluorocarbons (HFCs) from refrigeration. Overall, data has shown that the global anthropogenic GHG emissions were 52.4 Gt CO2e in 2019 with annual anthropogenic GHG emissions having increased by 59% since 1990. About 74% of the global anthropogenic GHG emissions come from fossil fuel combustion ((PBL

Netherlands Environmental Assessment Agency 2020). In 2018, Global energy use accounted for 36.9 Gt CO2 emissions in 2018, increasing by 46% since 2000 (Energy Information Administration (EIA) 2021). Furthermore, loss of forests (through conversion to agriculture or wood fuel or logging) and the use of fire for land clearing negatively impacts the global carbon cycle (FAO and UNEP 2020).

Other GHGs such as CH4 and N2O are emitted from both natural and anthropogenic sources. Primary anthropogenic sources of CH4 include domestic livestock, landfills, and natural gas systems. Agricultural soil management through fertiliser use contributes 75% of anthropogenic N2O. Other significant sources of GHGs are mobile and stationary combustion (Environmental Protection Agency (EPA) 2021). Hydrofluorocarbons (HFCs) are the fastest emerging group of GHG that are used in cooling, refrigeration and as solvents instead of ozone-depleting chlorofluorocarbons (CFCs) (Center for Climate and Energy Solutions 2021).

1.4 Relationship between adaptation and mitigation

The UNFCCC identifies two measures for climate change action and these include mitigation and adaptation. These two measures are interdependent as adaptation actions have consequences for mitigation and vice versa. Climate change mitigation is an anthropogenic intervention to reduce the sources or enhance the sinks of GHGs whilst adaptation is the adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2001). The absence of a relevant knowledge base and of human, institutional and organisational capacity can limit the ability to create synergies between mitigation and adaptation.

However, the opportunities for synergies are greater in sectors such as agriculture and forestry, but are limited in energy, coastal systems and health (Klein et al. 2007). Mitigation efforts can foster adaptive capacity if they eliminate market failures and distortions, as well as perverse subsidies that prevent actors from making decisions based on true social costs of the available options (ibid). For example, if afforestation is part of a regional adaptation strategy, it can also make a positive contribution to mitigation. The following are differences between mitigation and adaptation actions:

- Mitigation has global benefits while adaptation mostly works on the scale of an impacted system, which maybe either regional or local. In this regard, adaptation focuses on reducing the vulnerability of sectors, communities and environments to the impacts of climate change (Klein et al. 2007);
- Adaptation deals with direct prevention of damage, whereas mitigation is indirect damage prevention (Verheyen 2005);
- Mitigation can be measured and compared as CO2 equivalence whereas, benefits of adaptation are more difficult to express in a single metric, impeding comparisons between adaptation efforts (Klein et al. 2007). However, adaptation benefits are valued differently depending on the social, economic and political contexts within which they occur;
- The benefits of mitigation become evident after several decades because of the long residence time of GHGs in the atmosphere, whereas many adaptation measures would be effective yielding immediate benefits of reducing vulnerability to climate variability; and
- Mitigation is motivated by international agreements and ensuing national public policies. Alternatively, most adaptation actions have historically been motivated by the self-interest of affected private actors and communities, usually facilitated by public policies.

Box 1.2 Examples of mitigation and adaptation options

"Mitigation measures include policies linked to transportation, energy, food and agriculture, and land use that can reduce GHG emissions and they include:

• Energy policies promoting development and use of renewable energy, decrease production and use of fossil fuels, and reduction of energy demand;

• Transportation policies that promote fuel efficiency and active transport, such as walking and bicycling;

• Food and agriculture policies that promote sustainable practices promoting growth, enhance food security, promote consumption of fruits and vegetables, and decrease consumption of meat;

• Land-use policies that aim to protect existing forests and growth of new forests" (Levy and Patz 2018).

Adaptation measures installation of hard structures in areas vulnerable to coastal erosion, crop diversification, traditional rainwater harvesting and water conserving techniques; building of shelter-belts and wind-breaks to improve resilience of rangelands; monitoring of the number of grazing animals and cut trees; and setting-up revolving credit funds (IPCC 2007).

An assessment by Pavageau and Tiani (2014) on the implementation of REDD+ and adaptation to climate change in the Congo Basin and that of Olufunso et al. (2012) pointed out importance of integrating mitigation and adaptation. They argued that REDD+ has significant opportunities for addressing coping mechanisms to climate change, especially when REDD+ and adaptation process are considered in designing the projects. This requires a suitable policy and institutional framework for integrating forest based mitigation and adaptation in different landscapes. One opportunity that exists especially in the Least Developed Countries (LDCs) is the National Adaptation Programme of Action (NAPA) that includes forestry activities as part of the national interventions. This will create new opportunity for REDD+ activities to be aligned to NAPA in various landscapes addressing adaptation to climate change and emission reduction for climate change mitigation. The integration of mitigation and adaptation will improve efficiency of policy process and high level planning at global, regional, national and local levels in order to realise the expected outcome of the joint implementation of climate change mitigation and adaptation actions (Oeba 2021).

1.5 Paris agreement and NDCs

Parties to the UNFCCC meeting in Lima Peru in 2014, agreed that national contributions to climate change mitigation and adaptation actions be aggregated into Intended Nationally Determined Contributions (INDCs). After the Paris Agreement entered into force in 2016, Parties were called upon to transform their INDCs into Nationally Determined Contributions (NDCs), forming the basis of the post-Kyoto multilateral climate regime. NDCs are submitted every five years to the UNFCCC secretariat and successive NDCs are expected to reflect a progression from the previous NDC reflecting a country's highest possible ambition. Parties were requested to submit their new NDCs or updated NDCs by 2020 and every five years thereafter, irrespective of their implementation time frames (UNFCCC 2021a).

The adoption of the Paris Agreement in 2015 (UNFCCC 2015) saw countries committing to prevent dangerous impacts of climate change through Nationally Determined Contributions (NDCs). The Paris Agreement (PA) showed the full implementation plans of countries' contributions to GHG emissions reduction targets. The PA is estimated to cover only half of the emissions reductions that would be required under a no-policy baseline by 2030 (Rogelj et al. 2016). Hence, the PA is envisaged to stay on a global least-cost pathway consistent with keeping warming levels well below 2°C (Ibid).

Implementation of the PA works on a five-year cycle and requires economic and social transformation, based on the best available science. By 2020, countries were expected to have submitted their plans for climate action known as nationally determined contributions (NDCs) and their long-term low GHG emission development strategies (LT-LEDS) to the UNFCCC (UNFCCC 2016b). Box 1.3 shows examples of NDC activities in Africa. However, LT-LEDS are not mandatory but they provide a vision and direction for future development for the country (ibid). The PA provides a framework for the following:

Financial – The PA allows for the provision of financial assistance to countries that are less capable and more vulnerable to climate change. The PA also encourages voluntary contributions by other Parties. Climate finance for mitigation is needed because of the large-scale investments required to significantly reduce emissions. Therefore, climate finance is equally important for adapting to the adverse effects of a changing climate.

Technology – The PA encompasses a vision to fully realise technology development and transfer to improve resilience to climate change and reduce GHG emissions. A technology framework is established to provide overarching guidance to the well-functioning Technology Mechanism. The mechanism accelerates technology development and transfer through its policy and implementation arms. NDCs submitted to the UNFCCC identified some technologies intended for implementing adaptation and mitigation actions. These include energy-efficient appliances, renewable energy technologies, low- or zero-emission vehicles, blended fuel and climate smart agriculture. The main areas of technology needs included energy, agriculture, water, waste, transport, and climate observation and early warning (UNFCCC 2021b).

Capacity building support –Climate-related capacity-building support is given to countries that need it.

Box 1.3 Examples of NDCs in Africa

African NDCs require about US$226 Billion to fulfil their ambitious plans for renewable energy in the energy sector. A total of US$ 100 billion were unconditional targets (IRENA 2020).

Ethiopia - NDC expects forestry sector to contribute more than 50% (132 Mt CO2e) of the national goal to reduce emissions by 255 MtCO2e by 2030. The National REDD+ Strategy identified forests and REDD+ as central for reducing GHG emissions and outlines a series of actions to achieve this. The National Forest Sector Development Program aims to transform the forestry sector, being the main guiding document for coordinating strategic policy interventions and sector-wide investments for the coming ten-years. The targets include doubling forest cover to 30% land cover, reducing national emissions by half in 2030, and increasing the GDP contribution of the forestry sector from 4 to 8%.

Ghana - As part of a national development strategy, Ghana has developed 19 policy actions in 10 priority areas to achieve nationally determined contribution goals between 2020 and 2030. The 19 policy actions translate into 13 adaptations and 34 mitigation programmes of action. The 19 policy actions with potential to maximise the synergies between adaptation and economic diversification, resulting in mitigation co-benefits, will lead to the following long term outcomes:

- accelerated sustainable energy transition;
- resilient economies and societies built;
- enhanced early warning and disaster risk management;
- enhanced landscape restoration;
- responsible production and consumption;
- social inclusion focusing on youth and women; and
- smart and safe communities.

The implementation of the 19 policy actions in Ghana is expected to generate absolute greenhouse gas (GHG) emission reductions of 64 MtCO2e; prevent at least 2900 premature deaths per year from improved air quality; create over one million1 decent and green jobs and cumulatively benefit about 38 million people, with the majority being the youth and women (EPA and MESTI, 2021).

Kenya submitted her updated Nationally Determined Contribution (NDC) to the UNFCCC in December 2020. The country revised overall GHG emissions reduction targets upwards from 30% to 32% by the year 2030. The climate change goals for Kenya are not really about attaining net zero emissions, or even net zero CO2 emissions but focus is on progressive transition to development that reduces reliance on carbon within the conditional and unconditional NDC targets, while prioritising adaptation. The Climate Change Act requires mainstreaming of climate actions across sectors. A Climate Smart Agriculture Strategy was approved with priority actions of reducing emissions from agriculture production systems, with activities such as agroforestry implemented and providing mitigation co-benefits (Kibugi 2021).

1.6 Highlights of national policies, strategies and actions to mitigate climate change

There are several national and international mitigation initiatives, starting with Nationally Appropriate Mitigations Actions (NAMAs) and Nationally Determined Contributions (NDCs). Climate legislation is mitigation-focused legislation that exceeds sectorial actions while climate strategy is a non-legislative plan or framework designed for mitigation actions that encompass more than a few sectors, and has a coordinating body responsible for its execution (Dubash et al. 2013).

The risk associated with climate change impacts suggests a need for urgent action to significantly reduce GHG emissions. Reductions of GHG emissions can be achieved at relatively low costs when the right policies are in place, including the use of market-based instruments to develop a global price for GHG emissions, accompanied by better integration of climate change objectives in relevant policy areas such as energy, transport, building, agriculture or forestry, and other measures to speed technological innovation and diffusion (OECD 2007).

There are several possible policy approaches for maximising the potential of forests in climate change mitigation and adaptation, but the activities must be supported at the regional and national levels. For example, the success of REDD+ and Sustainable Forest Management (SFM) initiatives depends on how well their elements are integrated into national development strategies as part of holistic national land-use planning (CPF 2008). In this regard, laws and policies are key enablers for achieving net-zero targets expressed in instruments such as climate change framework laws and strategies, as well as instruments in relevant sectors such as forestry, agriculture land use and management. Forest policies and strategies should also target preserving the capacity of trees and forests to store carbon for as long as possible.

At the national level, Nationally Appropriate Mitigation Actions (NAMAs) are proposed as mitigation actions that are 'nationally appropriate' because they contribute to national development outcomes. In this regard, NAMAs provide a possible mechanism for connecting national policies and projects to the global climate regime. The low emissions development strategies are another related mechanism that are formulated to integrate climate and development strategies (Clapp et al. 2010).

Somanathan et al. (2014) reports that policy instruments and packages for climate change mitigation can be grouped into: economic instruments, regulatory approaches, information policies, voluntary actions, and provision of public goods and services and procurement by government.

Economic instruments - sometimes called market-based approaches due to the prices that are applied in environmental and climate policies. Economic instruments for climate change mitigation include taxes, subsidies and subsidy removal, and emissions trading schemes.

Regulatory approaches - Regulations and standards became the first environmental policies which continue to be very important in environmental and climate policies all around the world. They are conventional regulatory approaches that establish a rule and/or objective that must be fulfilled by the polluters who would face a penalty in case of non-compliance with the norm. For climate policies, categories of standards that apply include:

- Emission standards – can also be called performance standards and represent the maximum allowable discharges of pollutants into the environment;
- Technology standards - specific pollution abatement technologies or production methods are given (IPCC 2007); and
- Product standards - define the specifications for products that have potential to pollute the environment (Gabel 2000).

Information policies – Good quality information is essential to raise public awareness and concern about climate change. It identifies environmental challenges, to improve design and helps to monitor impacts of environmental policies. Good quality information also provides relevant information to inform consumption and production decisions. Eco-labelling or certification schemes for products or technologies, together with the collection and disclosure of data on GHG emissions by important polluters are good examples (Krarup and Russell 2005).

Government provision of public goods and services and procurement - Actions and programmes facilitated by governments to counteract or prevent climate change can be seen as public goods. Government can remove institutional and legal barriers for reducing GHG emissions as part of policy, including afforestation and conservation support.

Voluntary actions – These are actions taken by firms, NGOs, and other actors beyond their regulatory requirements. Voluntary agreements represent an evolution from traditional mandatory approaches based on conventional or economic regulations and intend to provide further flexibility to polluters. Voluntary agreements/ long-term agreements, are voluntary commitments done after negotiations process between the regulator and the polluter (Somanathan et al. 2014).

Further reading:

Somanathan E, Sterner T, Sugiyama T, et al. T. Zylicz T. 2014. National and Sub-national policies and Institutions. In: Edenhofer O, Pichs-Madruga R, Sokona Y, et al. (eds). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. ipcc_wg3_ar5_chapter15.pdf

1.7 Sustainable land and water management (SLWM)

Sustainable land and water management encompasses policies, technologies, and activities that integrate environmental and socio-economic principles. These simultaneously maintain or enhance production, reduce the level of production risk, protect the potential of natural resources, and prevent (buffer against) soil and water degradation, and are economically viable, and be socially acceptable (Smyth and Dumanski, 1993).

Deforestation and forest degradation, unsustainable agricultural practices on croplands, and excessive exploitation of natural habitats reduces primary production on as much as 20 percent of the land in SSA. World Bank has worked on some initiatives supporting land management in Africa (Box 1.4).

On the other hand, climate variability and change can expose unprotected soil to more extreme conditions and straining the capacity of existing land management practices to maintain resource quality, contributing to de-vegetation, soil erosion, depletion of organic matter and other forms of degradation. The resulting land degradation increases the vulnerability of rural people (especially those who depend on rain-fed agriculture) to extreme weather events and climate change (TerrAfrica nd). Therefore, sustainable land management entails the use of land within its capability to maintain the productivity and economic potential of the land, without diminishing its ecological functions such as soil water retention or biodiversity conservation.

Box 1.4 World Bank Sustainable land management

The World Bank group forest action plan of 2016-2020 resulted in the adoption of sustainable landscape management practices, for example, protection of vulnerable land, control of soil erosion, improving soil water storage and soil management to boosts carbon sequestration and soil fertility. The Eastern Province of Zambia benefited from these initiatives through improved sustainable land management and livelihoods diversification options that included climate-smart agriculture and forest-based livelihoods to reduce deforestation (World Bank 2016a).

In Ethiopia, the World Bank promoted the adoption of improved land management practices on communal and individual lands. Agroforestry activities and area closures to limit free grazing led to a 5.2 % increase in vegetation cover and moisture retention in the targeted watersheds. Furthermore, projects supported smallholder farmers and landless youth, to receive land holding rights through landholding certificates in exchange for managing communal lands. The projects also supported alternative livelihood activities supporting improved livestock production as well as poultry and beekeeping (World Bank 2020).

1.8 Environmental and social impact assessment of climate change mitigation

Sectors dealing with crop and livestock production, fisheries, forestry, and aquaculture depend on the proper use of land, water, and other natural resources. These natural resources are associated with social systems, rural livelihoods, values, and their culture. Environmental and Social impact assessments (ESIAs) are important tools for identifying and assessing social and environmental risks and benefits at the planning stage of an investment, and for building risk mitigation measures into project design and implementation (UNCTAD 2018). ESIA proposes appropriate mitigation measures to be included in the Environmental and Social Management Plan (ESMP).

Carbon Footprint Assessment (CFA) can be part of ESIA by measuring the total amount of CO2 and other GHGs of a defined population, system, or activity. The focus can include the carbon foot print of buildings and similar structures, integrating climate change mitigation measures into project specific ESIA. Including CFA as part of the ESIA, will provide project specific mitigation measures that directly reduce impacts of climate change through the reduction of GHG emissions (ARUP 2016). UNCTAD (2018) gave examples of ESIAs that have been conducted in West Africa and Mozambique;

Ghana - a fresh fruit and herb processing company identified a new potential supply area for fresh herbs, where production of other crops had declined due to poor crop and water supply system management. The company targeted 85 producers, to practice organic farming and soil conservation to avoid impacting on water quality and manage risks of soil erosion respectively. These efforts had positive environmental impacts.

Mali and Burkina Faso – promoted a Jatropha out grower scheme where Jatropha was inter-cropped with food crops and residues used to enhance soil fertility.

In text Question(s) (10 minutes)

i. Distinguish between natural and anthropogenic GHG sources and sinks.
ii. Explain any two policy approaches for climate change mitigation actions.
iii. The Paris agreement provides frameworks to support three areas of mitigation action. Discuss.
iv. Explain the relationship between mitigation and adaptation.
v. What is the importance of ESIAs?

Summary

In this chapter we have learnt that climate change mitigation includes all efforts to reduce or prevent emission of greenhouse gases into the atmosphere and can be in the form of modern technologies and renewable energies, improving efficiency of older equipment and machinery. Developing country parties can contribute to mitigation by reducing emissions from deforestation, reducing emissions from forest degradation, conserving forest carbon stocks, sustainable management of forests and enhancing forest carbon stocks. Mitigation approaches can take the form of conventional mitigation efforts, negative emission technologies or radiative forcing geo-engineering technologies. We also learnt that GHGs that are mainly defined by the Kyoto protocol include; CO2, N2O, CH4, and fluorinated gases such as hydrofluorocarbons, sulphur hexafluoride and perfluorocarbons. Carbon dioxide is the most abundant gas that can be reduced through forestry activities. Activities linked to sustainable land and water resource management can be important in mitigating climate change while supporting adaptation. We concluded the chapter by looking at environmental and social assessments for climate change mitigation initiatives

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Further readings:

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/

African Forest Forum. 2019. International dialogues, processes and mechanisms to climate change: A compendium for professional and technical training in African forestry. Technical Working Paper. 132 pp.

https://www.youtube.com/watch?v=SDRxfuEvqGg

Chapter 2: Forest and Tree-Based Mitigation Initiatives

2.1 Chapter Overview

Forests contribute to climate change mitigation through carbon sequestration as well as by offering economic, environmental, and socio-cultural benefits. In the tropical forest regions with high rate of deforestation and forest degradation, the promotion of forestry initiatives will enhance mitigation of GHG emissions. This chapter equips learners with knowledge on the various forest-based initiatives for climate change mitigation and how they can be implemented under different contexts.

Learning Outcomes

Learning outcomes

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

i. Identify forest based mitigation strategies;
ii. Explain the role of forests in climate change mitigation;
iii. Describe the various forest-based climate change mitigation initiatives;
iv. Explain other benefits of using forests to mitigate climate change;
v. Describe challenges associated with forest-based climate change mitigation;
vi. Identify appropriate mitigation measures at the national level (NAMA and others) in relation to forestry;
vii. Explain the different environmental policies related to climate change; and
viii. Describe the co-benefits and non-carbon benefits of using forests to mitigate climate change.

2.2 Introduction to Forest and tree-based mitigation initiatives

Forest based and tree based initiatives entail actions or options aiming at addressing emission reduction. Some of these include introduction and implementation of global programmes in forestry sector such as afforestation and reforestation in Clean Development Mechanisms, Reducing Emissions from Deforestation and forestation Degradation, forest based Nationally Appropriate Mitigation Actions, and Forest and Landscape Restoration commitment e.g. the African Forest Landscape Restoration Initiative to restore 100 million ha by 2030. These initiatives have the potential to reduce emissions especially from degraded landscapes. Chapter 3 of this compendium is dedicated on some of these initiatives.

In order to understand better forest and tree-based mitigation initiatives, let as briefly reflect on the role of forest in climate change mitigation and financing mechanisms to support the forestry sector in climate change mitigation.

2.2.1 Role of forests in climate change mitigation

The role of forests in combating climate change was formally recognised at the 2015 UN climate change

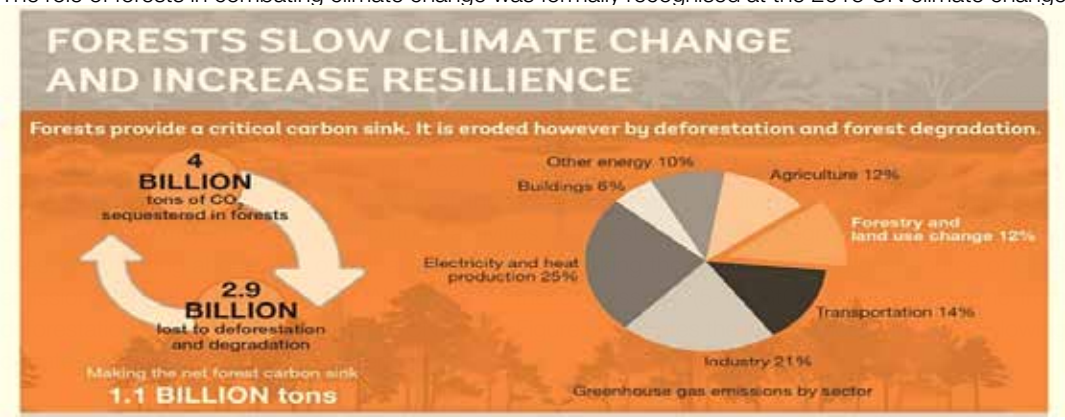

Figure 5: Carbon sink potential of forests and other sectorial emissions

(Source: World Bank 2016b).

Forest land, however, stores approximately 60% of the total terrestrial carbon stock in different carbon pools, giving them capacity to remove about 30% of the current anthropogenic CO2e emissions (Federici et al. 2017). Given the potential of forests to store carbon both above and below ground, their destruction causes direct emissions from deforestation which reduces their capacity to store carbon (van Goor and Snoep 2019). In this regard, forests become one of the most important solutions for addressing the effects of climate change because they can absorb one-third of the CO2 released from the burning of fossil fuels (about 2.6 billion tonnes of CO2) every year (IUCN 2021). Although carbon sequestration and biodiversity preservation are generally considered as public services/goods, they have an impact at scales varying from regional to global. The provisioning services such as food and other forest products have impacts at local scale as they affect local livelihoods.

2.2.2 Financing for mitigation options

Climate finance refers to local, national or transnational financing, drawn from public, private and alternative sources of financing. Financing seeks to support actions that will address climate change. Financing for climate action is supported by agreements adopted by the UNFCCC in 1992, including the principle of "common but differentiated responsibilities and respective capabilities." This principle recognises that developed nations, which have likely contributed more to the accumulation of greenhouse gases because they industrialised earlier, should play a larger role in solving the climate crisis and helping the countries that contributed less to its creation. Most climate finance (91%) globally is for mitigation activities through both public and private finance going into renewable energy, energy efficiency, sustainable transport, etc. Financing is either through UNFCCC mechanisms or non-UNFCCC mechanisms (multilateral, bilateral, private, domestic).

The UNFCCC mechanisms include the Global Environment Facility (GEF) - operating entity since the Convention's entry into force in 1994 and Green Climate Fund (GCF established at COP 16, in 2010, and in 2011 was also designated as an operating entity of the financial mechanism to support low emission and climate resilient development. The financial mechanisms are accountable to the Conference of Parties (COP), which decides on its policies, programme priorities and eligibility criteria for funding (GCF 2019).

Parties to the UNFCCC have established special funds in addition to providing guidance for GEF and the GCF:

a. **Special Climate Change Fund (SCCF)** - to finance projects relating to adaptation; forestry, energy, technology transfer and capacity building, industry, transport, agriculture, and waste management; and economic diversification that is financed abd managed by GEF;

b. **Least Developed Countries Fund (LDCF)** is another GEF financing that supports preparation and implementation of their National Adaptation Programmes of Actions (NAPAs);

Adaptation Fund (AF) established under the Kyoto Protocol in 2001- supports concrete adaptation projects and programmes in developing countries. Notably, at the Paris Climate Change Conference in 2015, Parties agreed that the mechanisms also support the Kyoto protocol; and

c. **Climate Investment Fund (CIF)** supports four types of programmes:

   iv. Clean Technology Fund;

   v. Pilot Programme for Climate Resilience integrating climate resilience into development plans and financing private public partnerships;

   vi. Scaling up Renewable Energy in Low Income Country Programme – renewable energy solutions; and,

   vii. Forest Investment Programme (FIP) – supports developing countries reduce emissions from deforestation and enhancing forest Carbon stocks (REDD+).

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

i. Explain some of the forest-based mitigation actions in your country.
ii. How are they achieving the goals of reducing GHG emissions?

2. 3 Forest and tree based climate change mitigation and sequestration practices

Forest based climate change mitigation is in several forms that aim at reducing emissions and increasing carbon sinks. These include:

- forest protection;
- forest conservation;
- sustainable forest management (SFM);
- agroforestry and on farm tree planting;
- afforestation and reforestation;
- urban forestry; and
- the management of protected forests.

Each of these practices is as discussed in the following sub sections.

2.3.1 Agroforestry and on-farm tree planting

Assemblages of trees not meeting the definition of forest based on areas also play a key role in carbon sequestration and the reduction of GHG emissions mainly within agricultural and urban lands. These are often referred to as trees outside forests (TOF) and can have very significant contributions to overall global and national carbon budgets (Schnell et al. 2015, Zomer et al. 2016). Agroforestry is among the highly flexible and versatile management option to improve GHG mitigation and production services. It can mitigate climate change through the intentional integration of woody plants into crop and livestock production systems that sequesters carbon. Equally, through agro forestry, a number of forest-derived services that support agricultural operations and adaptation needs related to food security and natural resource protection under changing conditions are also realized (Nair 2012, Vira et al. 2015).

Specifically, agroforestry has a globally mitigation potential between 0.11 and 5.68 billion tons of CO2 equivalents per year (Shukla et al. 2019). Tschora and Cherubini (2020), for instanceshowed that developing agroforestry within existing perennial crop plantations in some West African countries could absorb 0.14 GtCO2 per year over twenty years, as well as connecting forest remnants, providing fuel wood, improving soils, protecting crops against climate extremes and enhancing local food and energy security. Box 2.1 shows some benefits of agroforestry in Kenya.

Box 2.1 Agroforestry in Kenya

In Kenya, there is an Agricultural Carbon Project that promotes agroforestry through partnership with World Bank and Vi agroforestry, growing over 3 million indigenous agroforestry trees, in conjunction with other sustainable land management practices such as mulching, composting, and use of livestock manure. The farmers involved were trained to increase soil organic matter content to improve yields, provide resilience to droughts and heavy rains, limit erosion, and store carbon, for which the farmers receive payment. The project sequestered about 345 000 tons CO2 between 2010 and 2016, while improving agro-biodiversity, food security and adaptation to climate change as co-benefits. Farmers also had access to firewood, fruits and fodder in addition to climate change knowledge (Agroforestry Network, 2018)..

In this regard, tree-based agricultural practices are likely to store more carbon in the woody biomass and soil than treeless/more conventional agricultural alternatives under comparable conditions (Nair 2012). The GHG mitigation potential of agroforestry is however, affected by the way the trees, crops, livestock components, or a combination of the three are assembled into the many different agroforestry practices such as:

- alley cropping;
- improved fallow;
- riparian forest buffers;
- windbreaks and shelterbelts;
- silvopasture;
- home gardens;
- boundary planting;
- fruit orchards;
- hedgerows;
- woodlots and firewood plots; and
- forest farming.

As a GHG mitigation tool, agroforestry can also provide additional ecosystem goods and services that are of value to society, including increasing resilience to changing climate (Schoeneberger et al. 2017).

The specifics of agroforestry design and management activities influence the amounts and duration of carbon that is sequestered and the potential reduction in GHG emissions. Management in agroforestry systems is actively focused on growing excessive amounts of biomass and returning as much of the dead biomass as possible to the soil, thus increasing carbon sequestration. The amount of carbon sequestered depends on the tree species, the soil type, the climate and the form of natural resource management (Thissen 2020).

In Africa there exist various tree-based programmes aiming at emission reduction and better livelihood of the rural poor farmers. One of such programme is The International Small Group and Tree Planting (TIST) that is implemented in Kenya, Uganda, Tanzania (Box 2.2) and India. The following is an extract about the programme as a case study in emission reduction and income generation to the household.

Box 2.2 Case study: The International Small Group and Tree Planting (TIST)

TIST programme began in 1999 and currently has more than 100 000 farmers of which 70 000 are from Kenya keeping over 7 million trees relative to 20 million trees in three countries. These farmers are involved in tree planting, compost cover and use of organic materials to improve soil carbon, water holding capacity, binding soil rich nutrients and fertility for enhanced crop production. This improves the ecosystem's resistance to climate change and climate variability associated with drought and low amount of rainfall.

TIST farmers receives about US$0.02 per tree and 70% of the profits from carbon sales associated with emission removals. Overall in this programme farmers have received in the four countries (Kenya, Uganda Tanzania and India) US$ 140 million as benefits that are additional to the carbon income, translating to over US$8 of benefits from each tree planted and kept alive. Some of the income generating activities the farmers in TIST programme are involved including growing of fruit trees such as guavas, macadamia, grafted mangoes, avocado that directly generate income for the household (Oeba 2021)).

2.3.2 Afforestation and reforestation

Developed nations committed themselves to reduce CO2 emissions by ratifying the UNFCCC and they may partly offset their domestic CO2 emissions by sequestering carbon, among others, through afforestation and reforestation activities. Developing countries are eligible to implement afforestation and reforestation projects. Afforestation and reforestation are direct human induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources. Afforestation can take place on land that has not been covered by forest for at least 50 years. Reforestation can occur on land that was historically forested, but was subject to another land use (IPCC 2007).

However, reforestation bears risk to implementation and permanence as the negative emissions is mainly located in regions with high investment risks and weak governance, such as in Sub-Saharan Africa. The need for more land may lead to a reduction in agricultural land, threatening food security (Doelman et al. 2020). The major economic constraint to afforestation is the high initial investment for establishing new stands combined with the several-decade delay until afforested areas generate revenue.

However, the non-carbon benefits of afforestation, such as reduction in erosion or non-consumptive use of forests, can more than off-set afforestation cost (Richards and Stokes, 2004). Furthermore, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2021) stated that the planting of trees in ecosystems that have not historically been forests and reforestation with monocultures – especially with exotic tree species, is often detrimental to biodiversity. Therefore, the expansion of natural forest area is best achieved by allowing degraded forests to recover naturally using nearby remnants of primary forests and seed banks in the soil of recently cleared forests. This will create carbon-storing forests that are more resilient and longer-lasting than planting seedlings (Dooley and Mackey 2019).

2.3.3 Plantation of improved species

The potential to absorb carbon from the atmosphere differs in natural and plantation forests, with the natural forests storing more carbon that plantation/man-made forests with increasing rotation age improving carbon storage potential in plantation forests (Mujuru et al. 2014). Likewise, the carbon sink capacity depends on the type of plant species/clones/hybrids as well as by management factors such as irrigation, fertilisation, and thinning (Karoshi and Nadagoudar 2012).

Irrigation and fertilisation can be done to improve net primary production. Thinning schedules can be modified to stabilise forests against storms, drought, and disease and may also help capture added growth from CO2 fertilisation (Bernier and Schoene 2008). Furthermore, species can be improved for growth and resistance to drought, disease and pests using various breeding methods such as:

- line breeding;
- selection breeding;
- cross breeding;
- hybrid breeding;
- genomic selection;
- molecular markers;
- tissue and cell culture;
- genome editing; and
- genetic engineering.

2.3.4 Assisted Natural Regeneration (ANR)

According to Kpolita et al. (2022), assisted natural regeneration (ANR) is an agroforestry technique involving selection and preservation of seedlings, shoots and suckers of forest species based on their known usefulness such as; firewood, charcoal, edible caterpillars sawing, medicinal, soil fertility, conservation, and shade for crops that cannot withstand full sun. It increase productivity of agricultural and wood products, biodiversity and above-ground biomass in degraded areas. It is a simple technique to implement and can help maintain trees in fields in areas where pressure on the forest is high (Ibid).

> Niger is one of the world's poorest countries, with extremely harsh climatic conditions yet has restored 200 million trees in 20 years largely through a farmer-to-farmer movement with no government and little NGO support.

ANR actions regenerating the tree component initiated by farmers, is referred to as farmer managed natural regeneration (FMNR) (Binam et al. 2015). FMNR is considered a simple, low-cost and empowering land restoration technique for alleviating poverty and hunger amongst poor subsistence farmers through provision of timber and NTFPs and increasing resilience to climate extremes (Kpolita et al. 2022). Enabling conditions for successful FMNR are:

- ease of access to markets for the forestry products;
- benefits higher than from alternatives;
- a viable forestry production technology is available and known to farmers; and
- farmer access to sufficient areas of land and security of tenure to that land, and farmer confidence in being able to control risks, such as pests, fire, and theft.

Watch the following:

https://www.youtube.com/watch?v=0xF27ROVrbg : Farmer Managed Natural Regeneration: Pruning of natural regeneration

https://www.youtube.com/watch?v=hO1xlL9WCO8: Farmer managed natural regeneration in practice

2.3.5 Urban forestry and arboriculture for climate change mitigation

Urban forestry is the care and management of tree populations in urban settings for the purpose of improving the urban environment. It comprises all green elements under urban influence and includes the following (CTCN nd):

- public green spaces, such as parks, gardens, cemeteries;
- street trees and road plantations;
- semi-private space, such as green space in residential areas and in industrial or specially designated parks;
- public and private tree plantations on vacant lots, green belts, woodlands, rangelands, and forests close to urban areas;
- natural forests under urban influence, such as nature reserves, national parks and forests for eco-tourism; and
- Urban agricultural land, such as orchards, allotments etc.

In this regard, urban forestry is a vital component of intricate urban ecosystems providing several ecosystem services, both environmental, recreational, aesthetical, and economic benefits to urban communities (Vargas-Hernández et al. 2018). Trees in urban areas provide key environmental benefits including but not limited to the following;

- reduction of urban air pollution;
- reduction of urban heat island effects;
- air purification;
- soils conservation;
- improved biodiversity;
- improved soil fertility;
- reduced noise; and
- a barrier against natural disasters (Frigeri et al. 2017).

Other than environmental benefits, trees planted in urban areas can help to sequester CO2 making urban forestry a tool for mitigating CO2 emissions (Carter, 1995), offsetting up to 18.57% of carbon emitted by the industries in urban areas and storing substantial amount of carbon (equivalent to 1.75 times the amount of annual carbon emitted by industries energy use in the cities) (Zhao et al. 2010). Nowak (1994) asserted that large trees store approximately 1000 times more carbon than small trees, with trees of diameter >77 cm sequestering approximately 90 times more carbon than those with diameter <8 cm.

Overall, urban forests, like other forests, can be instrumental in climate change mitigation and adaptation, sequestering atmospheric CO2, reducing energy requirements for heating and cooling in buildings although trees can increase or decrease winter heating usage depending on location (Khanal and Straka 2021).

The International Society of Arboriculture (ISA) specified three main principles for the preserving trees, namely:

i. tree preservation must respect pattern of tree growth and development;
ii. focus on preventing injury to trees; and
iii. tree preservation requires space (Harris et al. 2003).

In this regard, Arboriculture plays an important role in parks and gardens..

Figure 6 shows an example of urban green space in Kigali, Rwanda.

Urban green and blue spaces can be used as nature-based solutions for climate mitigation and adaptation and also particularly good assets to use for social prescription and could have a significant impact on the feedback loop between health, drug prescription and their associated carbon emissions (Chastin et al. 2021).

Figure 6: Urban green space in Kigali, Rwanda (Ghana web.com)

2.3.6 Sustainable forest management (SFM)

Sustainable Forest Management (SFM) entails the human interventions promoting sustainable use and protection of forest resources to maintain and enhance their multiple forest uses. SFM is dynamic and evolves aiming at the maintenance and enhancement of the four pillars of sustainability (social, economic, cultural and environmental values) in all forest types, for the benefit of all generations (FAO/ITTO/INAB 2003). In this regard, FM can contribute to climate mitigation and reverse the impacts of climate change on land degradation (IPCC 2019a) because it encompasses initiatives that aim at sustainable utilisation of forest resources through local control and management of existing forest resources, the multiple roles of trees in farming systems and the importance of working through local institutions (FAO 2016). In this regard, SFM can help provide environmentally friendly forest products, protect biodiversity, secure freshwater supplies, and provide other essential ecosystem services.

> Sustainable forest management provides a flexible, robust, credible and well-tested framework for simultaneously reducing carbon emissions, sequestering carbon, and enhancing adaptation to climate change..

SFM encompasses seven thematic elements, namely:

i. extent of forest resources;
ii. biological diversity;
iii. forest health and vitality;
iv. productive functions of forests;
v. protective functions of forests;
vi. socioeconomic functions; and
vii. the legal, policy and institutional framework (FAO/ITTO/INAB 2003).

Sustainable forest management can prevent and reduce land degradation, maintain land productivity, and sometimes reverse the adverse impacts of climate change on land degradation and contributes to mitigation and adaptation (IPCC 2019a).

Figure 7: Sustainable forest management landscape in South Africa. (Institute of Forestry Research, South Africa 2021)

2.3.8 Management of forest reserves

Rising temperatures, droughts, rainfall variability and floods expose forests to threats such as death, diseases or fires. Although the forests are impacted by climate change, there is need to manage them for climate change mitigation. There are several ways to maximise the potential of forests for mitigating climate change and these include:

- combating deforestation and forest degradation;
- restoration of forest landscapes;
- unlocking benefits from forests; and
- creating enabling environment with clearly defined rights for land resources (IUCN 2021) by clarifying tenure and local forest rights and creating protected areas (Angelsen and Rudel 2013).

In this context, forests can be managed to mitigate change following three distinct paths of carbon conservation, storage, or carbon substitution (Brown et al. 1995, Brown 1997) (Figure 8).

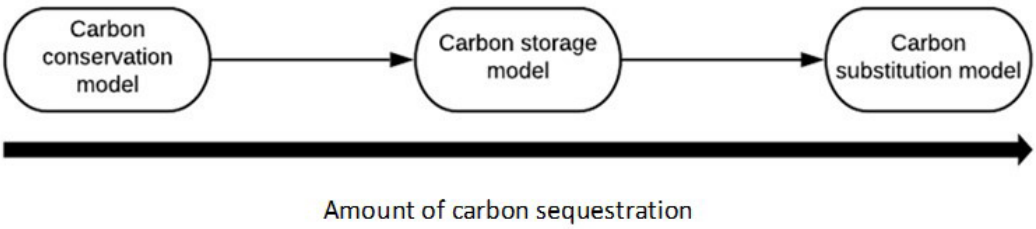

Figure 8: Paths for managing forests for climate change (Nunes et al. 2019)

The value of keeping a forest as a carbon sink for climate change mitigation or to harvest it depends on factors such as the:

- age and inventory of standing timber;
- growth rate;
- time frame under consideration;
- dynamics of the carbon fluxes (including threat of natural disturbances such as fire); and
- perspective of carbon displacement factors used when non-wood products are replaced by wood products (Pingoud et al. 2010).

> A displacement factor is the reduction in emissions achieved per unit of wood used, representing the efficiency of biomass in decreasing GHG emissions

Furthermore, there is need to reduce forests vulnerability to disturbances (Jactel et al. 2017) and conserve biodiversity (Lagergren and Jönsson 2017). However, increased carbon sequestration through substitution should be guarded to reduce threats to biodiversity.

The climate change mitigation initiatives can be in the form of use of new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour. There is need for political will and the involvement of forested regions, to promote forest carbon sequestration while enhancing economic, environmental, and sociocultural benefits. A crucial component is however, the reduction of carbon emissions from deforestation and forest degradation. There is also need for programs to identify opportunities to reduce climate related impacts associated

with forest operations. A summary of forest-based mitigation approaches (Collaborative Partnership on Forests (CPF) 2008) is given below:

Carbon sequestration – achieved through:

- increases in forests and trees enhancing forest carbon stock;
- afforestation, reforestation and forest restoration;
- increased tree cover in farming systems (agroforestry), rural landscapes and cities; and
- enhancing carbon stocks and sequestration capacity through management practices.

Forest carbon stocks conservation – achieved through:

- reducing deforestation and forest degradation;
- sustainable forest management practices and forest resource use;
- integrated fire management and management of forest health;
- biodiversity management; and
- protected area and wildlife management.

Carbon substitution- achieved through substitution of wood products and use of wood based bioenergy

Trees have different stages in their cycles where they capture carbon at different rates. In the early years of life, growth rates are high and, therefore, the accumulation rates of biomass and carbon are also extremely high (Nabuurs et al. 2015). As the trees continue to grow, they accumulate carbon at rates higher than respiration emissions up to a certain age until they reach a stage of a balance between capture and emission before they finally collapse stage where emission rates are higher than capture rates (Maxwell and Lecture 2016). The UNFCCC and the Kyoto Protocol, however state that trees and forests are temporal carbon sinks, as part of the stored carbon is released into the atmosphere after harvesting of the trees from forests or when the trees are burnt, or die (Kellogg 2019).

In text question (10 minutes))

i. Explain how carbon stock conservation is used as a climate change mitigation approach.

ii. Discuss the implications of internationally transferred mitigation outcomes (ITMOs) in the context of forest and tree based options for emission reduction.

2.3.9 Forest certification

Forest certification is a system of inspecting and tracking timber, paper pulp and other forest products to make sure they've been harvested according to a strict set of guidelines and includes the well-being of workers and local communities and other stakeholders (WWF nd). Sustainably managed forests absorb high amounts of carbon, making them important for reducing the impacts of climate change and the mitigation. Furthermore, sustainably managed healthy forests are more resilient to the impacts of climate change. There are several certifying bodies which include the following:

a) Forest Stewardship Council (FSC) - FSC is a body that supports sustainable forest management together with biodiversity, climate resilience, workers' and Indigenous Peoples' rights, and community livelihoods. It strives for global improvement of forest management, and creates an incentive for forest owners and managers to follow best social and environmental practices through certification. For example, South Africa, has 33 forest management certificates covering areas of

timber, bamboo plantations and other forested landscapes.

b) International Organisation for Standardization (ISO) - ISO is a global network that identifies International Standards that are required by business, government and society. The standards are developed in partnership with the sectors that will use them after adopting them through transparent procedures based on national inputs. These are then delivered for global implementation. ISO standards include ISO 14001:2015 which is intended for use by any organisations who want to systematically manage their environmental responsibilities, contributing to the environmental pillar of sustainability.

ISO 14004:2016 provides guidance for an organisation on the following:

- Establishment;
- Implementation; and
- maintenance and improvement of a robust, credible and reliable environmental management system, also contributing to the environmental pillar of sustainability.

c) Programme for Endorsement of Forest Certification (PEFC) - PEFC sustainable forest management certification enables forest owners to provide assurances that they manage their forests in line with challenging environmental, social and economic requirements – balancing people, planet and profit. Hundreds of thousands of forest owners around the world, from small, family and community forests to large company owned forests, have achieved PEFC certification, covering more than 300 million hectares of forest.

d) The African Organisation for Standardisation (ARSO) follows a set of threshold criteria based on ecological, social, climate relevant and credible implementation mechanisms that can be applied anywhere in Africa. In each country, local quality and standards comply to international requirements e.g. South African Forestry Assurance Scheme (SAFAS), standards Association of Zimbabwe, Kenya Bureau of Standards (KEBS), Ghana Standards Authority etc.

2. 4 Legislation and policies on climate change

The risk associated with climate change impacts suggests a need for urgent action to significantly reduce GHG emissions. Reductions of GHG emissions can be achieved at relatively low costs when the right policies are in place, including the use of market-based instruments to develop a global price for GHG emissions, accompanied by better integration of climate change objectives in relevant policy areas such as energy, transport, building, agriculture or forestry, and other measures to speed technological innovation and diffusion (OECD 2007). There are several possible policy approaches for maximising the potential of forests in climate change mitigation and adaptation, but the activities must be supported at the regional and national levels. For example, the success of REDD+ and SFM initiatives depends on how well their elements are integrated into national development strategies as part of holistic national land-use planning (CPF 2008). In this regard, laws and policies are key enablers for achieving net-zero targets expressed in instruments such as climate change framework laws and strategies, as well as laws and policies in relevant sectors such as forestry, agriculture and land use and management. Forest policies and strategies should also target preserving the capacity of trees and forests to store carbon for as long as possible.

There are several national and international mitigation initiatives, starting with Nationally Appropriate Mitigations Actions (NAMAs) and Nationally Determined Contributions (NDCs). The NAMAs are a result of negotiations pursuant to the Bali Action Plan concluded at COP 18 in Doha and refer to any action that reduces emissions in developing countries, prepared under the umbrella of a national government initiative (UNFCCC 2007). The NAMAs would be supported through:

- technology transfer;
- Finance; and
- capacity building, in order to manage forests to mitigate climate change within the context of REDD.

They can be policies directed at transformational change within an economic sector, or actions across sectors for a broader national focus. NAMAs are defined either at national level or at individual level, where the individual contribute towards meeting the objectives of NAMAs at the national level.

NAMA may also be a sectorial goal, a strategy, a national or sectorial programme, or a project-level action. There are differences between NAMAs implemented with international support and those domestically supported. Both types of NAMA may be registered with the UNFCCC (Ibid). The NAMAs and the Low Emissions Development Strategies (LEDS) are the two main types of planning instrument for national mitigation planning. LEDS planning document can either be LEDS framework plans or LEDS action plans. LEDS framework plans identify priority sectors for mitigation policies and actions on the basis of national conditions, existing national development policy frameworks and analyse of baseline GHG emissions by sector (FAO 2013a). In agriculture, forestry and other land uses (AFOLU) sector, there is a lack of NAMAs that have received financing.

At international level, the Clean Development Mechanism (CDM) supports afforestation and reforestation projects whilst the Reducing emissions from Deforestation and forest Degradation (REDD) initiative is based on financial incentives to preserve forests and thus maintain or increase carbon stocks. The REDD+ approach has been proposed for financing forest conservation, the enhancement of forest carbon stocks and SFM. This win for forests builds on the important Warsaw Framework for REDD+ that came out of the 2013 UN meetings.

All sectors that contribute to GHG emissions should design climate change mitigation policies to support their actions e.g. national climate change policies, providing support for mitigation and adaptation actions, national energy policies, agricultural policies that support climate smart agriculture, national REDD+ strategies, etc.

2. 5 Benefits of forest-based climate change mitigation

The implementation of forest and tree-based climate change mitigation options/strategies/initiatives offer a wide range of benefits including improving resilience of social and biophysical systems. Some of these benefits are highlighted in the following subsections.

2.5.1 Employment and income generation opportunities

Climate change threatens the provision of many vital ecosystem services and thus endangers the jobs that depend on them. The provisions of safe, healthy and decent working conditions are affected by environmental hazards and environmental instability which have greater impacts on the vulnerable workers (ILO 2018). ILO (2018) added that transition to a low-GHG economy is expected to cause a net creation of jobs through actions taken in the energy, transport and construction sectors.

Box 2.3. The ILO Guidelines for a just transition towards environmentally sustainable economies and societies for all

The Guidelines for a just transition towards environmentally sustainable economies and societies for all can be used to ensure that no workers are left behind during the transition to a green economy, and that the transition strengthens decent work. These guidelines offer a portfolio of policy options for addressing the issues associated with the greening of the economy and the workplace and, more broadly, with the transition towards sustainable development. The guidelines encourage governments to develop national policies and plans for climate change mitigation and adaptation and disaster preparedness, in order to strengthen resilience to the impacts of climate change and promote disaster preparedness (ILO 2015)

The international Energy Agency (2015) stated that the pursuit of sustainability in the energy sector would create around 18 million more jobs globally by 2030 compared to the business-as-usual path. The creation of employment will be driven by higher labour demand of renewable energy sources, as well as the entire value chain associated with renewable energy, electric vehicles and construction of the necessary infrastructure (Ibid).

Awono et al. (2013) identified at least 570 plants and 110 animal species harvested from the wild in Cameroon with the main non-timber forest products (NTFPs) fetching over US$1 billion annually. Small businesses across Cameroon and the Democratic Republic of the Congo employed more than 350 000 people to harvest 15 most widely used NTFPs, constituting more than twice the number of jobs in the formal forestry sectors. If the provision of forest products is sustained, emissions can be reduced while people get a livelihood from the forests.

In REDD+ initiatives, the sustainable extraction of (some) NTFPs can contribute to forest conservation due to their different re-vegetation patterns and growing characteristics when compared to trees. The usage and extraction of NTFPs will provide income from the forest which consequently represents an incentive for forest conservation. For example, collection of medicinal plants from forests contributed more than 50% of household income in Tanzania (Schaafsma et al. 2014).

In initiatives dealing with biofuels, the production of biofuels will have a substantial impact on jobs and market opportunities in biomass production, logistics and bio-refineries, where many additional jobs in traditional areas will be created to supply bio-refineries with needed feedstock. Furthermore, industries providing enzymes, microbes and other supplies for bio-refineries will create new and expanded job opportunities as well (Carr et al. 2010, Gibbons and Hughes 2011).

2.5.2 Biodiversity conservation

Climate change mitigation measures have a range of positive human health, ecosystem functioning, macroeconomic, social, and/or equity side effects that in some cases outweigh the importance of climate change mitigation benefits. These ancillary benefits include biodiversity conservation for actions especially dealing with natural ecosystems (Urge-Vorsatz et al. 2014).

Mitigation initiatives should identify potential opportunities of integrating biodiversity within the climate change policies, programmes and projects, clearly showing their interconnectedness. Forest-based climate change mitigation can help to achieve biodiversity benefits. As sustainable management of forest ecosystems curbs GHG emissions, the use of ecosystem-based adaptation (EbA) and mitigation (EbM) is about the management and rehabilitation of ecosystems for adaptation and mitigation of climate change.

The EbA is the use of biodiversity and ecosystem services as a component of the adaptation strategy to help societies adapt to the adverse effects of climate change. On the contrary, the EbM is the use of ecosystems for their carbon storage and sequestration potential to help in climate change mitigation (Epple et al. 2016). When considering the uncertainties linked to climate change impacts, the ecosystem-based approaches are considered "no-regret," or "low-regret" options because they are not likely to cause any harm. They also have potential to be more cost-effective than other measures because they provide multiple benefits (social, economic and environmental) (Doswald and Osti 2011, Roberts et al. 2020).

The options under EbA include the following:

- ecological restoration;
- wetland and floodplain conservation and restoration;
- afforestation and reforestation;
- fire management;
- conservation and replanting mangrove forest;
- green infrastructure (e.g., shade trees, green roofs);
- sustainable fisheries management;
- ex situ conservation and seed banks;
- ecological corridors;
- community-based natural resource management (CBNRM); and
- adaptive land use management.

Protecting and conserving forests ecosystems can be a cost-effective emissions mitigation strategy although it needs clear synergies with objectives of biodiversity conservation (Roberts et al. 2020). For example, it is important to mainstream the multiple co-benefits from wildlife and habitat protection in climate mitigation and adaptation planning.

2.5.3 Watershed conservation

Watershed conservation can be achieved through application of a set of actions aimed at ensuring the sustainable use of natural resources in a watershed. Watershed management is the management of all human activities and their effect on the environment within a geographical area defined by a watercourse, applied to promote coordinated actions and linkages between upstream and downstream environments and populations.

Integrated watershed management should be associated with the livelihoods of people, providing

opportunities for improved incomes and increased resilience to climate change. All land uses, water resources and natural resources within a watershed must be included in watershed management initiatives, including domestic and productive uses at all levels (FAO 2017a). Therefore, identifying needs at all levels will help establish interventions that support environmental protection as well as climate change adaptation and mitigation. Examples from Ethiopia, Kenya, Uganda, and Rwanda demonstrated that improving and strengthening watershed management can effectively address land and water resource challenges, while at the same time providing a first step to meeting the challenges posed by climate change (Joosten and Grey 2017).

The climate change mitigation initiatives in watershed areas promotes resilience of natural ecosystems by avoiding deforestation, reversing natural resource degradation, safeguarding agricultural productivity and maintaining ecosystem services. The benefits overflow by helping communities to adapt to climate change, conserving the environment and improving people's lives and livelihoods in addition to the reduction of GHG emissions. Furthermore, it allows diverse groups of stakeholders and institutions to work together to maintain watershed/ecosystem services for all, thus addressing issues that were previously addressed in a sectorial way (Ibid).

2.5.4 Aesthetic and recreational services

Climate change affects aesthetic value due to its effects on nature, the technological developments for mitigation to reduce GHG emissions (e.g. geo-engineering and structures for renewable energy) and changes to other human structures and activities e.g. changing crop types, transport modes and building structures. The aesthetic values are generated through appreciative experiences for climate change mitigation.

Beneficial effects include feelings of being uplifted, greater perceptual sensitivity and activation of imagination (Brady 2014). In an urban context, forests and parks can contribute to enhancing health through better air quality and provision of leisure spaces (European Environment Agency 2021). Climate change mitigation can increase biodiversity and improve aesthetic especially with restoration activities.

2.5.5 Poverty alleviation

Climate change mitigation activities may have adverse effects on poor and vulnerable households who depend on environmentally-damaging activities, such as unsustainable agriculture, charcoal production or logging. Climate change mitigation measures carry additional costs and can endanger incomes and livelihoods of the poor (Györi et al. 2021). For example, when the Chinese government announced the closure of thousands of their coal mines, about 1.3 million jobs were lost in the coal sector, along with 500,000 jobs in the steel industry (Yan 2016).

However, climate change measures based on creating 'green growth', 'green jobs', and the 'green economy' share a broad consensus that 'green transformation' needs to be designed in an inclusive way (ibid). These will lead to a net increase in employment, with new jobs mainly emerging in sectors that are characterised by high levels of informality and in-work poverty (Malerba and Wiebe 2020).

Avenues focusing at payment for ecosystem services (PES) explicitly incentivise owners/users of environmental assets such as forests or water resources, to conserve or use them in a sustainable manner by compensating them for the opportunity cost of sustainably using the natural asset. When the PES are higher than the opportunity costs of using assets in a sustainable way, there is an increase in the net income of the beneficiary. In this regard, if the PES target individuals living below the poverty line and benefits are sufficiently generous, PES can as well reduce poverty (Györi et al. 2021).

However, programme impacts may only last as long as payments for conservation are received, after which there is a risk that people will resume the unsustainable use of the environmental asset. The PES

should be linked to a long-term change of attitudes and values (Chan et al. 2017) or the promotion of alternative income-generating opportunities.

2.5.6 Forest governance issue in climate change mitigation initiatives

Climate change mitigation initiatives promote good governance arrangements at the national and sub-national levels across the globe increasing the participation at local level and improving their capacity to self-regulate. Multiple decision-making centres can contribute to solving a particular issue based on their statutory responsibilities as decision makers cooperate, compete, resolve conflicts, learn from each other, and mutually adjust their behaviour and/or negotiate (Heinen et al. 2022).

Other areas that need improved governance are linked to sustainable extraction mechanisms for NTFPs which need to be defined and integrated into policies in order to make it economically interesting for local farmers and forest dwellers to conserve forests (Nadkarni and Kuehl 2013).

2.6 Promotion of non-timber forest products and wood by-products

Forests provide NTFPs, that serve as source of food, fuel, medicine, raw materials and incomes. They are also keep traditional knowledge alive and can have an important role in climate action (Nadkarni and Kuehl 2013) for rural and urban communities in Africa. The goods are either used for self-consumption or sold at local markets and can play a key role for rural well-being, providing additional benefits apart from emissions reductions in activities targeting reducing emissions from deforestation and forest degradation. In Africa, biodiversity conservation promotes the continued provision of these benefits under a changing climate.

Timber and NTFPs have a tremendous potential to create rural employment, help in reducing poverty and reducing urban migration, their dependence on forest ecosystems, can be a strong incentive for forest conservation. Furthermore, NTFPs can be used to create emission reductions as a direct tool for carbon sequestration indirectly helping to store and sequester carbon in forest systems. NTFPs such as honey and mushrooms require healthy and functioning forest systems to be productive (Nadkarni and Kuehl 2013).

The use of timber and NTFPs in a REDD+ context needs to be based on their sustainable harvesting and extraction. Figure 9 shows some of the important fruits and ilala palm important for basketry in Southern Africa.

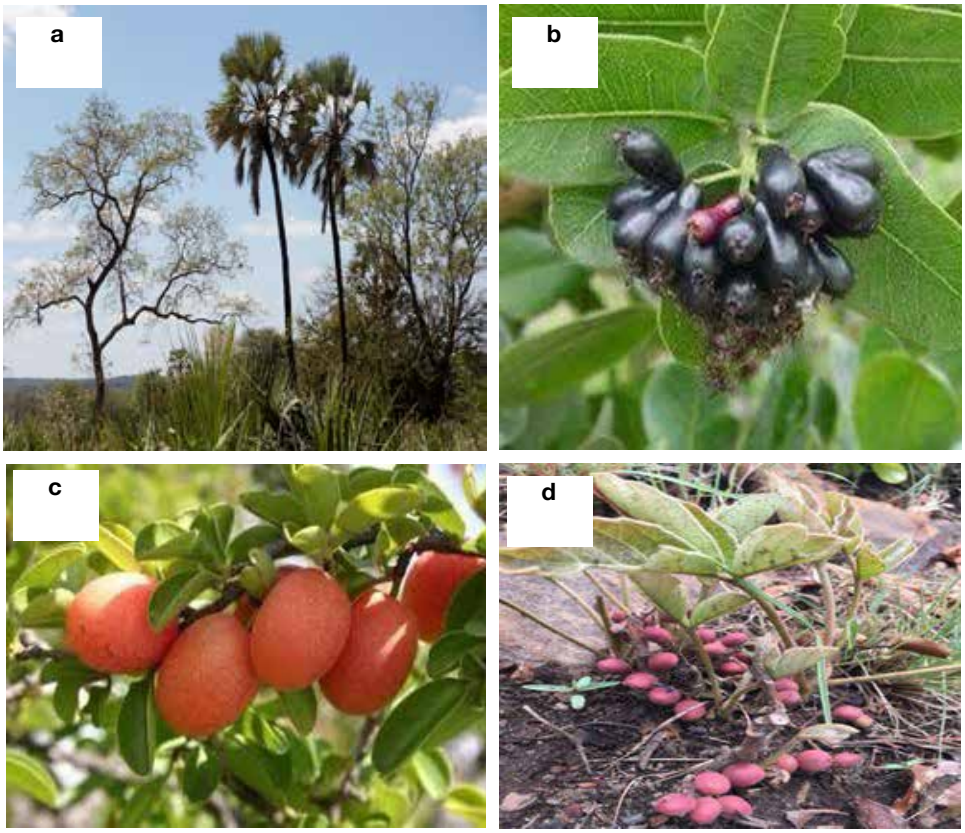

Figure 9: Examples of NTFPs a. Hyphaene petersiana/coriacea, b. Syzygium cordatum, c. Ximenia caffra and d. Lannea edulis (USAID 2022).

2.7 Biomass energy saving

More than 80% of rural households depend on wood fuel for energy. The use of biomass energy saving technologies can help to reduce deforestation and forest degradation through efficient ways such as use of fuel efficient stoves (DeWan et al. 2013) and efficient charcoal production (Schure et al. 2019). In other areas e.g. Small Grants Projects of GEF 6, in Lower Zambezi Biodiversity project, biogas and fuelwood saving stoves are used in addition to fire management, beekeeping and environmental awareness.

In Malawi, women are trained to make different types of energy efficient clay stoves by NGOs and they sell the stoves locally. The stoves are more efficient because a 40 kg bundle of firewood can last up to two weeks whereas in the old model the same firewood is consumed within three days. Another stove is the metal charcoal stove designed by US social enterprise Envirofit. The stove consumes up to 57% less fuel than a traditional charcoal stove, cooks food in half the time and produces up to 70% fewer toxic emissions (Bertrams and Gercama 2017). Another example is the EcoZoom stove used in Kenya with up to 70% savings of fuel consumption and 60% less smoke (Almanza 2020).

The benefits of alternative energy sources are not only reduction of emissions from deforestation but also include the reduction of soil erosion due to decreased deforestation, healthier population, and improved livelihood and household income.

Box 2.4. Case study: Biomass energy based carbon projects in Kenya for emission reduction and improvement of carbon sequestration in forest landscape

Most of the rural households in Kenya depend on biomass energy that is causing deforestation and loss of biodiversity. Furthermore, they use low efficient cook stoves that requires a lot of firewood to supply the needed energy for domestic use. There are projects that have promoted the use of improved cooking stoves and the planting of trees on farms. This reduces pressure on the forest resource base. The carbon credits are earned from the reduction of household wood usage. Some of these projects are:Kenya improved woodstoves;, and Hifadhi Livelihood in Mt. Kenya region. The improved stoves provide affordable, clean and efficient energy with reduced consumption of firewood by 40% and preservation of 2400 ha of forest. About 60 000 locally manufactured cook stoves have been distributed to households out of the 120 000 targeted in Embu County. Reforestation efforts have been supported through planting of 1 million seedlings. Women and children have also benefited through reduction in time spent collecting firewood from 6 to 3 hours enabling them to shift to other activities such as education, community leadership and entrepreneurship. Employment opportunities have been created directly and indirectly for over 300 staff involved in the project activities.

The improved cook stoves, tree planting and conservation of forests, reduced about 174 722 Mg CO2e yr-1 projected to reach 3.5 million Mg CO2e yr-1 thus mitigating climate change and contributing to sustainable development goals (Oeba 2021).

2.8 Forest-based challenges associated with climate change mitigation

The forest-based challenges associated with climate change mitigation are mainly associated with processes of mitigation options, addressing, drivers of deforestation, policy support and technical capacities to support climate change mitigation. The challenges can be categorised into technical, institutional or professional and financial.

2.8.1 Technical

The following are some of the documented technical challenges associated with forest based climate change mitigation in different landscapes:

- realistic baselines, to prove the additionality of the climate benefits from forest activities;
- measuring, monitoring, reporting, and verifying the actual emissions avoided or carbon stocks preserved in forests;
- lack of data, validity and credibility of data, and acceptance of the results of quantitative analysis based on that data is a challenge (Trollip and Boulle 2017);
- Ensuring that the emissions are not shifted elsewhere (leakage) or management of risks associated with permanence of carbon credits;
- benefit sharing mechanisms for local and indigenous peoples that also considers environmental co-benefits are not undermined (Virgilio and Marshall 2009);
- Addressing the underlying drivers of deforestation and land degradation;
- Inadequate capacity to ensure for multi-stakeholder engagement, community participation and support;
- increased rates of sedimentation swamping nursery areas especially for mangroves making it difficult to raise required seedling for afforestation and reforestation programme;
- species site matching for effective implementation of forest and tree based climate change mitigation;
- practitioners may not comprehend tree growing and husbandry practices;
- failure to meet planting targets due to challenges associated with collecting and nurturing sufficient numbers of seedlings in a protected nursery area, before transplanting them; and
- changes on weather patterns affecting phenology of the indigenous plants causing scarcity of seeds for nursery establishment and transplanting (Oeba 2021).

2.8.2 Institutional

The institutional challenges include the following:

- Lack of credible data and quantitative analysis which are necessities for effective policy formulation and implementation;
- Weak political and policy support and national implementation capacity;
- Insecure land tenure, which makes it difficult to ensure emission reductions are permanent that may therefore make investment unattractive;
- Lack of clarity over rights to carbon including where rights are well defined, they may exclude the poor; and
- lack of access to legal systems.

2.8.3 Financial

Financial challenges are the mainly linked to inadequate finances to prepare and respond to climate change disasters. In cases where there are financial instruments for the financing, the processes and procedures are somehow complicated and lengthy. Other financial specific challenges include the following (Oeba 2021):

- inadequate ready markets for ecosystem goods and services;
- uncertainty around investment returns;
- inadequate consideration of climate risk in investment decisions;
- high upfront costs of technology;
- most projects are mainly donor driven, beyond which, they are not sustainable;
- inadequate financial resources provided to support effective implementation of forest and tree based climate change mitigation activities;
- communities not ready to contribute towards climate change based projects;
- diversion of project finances into other uses;
- government priorities are often changing; and
- failure to meet carbon emission targets resulting to decline of carbon credit benefits

2.8.4 Social challenges

The social challenges include the following (Oeba 2021):

- high poverty as well as illiteracy levels in many areas where the projects are implemented;
- differential socio-economic status that disadvantage majority in terms of access to information and benefits;
- low returns to the targeted vulnerable communities to the impacts of climate change and climate variability;
- longer duration to get tangible returns;
- inadequate understanding of the project area economic needs;
- weak relationship by both project area residents and project implementers;
- inadequate strategies/tools of information sharing;
- low community support in livelihood activities related to mitigation that is key to the successful implementation of the forest and tree based project and programmes;
- benefits both carbon and non-carbon not well valued to meet the expectations of the community members and other stakeholders responsible in the implementation of M+A project activities;
- competing household needs versus development priorities; and
- distance to the main markets and therefore cannot sell forest products at competitive prices to generate the needed income for investing to support the costs of nurseries, planting, tending and protection (fire, human intervention, etc.) after plantation establishment among other needs.

In text question (10 minutes))

i. Identify two forms of national mitigation planning.

ii. Explain the relationship between NDCs and ITMOs.

iii. Explain the technical challenges associated with climate change mitigation.

Summary

In this chapter we learnt that forest based and tree based initiatives entail actions or options aiming at addressing emission reduction. In this regard, forest and tree resources play a critical role in climate change mitigation. Some of these include introduction and implementation of global programmes in forestry sector such as afforestation and reforestation in Clean Development Mechanisms, Reducing Emissions from Deforestation and forestation Degradation, forest based Nationally Appropriate Mitigation Actions, Forest and Landscape restoration commitment.

We also learnt about the various financing mechanisms supporting the forestry sector in climate change mitigation can be multilateral, bilateral, private, or domestic. The UNFCCC financing mechanisms include the Global Environment Facility, Green Climate Fund, adaptation fund and Climate Investment funds. In order to succeed, there is need for laws and policies in relevant sectors to act as key enablers expressed in instruments such as climate change frameworks and strategies, as well as laws and policies.

National and international mitigation initiatives, start with NAMAs and NDCs. The NAMAs are supported through technology transfer, finance and capacity building and can be implemented with international or domestic support. Another form of national mitigation planning instrument is the Low Emissions Development Strategies (LEDS). Before the Paris agreement, only developed countries made emission reduction targets and Paris Agreement allows developing countries to have mitigation targets through their NDCs, and they can also participate in international carbon markets as sellers or buyers of internationally transferred mitigation outcomes. In all these arrangements, forests are important in reducing impacts of climate change by absorbing CO2 from the atmosphere and protect communities from extreme weather events and sea level rise.

Forest and tree-based climate change mitigation and sequestration practices include agroforestry, afforestation/reforestation, plantations, farmer managed natural regeneration/ assisted natural regeneration, urban forestry, sustainable forest management, management of forest reserves and formulation of supporting policies and legislation. The benefits of climate change mitigation initiatives include non-carbon benefits such as employment and income generation, poverty alleviation, biodiversity conservation, watershed conservation, aesthetic and recreational services, provision of NTFPs and improved governance. The chapter concluded by highlighting technical, institutional and financial challenges of climate change mitigation.

Chapter 3: Clean Development Mechanism, Redd+ And Other Forest-Based Approaches For Mitigating Climate Change

3.1 Chapter Overview

This chapter focuses on clean development mechanism (CDM), REDD+ and other forest-based approaches for mitigating climate change. It builds an understanding of the evolution of the CDM and REDD+ processes, economic benefits from the mechanisms, governance issues involved, and multi-stakeholder participation in these processes. The discussions also include financing mechanisms for CDM and REDD+ and their relationship with Nationally Determined Contributions (NDCs). The chapter concludes by highlighting other forest based initiatives, the role of forest-based mitigation options at all levels and the national, regional and international commitments to climate change mitigation.

Learning outcomes

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

i. Identify forest-based mitigation initiatives, e.g. CDM, REDD+ and other approaches;

ii. Describe the CDM processes;

iii. Describe the phases and processes of REDD+;

iv. Describe the implementation processes of CDM and REDD+;

v. Explain how CDM and REDD+ projects lead to climate change mitigation;

vi. Identify financing mechanisms for CDM and REDD+ processes;

vii. Participate/contribute to the development of REDD+ project at local, sub-national, national, regional and international levels;

viii. Explain the role of NDCs forest-based options in climate change mitigation;

ix. Describe the role of other forest-based initiatives at regional and international levels in climate change mitigation; and

x. Explain the contribution of local, subnational, national forest-based climate change mitigation initiatives to the regional and international commitments.

3.2 Overview of international instruments for climate change mitigation

The key international instruments for climate change mitigation are anchored in the United Nations Framework Convention on Climate Change (UNFCCC) that provided CDM and REDD+ as forest-based mechanisms for mitigating climate change. The following sub sections highlights evolution of the CDM and REDD processes, implementation processes, the difference between RED, REDD, and REDD+, economic benefits from the mechanisms, governance issues involved, and multi-stakeholder participation in the CDM and REDD+ processes.

3.2.1 CDM Process

3.2.1.1 Definitions of CDM

The Clean Development Mechanism (CDM) is a market-based instrument established by the Kyoto Protocol (KP) to foster co-operation on afforestation and reforestation between industrialised and developing countries. The CDM is one of the three market-based flexibility mechanisms that were created under KP. CDM's purpose is to assist developed countries to achieve their emission targets at a lower cost by allowing offsets of their obligations through projects in developing countries (UNFCCC 2021c). The other two mechanisms were the Joint implementation and emission trading system. Under these systems, nations can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting the Kyoto targets (UNFCCC 2022).

The CDM provides an opportunity for industrialised countries to initiate projects such as rural electrification using solar panels, installation of more energy-efficient boilers or afforestation and reforestation in developing countries and trade their respective carbon credits. In this regard, CDM directs finance from public and private sectors in developed countries to innovative low carbon projects in developing countries. This is to reduce CO2 concentrations in the atmosphere through enhancement of forest carbon sinks and reservoirs. In forestry, this is mainly through afforestation and reforestation projects.

Collaborative Partnership on Forests (2008) showed that although afforestation and reforestation activities are included in the CDM since 2001, a few projects have been implemented in Africa due to the high transaction costs. However, given the potential of afforestation and reforestation in carbon sequestration, CDM procedures need to be simplified. In developing countries, there is risk of displacement of forests that are not eligible for the CDM except afforestation and reforestation (GOFC–Gold 2016). An example of a CDM forestry project in Africa is the Humbo project in Ethiopia.

3.2.1.2 Evolution of the CDM and transitioning to SDM

The KP had the first commitment in 2008-2012 and the second commitment post from 2012 -2020. In the second commitment period, the CDM had a low demand for certified emission reduction (CERs) compared with demand in the first commitment period of the Kyoto Protocol (2008–2012) (UNFCCC 2021d). Under the Paris Agreement of 2015, all parties are expected to make and implement climate commitments called nationally determined contributions (NDCs) to help fulfil the Paris Agreement's goals. This is to limit warming to 1.5 degrees and to decarbonise by the second half of this century. The Paris agreement's Sustainable Development Mechanism (SDM) was established to reach the goals of the Paris Agreement and become the predecessor to the CDM and JI.

The CDM catalogue of methodologies and associated emission reduction estimates can be adopted for SDM to provide a quantified estimate of emission reductions for a given amount of financing (Carbon Market Watch 2017). The difference between the two mechanisms is that the CDM was established as an offsetting mechanism where emissions in developed countries that had climate targets were met through

emission reducing projects in developing countries that had not targets. The SDM must however, function in a world where all countries have climate mitigation targets, contributing to sustainable development, and delivering an overall mitigation of GHG emissions through results-based finance (Ibid).

Differences between NAMAs and CDM

CDM follows a project/activity-based approach whilst NAMAs are a mechanism for countries to reduce their own GHG emissions in one or multiple sectors and involve a wider range of activities with broader time horizons. They also provide more opportunities for large-scale national GHG reductions. Furthermore, there has not been any decision for an international climate negotiation option to issue carbon credits from NAMAs

The CDM mechanism innovated and transformed global climate change cooperation, leading to the registration of 7 800 projects, with about 355 Programs of Activities (POAs) issue of 2 billion CERs with the procedural and institutional framework applied in more than 140 countries (UNEP DTU 2021). Parties to the Kyoto Protocol and other governing bodies should plan and manage the transition from the Kyoto environment into the Paris environment (Kainou 2022). Kainou (2022) also suggested that CMA (COP serving as the meeting of the Parties to the Paris Agreement) and CMP could mutually authorise the temporary use of the CDM mechanism (including its infrastructure) under Article 6.4 until the Article 6.4 mechanism becomes available. In the absence of CDM transitional arrangements, or for CDM activities that do not qualify for a possible transitional arrangement, project developers could reapply so that their activities become recognised under the Paris Agreement as either under Article 6.4 market mechanism or as a bilateral cooperative approach between two governments under Article 6.2 (Climate Focus 2017).

The CDM project cycle is a seven-step process which starts with preparation and submission of project design document (PDD) by the project participant, making use of approved emissions baseline and monitoring methodology. This is then approved by the Designated National Authority (DNA) housed in each country. This is followed by validation done by independent assessment by accredited designated operational entity (DOE), private third-party certifier. Validated project is submitted for registration and formal acceptance as a CDM project activity by the Executive Board. Registration is the prerequisite for the verification, certification and issuance of CERs related to that project activity.

Verification is the independent review and ex post determination by the designated operational entity of the monitored reductions in anthropogenic emissions by sources of greenhouse gases that have occurred as a result of a registered CDM project activity during the verification period.

Certification is the written assurance by the designated operational entity that, during the specified period, the project activity achieved the emission reductions as verified.

The project developer then monitors, report and request for issuance. The Designated Operational Entity verifies the emission reduction, in the amount claimed, according to approved monitoring plan and the executive board issues CER. Figure 10 shows the CDM project cycle.

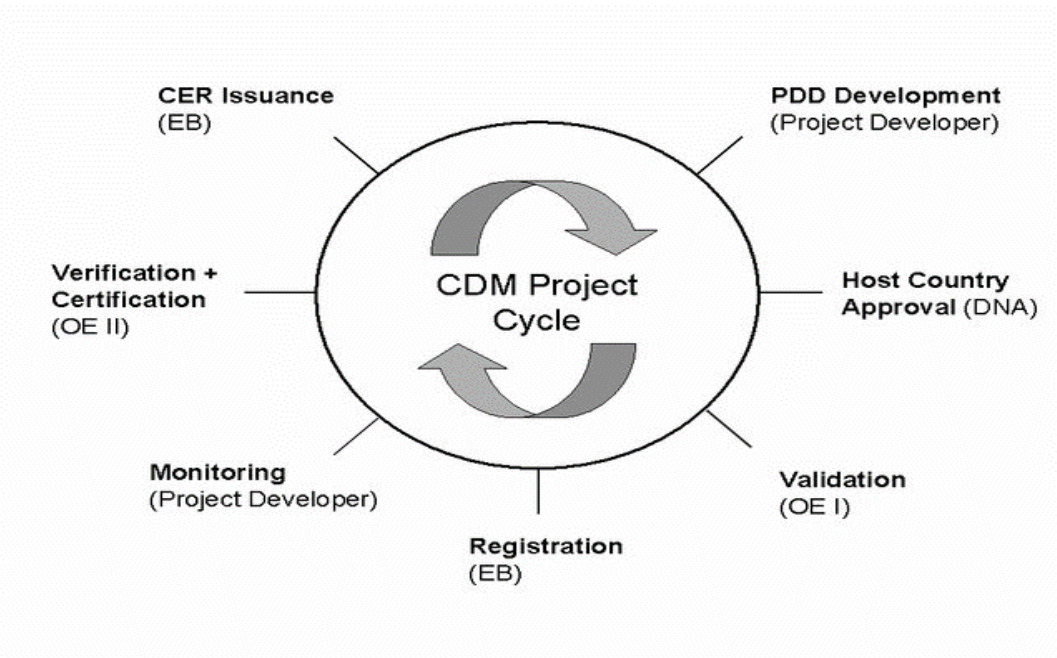

Figure 10: The CDM project cycle (Michaelowa et al. 2004)

3.2.1.3. Guidelines for the Development and Implementation of CDM

The detailed rules and modalities for the CDM were agreed upon by the Kyoto Protocol parties in 2001, as part of the Marrakesh Accords, in that same year. The CDM is one of the international legal frameworks regulating anthropogenic GHG emissions and their mitigation, as well as global adaptation to climate change. Below is an outline of regulatory frameworks for CDM (Curnow and Hodes 2009):

The UNFCCC - provides a framework for activities addressing climate change, including the preparation of national GHG inventories, the consideration of climate change in the development of domestic policy, the transfer of technologies with which to tackle climate change, and the raising of awareness of climate change and its impacts.

Kyoto Protocol – is legally binding, quantified emission reduction obligations under international law since 1997. To participate countries should ratify the protocol and are expected to conform to the CDM methodologies and guidelines in order to benefit from the initiatives.

Host Country should have laws which address the implementation of CDM, without impacting negatively on the development of CDM projects. In the same way countries should have domestic laws relevant to CDM Projects.

Several compliance programs and voluntary standards recognise and accept Certified Emission Reduction (CERs) from CDM. The schemes or standards include the Verified Carbon Standards (VCS) and the European Union Emissions Trading System (EU ETS). Another scheme is the Gold Standard which certifies projects that use CDM methodologies and also comply with additional Gold Standard criteria (Broekhoff et al. 2019).

The Clean Development Mechanism (CDM) requires the application of a baseline and monitoring methodology in order to determine the amount of CERs generated by a mitigation CDM project activity in a host country. The Methodologies are classified into five categories: Methodologies for large-scale CDM project activities;

- Methodologies for small-scale CDM project activities;
- Methodologies for large-scale afforestation and reforestation (A/R) CDM project activities;
- Methodologies for small-scale A/R CDM project activities; and
- Methodologies for carbon capture and storage (CCS) project activities.

To secure this approval, project developers should demonstrate how the project contributes toward the sustainable development objectives of the host nation. Furthermore, both should agree to undertake the initiative voluntarily including the participation of stakeholders and the following:

a. The project must not cause any degradation in local social, economic or environmental domains.

b. Project emission reductions must be above and beyond BAU. Emission reductions that are additional to that which would occur in the absence of the certified project activity will only be eligible to earn CERs (UN 1998). The project must demonstrate that it was undertaken for its emission reduction benefits known as "additionality".

c. Project must generate real, measurable and verifiable GHG reductions. The project must measure and report the amount of GHGs reduced (in tonnes) verified by an independent party. The project also can not cause GHGs to increase in another location, e.g. across a border - this is known as "leakage".

d. Projects must bring appropriate technology. Technologies that are transferred must be appropriate to the needs and business environment of the host country.

e. Total involvement. The owner of the credits must be identified and involved in all contract negotiations about transfer of ownership of the CERs and Parties must be able to prove that the CERs generated are owned by the party selling them.

The South African carbon tax system came into force in 2019. Under this system, major carbon emitters, such as electric power and mining companies, are taxed according to their emission volume at a nominal tax rate of around $8/tonne of CO2 but are exempted from paying taxes for the portion of their emissions that is covered by voluntarily cancelled certified emission reductions (Kainou 2022).

3.2.1.4 Economic benefit of CDM

The CDM project activities also offers economic activities apart from mitigation of GHG emissions. In addition, they as well provide the following benefits related to sustainable development:

- technology transfer;
- poverty reduction;
- access to energy efficient lighting and cooking;
- improvement of air quality and living conditions; and
- reduction of costs and generation of jobs and skills.

For instance, in China, a CDM afforestation/reforestation project promoted local economic growth by optimising the local industrial structure, increasing the regional capital stock and raising the regional government's fiscal revenue and expenditure (Hu et al. 2021).

Significantly greater investments are required to reduce emissions from developed countries own advanced and huge industries than it would take to develop cleaner processes in developing countries. In developing countries, marginal investments can significantly reduce emissions through small-scale and effective technology upgrades (Ukabiala nd). In this regard, there was a liquidation of the CDM scheme, which centred on the cancellation system and was almost completed by 2020. The liquidation was aided

by the fact that many investing companies begrudgingly accepted loss-cutting cancellation of certified emission reduction credits upon expiry of the project period (ten years, or seven years with two possible renewals). However, the CDM scheme was revived with unexpected support from the US and developing countries (Kainou 2022).

Activity 3.1 (Brainstorming) (20 Minutes)

Explain the prospects of REDD+ implementation in your country or region.

Other CDM projects include biomass energy based activities that are implemented in different parts of the developing world are significantly addressing GHG emission reduction under the compliance and voluntary carbon offset mechanisms. In addition, bioenergy and corresponding feed stocks are also increasing in addressing climate change mitigation with investment benefiting communities to adapt to climate change and variability (IPCC 2019a, Calvin et al. 2021). The overall effect for some of these projects that promote efficient technologies is their ability to reduce reliance on forest and tree resources commonly used as energy in most rural areas. The result is increased carbon sink in forest and farm landscapes that can enhance the resilience of social and biophysical systems.

3.3 REDD+ mechanism

3.3.1 Evolution of REDD+

The REDD+ process began with the concept of Reducing Emissions from Deforestation (RED) which was first proposed at Conference of the Parties (COP) 11 in Montreal in 2005. This was later change to REDD where the second 'D' represented forest degradation, or the shifts to lower carbon-stock densities within the forest. Then REDD+ emerged where the "plus" includes afforestation, poverty alleviation, biodiversity conservation and improved forest governance adopted at COP 19, in 2013 in Warsaw, supported by seven decisions making the Warsaw Framework for REDD-plus (Decisions 9-15/CP.19). The chronology of major decisions by the UNFCCC COP, starting with the Kyoto Protocol (KP) is outlined below:

i. **Kyoto Protocol (1997)** - incorporated provisions on land use, land use change and forestry (LULUCF) activities in developed countries (Annex I), permitting them to credit to their reduction or stabilisation targets removals in the LULUCF sector. Flexibility mechanism under the Protocol (CDM and JI), provided options for Annex I countries to meet their emission reduction targets by investing in "offset projects" in developing countries.

ii. **COP 11 Montreal (2005)** - The concept of Reducing Emissions from Deforestation (RED) was introduced. This only included changes from "forest" to "non-forest" land cover types and details very much depend on the national definition of a forest.

iii. **COP 13 Bali (2007**) - Bali Action Plan was developed for REDD catering for deforestation and forest degradation and provided five pillars that form the basis of future activities by the Parties outside the Kyoto Protocol: adaptation, mitigation, shared vision, finance and technology transfer. RED was expanded to include forest degradation, the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in the scope of methodological issues to be explored by Subsidiary Body on Scientific and Technical Advice (SBSTA).

iv. **COP 14 Cancun (2008)**. Subsidiary Body on SBSTA identified the REDD+ methodological concerns that needed to be elaborated and these were linked to: estimation and monitoring, reference emission levels, displacement of emissions, national and subnational approaches, capacity-building, effectiveness of actions and cross-cutting issues. The "plus" in REDD+ was explicitly recognised as additional activities that can be financed focusing on the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

v. **COP 15 Copenhagen (2009)**. Agreement on five activities related to REDD+.

vi. **COP 16 Cancun Agreements (2010)**. Established five REDD+ activities and elements to be developed by developing country Parties who want to participate in REDD+ and these included: a national strategy or action plan, national forest reference emission level and/or forest reference level (FREL/FRL), national forest monitoring system and safeguard information system (SIS). Establishment of the seven REDD+ safeguards. Other issues identified for inclusion in developing country REDD+ strategies and action plans include: drivers of deforestation and forest degradation, land tenure, forest governance, gender considerations and safeguards.

vii. **COP 17 in Durban (2011)** added safeguards information systems and modalities relating to FREL/FRL.

viii. **COP 18 in Doha** (**2012**) developed work program to focus on ways and means to transfer payments for results-based actions, ways to incentivise non-carbon benefits, and ways to improve the coordination of results-based finance.

ix. **COP 19 Warsaw** (**2013**). Warsaw Framework for REDD+," agreed on seven decisions completing the "package" of REDD+ rules and procedures needed to get results-based actions and payments off the ground.

x. **COP 20 Lima** (**2014).** The need for further guidance on SIS and non-market-based approaches for REDD+.

xi. **In December 2015**, the Paris Agreement was adopted and this became the latest step in the evolution of the UN climate change regime highlighting a new way for global efforts to combat climate change. The UNFCCC (2021) encourages forest-based nature-based solutions through its REDD+ framework.

3.3.2 Guideline for the Development and Implementation of REDD+

REDD+ is a financing framework aimed at transforming land use patterns in developing countries and a bridge to finance the transition to a low carbon development pathway. REDD+ focuses on investments in low carbon growth opportunities that reduce pressure on forests and the strategies include a portfolio of activities including multiple use landscapes, sustainable extractive activities and traditional conservation strategies. Development and implementation of REDD+ follows key steps and procedures but has to include the following:

- explanation of mitigation strategies;
- financing (Public, private or other);
- stakeholder involvement; and
- how benefits will be shared, biodiversity and ecosystem services, institutional frameworks and issues of leadership and management.

Local empowerment and local "ownership" in REDD+ programs are critical to long-term success. These includes processes that meet the principle of free, prior, and informed consent (FPIC) and proper identification and representation of stakeholders in different planning processes. Furthermore, REDD+ programs should create sustainable economic alternatives to forest destruction that generate economic growth with long-term livelihood improvement, protecting biodiversity and ecosystem services. REDD+ program should also assess the legal and institutional arrangements to determine appropriate combinations of existing and new institutions to support the REDD+ program. Above all these, the need for strong political will and capacity cannot be over emphasised.

The REDD+ safeguards are applicable to governance, rights and traditional knowledge of indigenous people, participation by stakeholders, conservation of natural forest and biodiversity, permanence and leakage. Parties are required under the Warsaw Framework to provide a summary of information on how safeguards are addressed and respected, before results-based payments can be received (Braña Varela et al. 2014, Rey et al. 2018). Positive impact to stakeholders, including forest-dependent communities, and involving them in all stages of design and implementation, goes hand in hand with ensuring permanent carbon storage. In addition to the UNFCCC safeguards the main funding mechanism for REDD+ have additional safeguards supporting their operations.

3.3.3 REDD+ phases

The UNFCCC has outlined a three-phased approach to implementing REDD+ (Angelsen et al. 2012, UNFCCC 2010, 2014a).

a. **Phase I** – the 'readiness' phase – at this phase national strategies, policies and measures, accounting frameworks and capacity building are developed.

b. Phase II – the 'implementation' phase – involves implementation of national strategies, policies and measures, technology development and results-based demonstration activities.

c. Phase III – the 'results-based payment' phase – involves payments for fully measured, reported and verified emission reductions.

3.3.4 Regulatory framework on REDD+

The regulatory frameworks dealing with REDD+ are based on the progression of international agreements culminating in the Warsaw agreement which saw the emergence of the Warsaw Framework for REDD+ (REDD+ rulebook) where the UNFCCC COP established rules and provided methodological guidance for the operationalisation of REDD+. The frameworks give requirements to be met by developing country Parties participating in a future international REDD+ mechanism of the UNFCCC and receive results-based payments. The five core elements of the regulatory framework on REDD+ are linked to:

- finance;
- institutional arrangements;
- safeguards;
- national forest monitoring systems (including measurement, reporting and verification); and
- reference emission levels or reference levels.

These are supported by decisions 9-15/CP.19 of the Warsaw Framework (Warsaw Framework for REDD-plus | UNFCCC

3.3.5 REDD+ and NDCs

We learnt in chapter 1 that NDCs are high-level political commitments made by countries to undertake transformative low-carbon and climate-resilient action and contribute to the global response to climate change with 57 % of the updated or new NDCs referring to forests as a national opportunity for reducing GHG emissions (UNFCCC 2021a).

The UN-REDD Programme provides technical analysis and practical knowledge to countries on how to better integrate and align their REDD+ efforts to the provisions of the Paris Agreement, related to the submission and review of their NDCs. In this regard, REDD+ can enhance NDC ambition and implementation in the forest sector, and the lessons learnt from REDD+ implementation can inform technical guidance, dialogue and initiatives related to the nature-based solutions in NDCs (UN-REDD 2022). Twenty tropical forest countries were supported by the UN-REDD Programme to integrate and enhance LULUCF sector actions relating to REDD+, thus increasing the ambition of their NDCs (Ibid). REDD+ actions are used as catalysts to deliver NDCs goals for climate change mitigation and adaptation where Agriculture, Forestry and Other Land Use (AFOLU) are amongst climate actions included in most NDCs. Many NDCs made specific reference to REDD+ plans, offering an opportunity to mainstream REDD+ and climate efforts into national planning processes and actions (FAO 2017b).

3.3.6 Governance issues

REDD+ has benefits of improved forest governance, improved stakeholder participation in land-use planning, enhanced tenure and access security and reveals areas of social importance (Madeira et al. 2012). Governance system for REDD+ has basically three different components of legal, compliance and institutional frameworks. To address underlying governance issues, the following should be addressed to ensure the realisation of REDD+ goal:

- access to information;
- access to justice;
- public participation;

- carbon rights;
- clear land tenure rights;
- gender equality;
- anti-corruption;
- benefit distribution; consistency between sectorial laws and policies; and
- vertical and horizontal coordination (Denier et al. 2014).

The links between the three governance frameworks is shown in figure11.

3.3.6.1 Legal frameworks

The key elements of the legal framework are represented by non-binding policy instruments in the form of strategy, policy, plans and programmes and legally binding instruments composed of statutory law and regulations. Legal status of customary law is however not very clear because it is not established or defined by the state and is not normally enforceable in national courts.

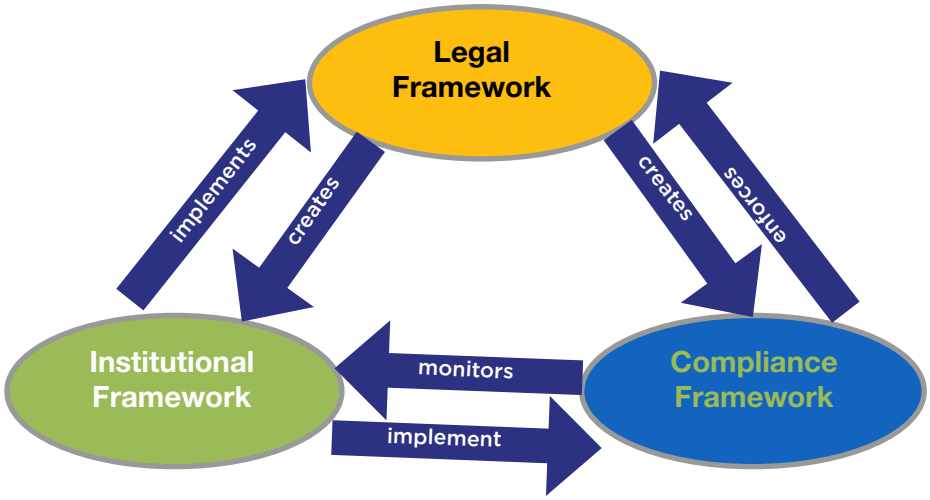

Figure 11: The inter-linkages between components of a REDD+ governance system (Denier et al. 2014)

3.3.6.2 Compliance frameworks

The compliance framework ensures that actions comply with the rules set out by the legal framework and addresses any grievances that may arise. The framework is created by the legal framework and implemented by the institutional framework. The compliance framework is composed of monitoring, enforcement (or 'non-compliance'), and dispute resolution functions. Monitoring is done to track performance of implementing entities in accordance with the rules established in the legal framework. Enforcement measures are triggered when non-compliance occurs. These could be administrative or judicial in nature, and should aim to provide a legal avenue for redress (Denier et al. 2014). Furthermore, the governance system will need to ensure that actors who might be affected by the implementation of an activity are supported by strong mechanisms for addressing grievances.

3.3.6.3 Institutional frameworks

An institutional framework is primarily composed of public administrative bodies whose mandates and powers are established by the legal framework. This includes institutions or agencies responsible for delivering the following:

- REDD+ strategies and action plans;
- national or subnational reference levels;

- a robust and transparent system to measure, report and verify (MRV) forest change;
- a system to provide information on how safeguards are being addressed and respected; and
- a system for the receipt, management and disbursal of REDD+ finance (UNFCCC Decision 1.CP/16, UNFCCC Decision 9/CP.19).

Denier et al. (2014) showed that the institutional framework has two roles:

- the implementation of the strategies, policies, programmes, plans and legislation, which constitute the legal framework at national and sub-national levels. This can include implementing mechanisms for stakeholder consultation, and ensuring participation in planning and implementation; and
- the implementation of the compliance framework.

3.3.7 Economic benefits of REDD+

The implementation of REDD+ options can have varied economic benefits from the different combinations of forest conservation for biodiversity, the carbon stocks, and other ecosystem services (Narloch et al. 2012). These benefits from the forest can have high economic values through the production of various goods and services that support local livelihoods and national economies (TEEB 2010). REDD+ initiatives can develop new enterprises including low carbon enterprises and improve performance of existing enterprises, including those targeting access to niche markets for sustainable goods (Madeira et al. 2012). However, economic importance of REDD+ options are not valued and therefore, are not visible because they are not directly accounted for in local and national markets.

Forests provide NTFPs that serve as food, raw materials and medicine in rural communities as the goods are either used for subsistence or are sold at local markets and can play an important role for rural well-being and livelihoods. These create a saving on the purchase of food and the income from NTFPs sales.

3.3.8 Pro-poor REDD+ approach

The poor people in developing countries are often dependent on forests for both subsistence and cash income because of lack of alternative sources of income and livelihoods. They resort to forest resources for survival as they are perceived as free or open access goods especially timber, firewood and charcoal.

> REDD+ pilot projects in Tanzania have demonstrated importance of pro-poor approaches by increasing the reach and effectiveness of interventions. The approaches consider interests of the poor, forest dependent communities (mainly women and other marginalised groups) and the need to strengthen their rights and improve livelihoods (CTCN 2015).

Therefore, REDD+ effectiveness depends on involvement of the poor and vulnerable groups (women, landless and youths) in the project cycle. This includes helping communities to secure tenure rights for trees and forests and helping with alternative sources of income that eliminates unsustainable harvesting of forests products (CTCN 2015).

Box 3.1 Case study: Chyulu Hills REDD+ project in Kenya

The Chyulu Hills REDD+ project (CHRP) is located in the Tsavo-Amboseli ecosystem, south eastern Kenya stretches over an area of 410 533.84 ha and is managed by nine partners. The project is expected to reduce 1.1 million tCO2e annually amounting to 28.1 million tCO2e over a 30 year crediting period (2013-2043). Initial measurement and reporting showed that the project prevented emissions of 2 049 409 tCO2e by 2016 expected to reach 5.0 million tCO2e by 2021. Some of these carbon credits were sold in 2017 and proceeds were shared among implementing institutions and communities. The income generated from sale of carbon credits continue to play an important role in the implementation of the project activities. For example, other than emission reduction for climate change mitigation, the project is promoting climate change adaptation through restoration of biodiversity and supporting livelihoods.

A pilot bee keeping program was initiated by Maasai Wilderness Conservation Trust (MWCT) in two locations, supports 13 local women's groups in traditional beading and their marketing and another and 10 operators with grass seed bank whose first seed harvest yielded 410 kg of seeds. This is in addition to employment opportunities for security guards to reinforce the protection of the grass seed bank. They also harvest hay for sale. The achievements realised from REDD+ projects in Kenya corroborates well with other cases in developing world that experience high rate of deforestation and forest degradation (Oeba 2021)

Box 3.2: Kasigau Corridor REDD+ Project Phase I- Rukinga Sanctuary (KCRPI), Kasigau Corridor REDD+ Project Phase II- Community Ranches (KCRPII)

REDD+ projects implemented in Taita-Taveta County, coastal Kenya have demonstrated significant emission reduction over time. For instance, during the seventh monitoring period in 2020, KCRPI sequestered a total of 3 584 770 tCO2e (3.6 million tCO2e of ERs) as compared to 15 347 597 tCO2e (15.3 million tCO2e of ERs), from KCRPII resulting to average carbon stock of 82.22 tCO2e per ha and 91.94 tCO2e per ha, respectively. Cumulatively, they reduced about 18.9 million tCO2e from the atmosphere that could have not been realised without REDD+ initiatives.

Some of the key unique benefits the project has provided include, marketing and sales support to 49 craft groups in 2020, comprising of 1506 women. These groups were supported with funding of KES 17 265 500 (US$ 170 000) from sale of carbon credits to assist women undertaking traditional and practical basket weaving and beadwork. The KCRPII supported these women groups since 2015. Cumulatively, the project has assisted them with a gross of more than US$ 520 000 in funding between 2015 and 2020, directly benefiting women and their household. In the same vein, KCRPI improved livelihoods of women by supporting four women groups with greenhouses for agri-business to enhance food security and provide household income. These gains are quite instrumental in halting the illegal activities linked to deforestation and forest degradation through alternative livelihoods. Projects also provided education and training to improve skills and knowledge on organic farming in greenhouse.

The projects also produce eco-charcoal processing 1000-1500 of 0.5 kg briquettes/week. This has provided sources of livelihood that reduces felling of trees for charcoal production resulting to the build-up of carbon stock in protected areas. This has been strengthened with long-term monitoring system for a set up rotational harvest plan. The success of this will result to increased income to households, improve carbon stock and create employment opportunities for the community. The expansion of project activities beyond carbon credits demonstrates how adaptation mechanisms are well entrenched in the implementation for the wider benefits to the communities and ranch owners. Other livelihood activities include:

- Eco Factory expansion and print employed 342 staff as at 2021 compared to over 100 rangers for carbon stock enhancement. 90% of staff are locals with 30% females;
- local production clothing factory;
- wildlife Works Soap factory;
- tree nursery and Amiran greenhouses;
- Jojoba propagation;
- reforestation of Mt. Kasigau and surrounding area;
- wildlife Works Eco charcoal production facility;
- establishment of the Tsavo and Rukinga Conservancies; and
- employment of Community Wildlife Scouts and project product sales and marketing.

The projects have also benefited the communities since 2012 with 32 water related projects providing pipelines, storage tanks, rock catchment, gutters and water pans across all project location in community areas and schools, reaching an estimated 55891 community members. This addresses the challenges experienced by women and girls in accessing quality drinking and domestic water (Oeba 2021).

In text Question(s) (10 minutes))

i. Why is CDM called a market based mechanism?

ii. Explain the chronology of REDD+.

3.3.9 Funding sources (mechanisms and opportunities) for REDD+

The UNFCCC mechanisms were discussed in section 2.3 and those specific to REDD+ are GEF and GCF. The Special Climate Change Fund supports projects relating to forestry, energy, technology transfer and capacity building, industry, transport, agriculture, and waste management and economic diversification. Another funding mechanism is the CIF that supports clean technology, renewable energy and projects focusing on reducing emissions from deforestation and enhancing forest carbon stocks (i.e. REDD+).

3.3.10 Non-carbon benefits

Non carbon benefits were extensively discussed in section 2.5 and they apply to all forest based initiatives where the main target is emission reduction or carbon sequestration.

3.3.11 Measurement, Reporting and Verification (MRV) in REDD+

The emergence of UNFCCC's decisions on REDD+ in general and MRV in particular has however, introduced new ideas and demands for forest monitoring in developing countries. REDD+ countries are not only required to monitor, report and verify REDD+ impacts but also to establish National Forest Monitoring Systems (NFMS) to perform MRV (UNFCCC 2009, 2010). The established NFMS are required to:

i. use a combination of remote sensing and ground-based methods;

ii. provide estimates that are transparent, accountable and publicly available; and

iii. involve non-state actors including indigenous and forest communities (UNFCCC 2009).

These demands can be read as calls for change in the institutional arrangements for forest monitoring in developing countries for three reasons. Although forest monitoring has mainly been concerned with assessment of timber stocks (Mohren et al., 2012), MRV requires assessment of forest carbon stocks and their changes as an additional forest variable.

The UNFCCC also encourages REDD+ countries to involve indigenous and local communities in forest monitoring (UNFCCC 2009), and to provide forest carbon estimates that are transparent and accountable. Furthermore, forest monitoring should involve other state agencies as they use both remote sensing and ground-based methods causing a need for other non-forestry agencies. Participation, transparency and accountability constitute key principles of good governance (Kishor and Rosenbaum 2012, Secco et al. 2013). It is clear that good governance in national forest monitoring and carbon accounting for REDD+ is imperative. The UNFCCC specifies the technologies and methodologies that can be used for measuring forest area and area changes, and for estimating forest carbon emissions (IPCC 2003, 2006, UNFCCC 2009). This calls for changes in the 'how', 'what', and 'who' participates in national forest monitoring (Gupta et al. 2014).

The PA established the enhanced transparency framework (ETF) to build mutual trust and confidence and promote its effective implementation. The modalities, procedures and guidelines (MPGs) for the ETF were adopted by CMA 1, in Katowice (2018). The framework builds on and enhances existing MRV arrangements under the UNFCCC, providing built-in flexibility which considers different capacities of the Parties and builds upon collective experience (UNFCCC 2020). The ETF has the following features:

common modalities, procedures and guidelines (MPGS) for all parties;

flexibility for developing country parties that need it in light of their capacities;

building on and enhancing existing transparency arrangements; and

facilitating continuous improvement.

National GHG inventory reports progress made in implementing and achieving nationally determined contributions (NDC) and MPGs are guided by the seven principles:

i. building on and enhancing the transparency arrangements under the Convention; recognising the special circumstances of LDCs and SIDS, and implementing the ETF in a facilitative, non-intrusive, non-punitive manner; respecting national sovereignty and avoiding placing undue burden on Parties;
ii. recognising the importance of facilitating improved reporting and transparency over time;
iii. providing flexibility to those developing country Parties that need it in the light of their capacities;
iv. promote transparency, accuracy, completeness, consistency and comparability;
v. avoid duplication of work and undue burden on Parties and the secretariat;
vi. ensure Parties maintain at least the frequency and quality of reporting in accordance with their respective obligations under the Convention; and
vii. ensuring that double counting is avoided

Further reading:

UNFCCC 2020. Technical handbook for developing country Parties on Preparing for implementation of the enhanced transparency framework under the Paris Agreement. Available at: ETF Handbook (unfccc.int)

3. 4 Other forest-based climate change mitigation initiatives

3.4.1 Internationally Transferred Mitigation Outcomes

The Paris Agreement differs significantly from the Kyoto Protocol in ways that have important implications for the design of the framework for market-based mechanisms. The compliance regime in the Paris Agreement is less centralised than the Kyoto Protocol which is mainly based on transparent reporting as the means for assessing progress against its objectives. Another major difference is that developing countries participated in the international carbon market as hosts for CDM activities under the Kyoto Protocol without having mitigation targets on their own. Under the Paris Agreement, developing countries also have mitigation targets through their NDCs, and can participate in international carbon markets as sellers or buyers of internationally transferred mitigation outcomes (ITMOs).

Article 6 of the Paris Agreement contains two carbon market routes; Article 6.2 involves limited international oversight and covers cooperative approaches that lead to a transfer of ITMOs and provides an accounting framework for managing all types of cooperative approaches, be it emissions trading between states, linking of Emissions Trading Schemes (ETSs), bilaterally or multilaterally designed, or agreed baseline-and-crediting mechanisms. In this regard, countries are free to "relabel" CDM activities into activities under Article 6.2. For ITMO transactions under Article 6.2, countries are likely to have to apply "double bookkeeping" as was the case for industrialised countries under Joint Implementation, called "corresponding adjustments" in the Paris Agreement. This entails climate change mitigation achieved in one country but claimed by another for achieving their NDC targets which may also build on the CDM rules and experience. Malawi has embarked on initiatives supporting ITMOs (Box 3.3).

Box 3.3: ITMO in Malawi

Malawi has a cook stove and sustainable biomass programme expected to generate an estimated 10 million ITMOs over an 8-year period (2022-2030) in urban and peri-urban areas. The emission reductions will be generated from a stove programme targeting rural communities developed under the Verra Verified Carbon Standard (VCS), with the Verified Carbon Units (VCUs) sold into the voluntary carbon market. About 200 000 rural households will receive two TLCRS, expected to reduce about 8 million Mg CO_2e between 2022 and 2030 (KLIK Foundation 2022). .

Article 6.4 creates a new mitigation and sustainable development mechanism with a governance structure subject to centralised oversight (as was the case under the CDM). It generates emission reductions (A6.4ERs) that will then become ITMOs once internationally transferred. Article 6.4 may take up CDM modalities and adopt elements of the CDM if Parties and international regulators are willing to do so. To what extent developing countries have to apply "corresponding adjustments" under the Article 6.4 mechanism is still heavily contested by a few countries. Article 6 of the Paris Agreement enables countries to use international carbon market mechanisms towards the achievement of mitigation targets in their NDCs. All countries were eligible as host countries under Article 6.4 mechanism.

Article 6.4 establishes a new crediting mechanism under international supervision that could be used for similar purposes where the ITMOs could be international units transferred between electronic registries or they could be amounts that are reported by countries for accounting purposes (Howard et al. 2017, Schneider et al. 2017). Requirements for activities under Article 6.4 show similarities with those of the CDM including;

i. being supervised by a body designated by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement;
ii. involvement of public and private entities;
iii. having real mitigation benefits that are measurable and long-term;
iv. assurance for additionality; and
v. verification and certification of emission reductions by designated operational entities.

Building on CDM rules and institutional arrangements, and taking into account related lessons learnt with the CDM, may also contribute to the environmental integrity and acceptance of the new Article 6.4 mechanism.

3.4.2 Non-Market-Based approaches

Non-market based approaches can include anything and everything that is not market- based. The non-market approaches mechanism focus on cooperation on climate policy, and can include fiscal measures, such as putting a price on carbon or applying taxes to discourage emissions but do not result in tradable units. The broad classifications of non-market-based policies and measures include the following (UNFCCC 2014b):

- **Economic and fiscal instruments** - include policies such as energy and carbon taxes that act as incentives to shift towards using fuels which emit less carbon when combusted.
- **Regulations** - includes rules, standards and permitting requirements that are used to directly shape the market by reducing the role played by less-efficient, more carbon-intensive products, such a prosecuting those selling poorly performing equipment, or by increasing the role of climate-friendly operating practices. Examples of regulations include industrial permits and approvals, building codes, standards for appliance and equipment efficiency, landfill operating standards and vehicle standards;
- **Voluntary agreements** - known as long-term agreements, are contracts negotiated between industry and government, mostly including voluntary targets and time frames. Voluntary environmental agreements may be binding once entered into, and may also involve regulatory or fiscal sanctions in the case of non-compliance. Voluntary agreements can be classified into four types:
    i. (unilateral commitments by industry;
    ii. private agreements between industry and stakeholders;
    iii. environmental agreements negotiated between industry and government; and
    iv. voluntary programmes developed by government that individual firms can join.
- **Framework targets** – These establish legally binding or indicative goals for GHG emissions, technology shares, fuel shares and efficiency, followed up with monitoring, reporting and verification procedures to ensure compliance;
- **Information, education and awareness programmes** - These help individuals to understand and address the impact of climate change, encourage them to change attitudes and behaviour and help them to adapt to climate change related trends. Information can be passed on in several of ways, including through:
    » public awareness campaigns;
    » the use of labels for household appliances and office equipment;
    » ratings and certification programmes;
    » audits for buildings; and
    » best practice manuals,

- **Research and development** – Includes policies that lead to the development of new products or procedures, or to the improvement of existing products or procedures. Such policies do not have an immediate impact, but help to ensure that in the long term countries will be able to respond adequately to climate change while improving their competitive position in the potential markets for the new technologies. They include direct funding and contributions to joint international research efforts.

3.4.3 Regional and international regulations on emission reduction

There are regional and international regulations that promote initiatives that reduce emissions and increase carbon sequestration. These include the SDGs, Africa agenda 2063, AFR 1000 etc. Some of these will be discussed below.

The UN Strategic Plan on Forests (UNSPF) is a reference for forest-related work of the United Nations (UN) system by creating a framework for forest-related contributions to the implementation of SDGs, the Paris Agreement adopted under UNFCCC (2015), UN Forest Instrument (2007), UN Convention on Biological diversity (CBD) (1992), UNCCD (1992), and other inter-national forest-related instruments, commitments, processes and aspirations. In this regard, the UNSPF is guided by six voluntary and universal global forest goals with 26 associated targets also to be achieved by 2030. Relative to climate change mitigation, the global forest goal Number 1 under UNSPF supports SDGs 13 and 15 while goal 5 supports SDG 15. Global Forest Goal 5 stresses the need to promote governance frameworks to implement SFM, including through the UNFI, and enhance the contribution of forests to the 2030 Agenda.

> UNSPF Goal 1- "Reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation and contribute to the global effort of addressing climate change".

The SDGs are a set of 17 aspiration goals with 169 targets contained in paragraph 54 of the UN Resolution A/RES/70/1 of 25 September 2015 (2030 Agenda for Sustainable Development 2015). Goal 13 and goal 15 are associated with climate change and forests respectively.

> Goal 13: Take urgent action to combat climate change and its impacts
>
> Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Agenda 2063 is the African continent's strategic framework that aims to attain inclusive and sustainable development. It is Africa's blueprint and master plan for transforming Africa into the global powerhouse of the future (African Union Commission 2015). Paragraph 17 and 18 under Agenda 2063 Aspiration 1, states that:

'Africa will participate in global efforts for climate change mitigation that support and broaden the policy space for sustainable development; and that Africa shall have equitable and sustainable use and management of water resources for socio-economic development, regional cooperation and the environment'.

Agenda 2063 advocates for environmentally sustainable and climate resilient economies and communities in African states (Ibid). Some goals of Agenda 2063 are also linked to SDGs number 6, 7, 13 and 15. The African Ministerial Conference on Environment (AMCEN) advises the Committee of African Heads of States and Governments on Climate Change issues.

Forest landscape restoration is the process of regaining ecological functionality and enhancing human well-being across whole deforested or degraded landscapes providing multiple benefits and land uses over time. The Bonn Challenge is a global aspiration which targeted to restore 150 million hectares of the world's deforested and degraded lands by 2020 and 350 million by 2030. The Bonn Challenge facilitates implementation of national priorities related to water, food security, and rural development, while at the same time assisting countries to contribute to the accomplishment of international climate change, biodiversity and land degradation neutrality obligations.

In Africa, the African Forest Landscape Restoration Initiative (AFR100) was launched to support leadership and collaboration for forest landscape restoration (FLR) and the Bonn Challenge. Seventeen African countries have contributed 63.3 million hectares to the Bonn challenge (IUCN 2016). Principles of forest landscape restoration are shown in figure 12.

Figure 12: Principles of forest landscape restoration (IUCN 2022)

The African Union leadership from 11 countries came together in 2007 with an initiative of restoring degraded landscapes by growing an 8000 km natural wonder across Africa, from coast of Senegal to the coast of Djibouti forming the great green wall (GGW). The movement has more than 20 African countries signed up targeting to restore 100 million hectares of degraded land. It is envisaged that the GGW will sequester 250 million tons of CO2 and creating 10 million jobs in rural areas by 2030 (Banana 2022). Therefore, the GGW is more than just growing trees and plants, but is transforming the lives of millions of people in the Sahel region, thus directly supporting the Global SDGs (GGW nd). Forest landscape restoration is an effective mechanism important in operationalising key elements of global processes such as SDs, the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity, the Aichi Targets, and the United Nations Convention on Combating Desertification. The UN Convention to Combat Desertification is a key partner in the GGW initiative (IUCN 2016).

Other initiatives are implanted at sub-regional level e.g. East African Community (EAC) SADC has a Protocol on Environmental Management for Sustainable Development. The objectives include the promotion of effective management and response to impacts of climate change and variability. One of the climate change obligations is for Parties to take nationally appropriate voluntary climate change

mitigation measures. Furthermore, the SADC climate change strategy and action plan was developed and approved by Ministers responsible for Environment and Natural Resources in 2015. The strategy provides a broad outline for harmonised and coordinated Regional and National actions to address and respond to the impacts of climate change (SADC Secretariat 2015).

Further Reading

African Forest Forum. 2019. International dialogues, processes and mechanisms to climate change: A compendium for professional and technical training in African forestry. Technical Working Paper. 132 pp.

Box 3.4 Examples of restoration initiatives in Africa

Burkina Faso - assisted natural regeneration of trees has greatly benefitted small landowners with improvements in soil fertility and crop diversification which helped them withstand seasonal food deficits.

In Malawi and Ethiopia, IUCN and the World Resources Institute (WRI) assisting in the identification of areas for restoration of degraded landscapes that can contribute to food security, disaster risk reduction, access to water and gender inequity (IUCN 2016).

In Ethiopia, the restoration of native forests in Humbo is expected to absorb about 880 000 metric tons of CO2 over 30 years, generating carbon payments and income from forest products. Ethiopia has two major REDD+ programmes: The REDD+ Investment Programme, and The Oromia Forested Landscapes Programme, funded through the Ethiopia-Norway REDD+ Partnership and World Bank BioCarbon Fund Initiative for Sustainable Forested Landscapes respectively. Ethiopia can receive results-based payments for emissions reduced, as measured and reported through a REDD+ MRV system. Ethiopia has also received readiness funding from the Forest Carbon Partnership Facility and the two REDD+ programmes (World Bank 2021a).

In text question (5 minutes))

i. Explain the circumstances that triggered the emergence of SDMs.
ii. List at least core elements of REDD+.
iii. Explain the link between REDD+ and NDCs.

Summary

In this chapter we got an understanding of the evolution of the CDM and REDD initiation and implementation processes and the evolution from RED to REDD, and REDD+. We also learnt about the economic benefits arising from the mechanisms, governance issues, and multi-stakeholder participation. The KP had three market-based flexibility mechanisms (CDM, JI and emission trading system) that created to assist developed countries to achieve their emission targets at a lower cost by allowing offsets of their obligations through projects in developing countries over two commitment periods of 2008-2012 and 2013 to 2020. In 2015, the Paris Agreement expected all parties to make and implement climate commitments called nationally determined contributions to help fulfil the Paris Agreement's goals of limiting global warming to 1.5 degrees and to decarbonise by the second half of this century.

The Paris agreement's Sustainable Development Mechanism was then established to reach the goals of the Paris Agreement and become the predecessor to the CDM and JI while adopting the CDM catalogue of methodologies and associated emission reduction estimates. We discussed the REDD+ process, its financing mechanisms, regulatory frameworks, governance and associated benefits. The reporting of REDD+ initiatives are based on guidelines for measurement, reporting and verification. Under the PA, countries are expected to report their activities following ETF guidelines.

We have also learnt that under the Paris Agreement, developing countries with mitigation targets through their NDCs, can participate in international carbon markets as sellers or buyers of internationally transferred mitigation outcomes. Requirements are like CDM processes. Apart from the market-based measures, there are non-market-based policies and measures such as economic and fiscal instruments, voluntary agreements, regulations and framework targets. The chapter concluded with national, regional and international initiatives that promote forest-based mitigation measures and some case studies.

Chapter 4: Non-Forest Climate Change Mitigation Initiatives And Other Approaches

4.1 Chapter Overview

There are measures outside the forestry sector that hold potential to contribute significantly to climate change mitigation. Such measures are found in sectors like agriculture as well as in other land use sectors. If properly employed, such measures can significantly address climate change mitigation and the reduction of greenhouse gas emissions. This chapter provides learners with knowledge and skills on alternative mitigation initiatives.

Learning outcomes

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

i. Explain mitigation measures from different sectors with emphasis on agriculture;
ii. Describe alternative livelihood with climate change mitigation potential; and
iii. Describe other non-agriculture mitigation measures (e.g. the use of renewable energy).

4.2 Climate change mitigation measures in Agriculture

4.2.1 Climate-friendly agricultural practices

The use of ecosystem-based mitigation approaches can be extended beyond the forestry sector to include agriculture and other land uses, referred to as the Agriculture, Forestry and Other Land Use (AFOLU). Interventions can generate multiple benefits, such as:

- landscape restoration that provides climate change mitigation;
- biodiversity conservation;
- livelihoods benefits for local communities (e.g. NTFPs); and
- water regulation (Doswald and Osti 2011).

There are a variety of practices that can be used to reduce GHG emissions related to production of crops and livestock. Climate friendly agricultural practices aim at promoting sustainable agricultural practices to improve the capacity of farming systems to adapt to climate change, enhance biodiversity, increase carbon storage and reduce emissions. These practices include the following:

- measures such as increasing productivity of the land or increasing soil carbon content through cover crops;
- farming with perennials;
- reduced tillage;
- rotational grazing;
- diversification of planted crops and forest species;
- agroforestry and agro-ecology;
- conservation agriculture;
- organic farming;
- soil conservation; and
- the reducing use of fertiliser.

These can create low emission farming systems, offering an estimated annual climate change mitigation potential of 3-6 giga tonnes of CO2 equivalent (IPBES 2021). Some of the mitigation actions may not have a direct impact on farm productivity. However, they may help farmers meet other objectives such as water quantity or water quality improvements. We discussed agroforestry in section 2.3.1 where its importance in agriculture systems was emphasised. Some of the climate friendly agricultural systems with potential to reduce GHG emissions are discussed below:

- **a) Sustainable intensification** – can reduce emissions intensity of agriculture by producing more with less land while decreasing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services (Pretty et al. 2011). It is a result of using inputs more efficiently or adding new inputs that address limiting factors of production. Intensification is based on alterations in the types and use of direct inputs, e.g. improved crop and livestock varieties/breeds, agrochemicals, water and mechanization. In addition, a variety of agronomic practices is available, broadly aimed at optimised density, rotations and precision of farming methods.

  Intensification reduces the need for clearing more land to increase food production, thus reduces GHG emissions without degrading soils and causing wider environmental degradation (Vanwalleghem

et al. 2017). Intensification of crop and livestock production has potential to mitigate agricultural emissions in developing countries and avoiding production of emissions and land use change between 100 and 400 Mt CO2e per year by 2050. When compared to a less fertiliser-intensive intensification pathway, the potential emission reduction increases by 30 percent (Valin et al. 2013).

Further reading:

Titonnel P, Giller KE. 2013. When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture. Field Crops Research 143: 76-90. Available at: When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture - ScienceDirect

- **b) Manure management** - About 16% of agricultural GHG emissions are caused by manure deposited on pastures and 7 % are from stored manure with manure and urine accounting for about a quarter of direct agricultural GHG emissions (FAO 2013a). Emissions from manure can be reduced through:
    - application of more efficient use of manure as an energy or crop nutrient source;
    - reducing emissions from stored manure through practices by reducing storage time;
    - avoiding straw/hay bedding;
    - covering the manure;
    - changing the diet of livestock to manipulate the volume and composition of manure; and
    - using waste management systems that facilitate better handling of manure and diversifying the farming systems to integrate crops and livestock to increase effectiveness of manure nutrient use (Dickie et al. 2014). Use of manure can sequester more carbon than inorganic fertiliser application (Mujuru et al. 2016).
- **c) Conservation agriculture** - Conservation Agriculture (CA) entails the application of three related principles of:
    - no or minimum mechanical soil disturbance; and
    - biomass mulch soil cover and crop species diversification, in conjunction with other good complementary agricultural practices such as integrated crop production and management. The global adoption of CA since 2008, has been highest in South and North America and least in Africa (Kassam et al. 2019). Overall CA practices of no-till with the use of cover crops produced fewer CO2 emissions than conventional tillage and fallow (O'Dell et al. 2020). In other studies, minimum and no tillage practices sequestered more carbon than conventional tillage (Mujuru et al. 2013) and the increase in carbon stocks depends on the available inputs from litter and root biomass. Furthermore, soil conservation is important in reducing carbon emissions from soils.

4.2.2 Appropriate use of chemical fertilisers

Nitrogen fertilisers (both synthetic and organic) on croplands are responsible for nitrous oxide emissions when they have not been absorbed by plants, and they leach into the environment. The run-off fertiliser creates GHG emissions in the form of nitrogen oxide and contaminates both ground and surface water quality. Nitrogen balances in agricultural soils vary greatly in space and time making it difficult for farmers to know optimum prescriptions needed by plants at a particular time. Subsequently, farmers tend to over-apply fertiliser as an insurance mechanism against low yields (Dickie et al. 2014).

Given these challenges, the global technical mitigation potential for reducing nitrous oxide from soils is estimated as 325 Mt CO2e. Better management of fertiliser application is achieved by increasing nitrogen use efficiency within the cropping system. This is achieved by matching the nitrogen supply

from fertilisers with the crop nitrogen demands, bearing in mind key aspects of amount applied, timing of application, type of fertiliser and placement where the plant can most easily reach the fertiliser e.g. avoid broadcasting the fertiliser.

Optimal nitrogen use efficiency can be improved through plant breeding and genetic modifications. This is to increase the uptake of nitrogen by the crop is needed to achieve the same yields, accounting and using organic fertilisers to make agricultural systems are less dependent on external inputs, use appropriate decision support tools for input management, ensure regular soil testing to develop the correct nutrient regimes, and use of technologically advanced fertilisers (Ibid).

4.2.3 Managing livestock systems to reduce methane emissions

In livestock systems, emissions can be reduced by reducing emissions from enteric fermentation which is part of the digestive process in herbivorous animals ('ruminants' such as cows, goats, buffalos and sheep). The ruminants have a rumen, a large four-compartment stomach with a complex microbial environment which allows the animals to digest complex carbohydrates, resulting in the production of methane as a by-product. Enteric fermentation is responsible for over 40 percent of direct agricultural emissions, with dairy and beef cattle accounting for almost two-thirds of all emissions from enteric fermentation (Dickie et al. 2014).

Enteric fermentation can be reduced in several ways such as:

- improving forage quality by processing feeds to improve digestibility, and adding grain-based concentrates to livestock diets can improve the diet and nutrition of the animals;
- use of supplements and additives reduce methane by changing the microbiology of the rumen, usually without yield improvements; and
- reducing the number of animals necessary to sustain a given level of production.

4.2.4. Low-emission farming systems

Low emission farming systems include agriculture intensification, conservation agriculture, agro-ecology, organic farming, manure management, and fertiliser management. In livestock systems, emissions can be reduced by reducing emissions from enteric fermentation which is part of the digestive process in herbivorous animals ('ruminants' such as cows, goats, buffalos and sheep).

4.2.5 Use of bio char

Soils play a role in the natural carbon cycle, having more carbon than the atmosphere and terrestrial plants combined. We have learnt that the process of storing organic carbon in soils is termed soil organic carbon sequestration.

An alternative to the use of carbon-rich soil amendments such as biochar, that has low decay rates and long mean residence times can be a solution in agricultural systems (Gross et al. 2021). Biochar is a solid porous material produced through carbonisation of biomass under low or no oxygen conditions. Type of raw materials and pyrolysis temperature are the major factors that influence the quality of biochar that can be used in any conditions (Das et al. 2021). Biochar is a viable climate change mitigation option because of its ability to sequester carbon for centuries and to reduce greenhouse gas (GHG) emissions from soils.

Biochar with a lower nitrogen (N) content, and a C/N ratio >30, were more suitable for mitigation of N2O emissions from soils. Furthermore, biochars that are produced at a higher pyrolysis temperature, and with O/C ratio <0.2, H/Corg ratio <0.4 and volatile matter below 80% may have high C sequestration potential than those not having these characteristics. Biochar reduces rate of organic carbon mineralisation and

the proportion of mineral-bonded organic carbon, making it an effective strategy for carbon sequestration (Brassard et al. 2016).

Activity 4.1 (Brainstorming) (20 minutes)

- Describe how food systems can be used in the battle to reduce GHG emissions..

4.3. Climate-conscious consumption

4.3.1 Reducing food losses and curbing meat consumption

Food wastage' refers to both food losses and wastage whose carbon footprint is estimated at 3.3 Gt CO2e, making it the third largest source of emissions after China and the United States of America (FAO 2013b). About one third of all food intended for human consumption is lost or wasted in the value chain from production, handling and storage, processing and packaging, distribution and market, and consumption (Ibid).

Reducing food loss and waste can increase food availability and access by increasing local supplies and freeing available resources (Dickie et al. 2014). FAO (2013b) added that cereals, fruits and vegetables and meat account for 53, 44 and 7% share of losses by calorie respectively and emissions of 34, 21 and 21%. The increase in consumption and production of meat, especially beef, has caused considerable environmental damage including deforestation, water contamination and soil degradation apart from health issues. In this regard dietary alterations to reduce demand for meat by a relatively small amount would have a significant absolute impact on GHG emissions and other impacts. Decreasing meat production, primarily of ruminants, soil degradation, pressure on forests, reduces water use, and reduces pollution into water systems (Dickie et al. 2014).

4.3.2 Switching to second or third generation biofuels

Materials that can be burnt directly to provide energy are considered as primary biofuels, and include firewood, pellets, wood chips, animal waste, forest and crop residues (Gibbons and Hughes 2011). Biomass encompasses a wide spectrum of plant materials that range from agricultural and forestry wastes to municipal wastes to crops grown specifically to make biofuels, such as bioethanol and biodiesel. There are different technologies used to convert these biomass feed-stocks to biofuels which produce low amounts of GHGs when burnt (US Department of energy 1999). But by using alternative fuels we can offset the use of petroleum product. The use of biofuels such as bioethanol in place of gasoline, reduces atmospheric CO2 in three ways:

i. avoiding emissions linked to gasoline;
ii. the CO2 content of fossil fuels remains in storage; and
iii. a mechanism for CO2 absorption is provided through the growing of new biomass for fuels.

In this regard, the compatibility of biofuels with the natural carbon cycle offers the most beneficial alternative for reducing GHGs from sectors such as transportation sector (Ibid). In other instances, livestock manure can be used as a source of bioenergy to displace fossil fuels either as a source of biogas, electricity, or transportation fuel. Some of the biofuels compete with food requirements for humans (may lead to clearing of more land) and contribute emissions during their processing.

Biofuels can be classified as first, second, third and fourth generation (Kalita 2008, Inderwildi and King 2009, Aylott 2010, Dragone et al. 2010). However, productions of biofuels, especially first-generation need the biomass to be available.

These **1st generation** biofuels are made from feed-stocks that have traditionally been used as food (e.g. ethanol from corn and biodiesel from oilseeds). The 1st generation biofuels include:

i. bioethanol produced by starch fermentation from corn, wheat, corn or potato) or sugars (from sugarcane or sugar beet), and
ii. biodiesel produced by transesterification of oil crops (e.g. soybeans, rapeseed, sunflower, coconut and palm) and animal fats.

The 2nd generation biofuels are made from non-food feed-stocks and includes:

i. liquid fuels derived from Jatropha seed oil and from a catalytic conversion process of synthetic gas from the gasification of biomass.

ii. 2nd generation ethanol which is a liquid fuel from non-food bio-material parts of crops, such as biomass and bio-waste having high cellulose and from other forms of ligno-cellulosic biomass such as wood, grasses, and municipal solid wastes.

The 3rd generation biofuels include:

- algae-derived fuels such as biodiesel from microalgae oil,
- bioethanol from microalgae and seaweeds, and
- hydrogen from green microalgae and microbes.

The 4th generation biofuels include “Drop in” fuels like “green gasoline,” “green diesel,” and “green aviation fuel” produced from biomass.

4.4. Rangeland management

Carbon stores in grazing lands can be protected and increased through a variety of measures that promote productivity of grasses. Improved pasture management practices include the following:

- timing and rotation of livestock;
- managing stocking rates;
- introducing some grass species or legumes with higher productivity; and
- application of compost, biochar, fertiliser, or irrigation to increase productivity.

These practices can also increase soil organic carbon storage (Schnabel et al. 2001) depending on soil type, diversity of plant species and climatic conditions and carbon accumulation on optimally grazed lands is greater than on ungrazed or overgrazed lands (Liebig et al. 2005).

Globally, livestock production contributes significantly to rural livelihoods (Asner et al. 2004) although the sector has also been identified as a significant source of GHG emissions (mainly methane) and land-based degradation caused by production of industrial feed and soil erosion linked to overgrazing (Gerber et al. 2013). IPCC (2019a) highlighted that there are options that have great potential to mitigate climate change in livestock systems and these include better management of grazing lands to increase net primary production and soil organic carbon stocks.

In text question (10 minutes))

- What is a second generation biofuel?
- Explain how smart agricultural practices can be applied in your country or region.

4.5 Safety-net alternative livelihoods (alternative to forests) as climate change mitigation measures

Most rural communities in Africa depend directly or indirectly on natural forests for their livelihoods but climate change impacts on the availability of forest resources, posing new challenges on natural resources, biodiversity, agriculture, rural livelihoods and food availability (Hashida and Lewis 2019, Weiss et al. 2019).

Alternative livelihoods can reduce deforestation and forest degradation through initiatives that substitute livelihood strategies that cause harm to the forest resource base. Such alternative livelihood projects can be part of a broader integrated conservation and development programme or can be a stand-alone initiatives aiming at providing local people with an alternative means of making a living that reduces pressure on the forest resource (Roe et al. 2015). Figure 13 Shows women beekers celebrating receipt of beehives under GEF 6 project in Zambaexi valley Zimbabwe and honey harvest.

a. b.

Figure 13: a. Women beekeepers receiving bee hives under GEF 6 in lower Zambezi, Zimbabwe and b. Honey harvests from an individual farmer's hive

Income generation through beekeeping provided a strong incentive for communities to conserve the forests (Matsvange et al. 2016). Other activities include, support to small-scale agricultural production, poultry and small livestock production, ecotourism, fish farming and craft production (Roe et al. 2015, Harvey et al. 2018). Such small-scale livelihood projects have contributed to both improved livelihoods and enhance forest conservation for communities in Madagascar (Harvey et al. 2018).

4.6 Resource substitution as a mitigation measure

Resource substitution shows the potential GHG emissions reduction from the marginal replacement of a non-wood based functional equivalent product. Wood has been identified to have significant sustainable environmental benefits contributing to climate change mitigation and the benefits provided by product displacement (Lippke et al. 2010, Ramage et al. 2017). The high potential of wood to mitigate climate change can be focused mainly on the construction sector, where wood can replace concrete, steel, and other non-renewable goods with long-lived wood products and other options of using wood waste for bioenergy, and carbon storage in other wood products (Leskinen et al. 2018).

The climate change mitigation benefits of such substitution are often presented and quantified as displacement factors measured in terms of carbon fluxes (Howard et al 2021). Leskinen et al. (2018) estimated about 1.2 kg carbon emission reduction for every kilogram of carbon in wood products used to substitute non-wood products in the construction industry although substitution factors did not provide sufficient information to guide policy making.

Wood and engineered wood products have lower GHG emissions than mineral based materials. In some developed countries, advances in engineered wood products is supported by adoption of new regulations and superior physical, environmental and economic properties for the products compared to mineral-based building materials engineered. The engineered products include cross-laminated timber (CLT), glued laminated (glulam) wood, laminated veneer lumber (LVL), and wood fibre insulated boards (WFIB) (Hildebrandt et al. 2017). In terms of energy, an increase of renewable energies in the energy mix could reduce emissions from fossil energy-intensive materials.

4.7 Renewable energy

4.7.1 Concept of renewable energy

Globally, fossil fuels are used as primary energy threatening their depletion and the release of various harmful GHGs. Renewable energy is from sources that are naturally replaced but are essentially inexhaustible in time but limited in terms of the amount of energy that is available per unit time. The renewable energy is sometimes called clean energy or green energy, because it comes from natural sources or processes that are constantly replenished.

Basically green energy is from renewable zero emission sources that do not cause atmospheric pollution. Green energy is from natural sources such as solar, wind and water. However, where these sources, damage natural habitats and cause deforestation, they do not become clean.

> Speeding up the transition to clean, renewable energy is one of the best ways to curb the dangerous carbon pollution that causes climate change. (Natural Resources Defense Council 2022a).

4.7.2 Types and characteristics of renewable energies

The major types of renewable energy sources are described by Natural Resources Defense Council (2022b) as:

a. biomass – includes organic material from plants and animals. The combustion of biomass releases chemical energy as heat that can generate electricity through a steam turbine, ethanol, wood and wood waste, crops, trees, biodiesel, municipal waste, landfill gas and biogas. The first generation biofuels are produced from food crops rich in starch and sugar, with potential to cause an imbalance in the food and feed supply chain, causing sustainability problems (Kumar et al. 2018). On the other hand, the second generation biofuels which are not edible, are lignocellulose biomass that is a carbon-neutral renewable feedstock, does not interfere with food and feed supplies (Ibid).

b. hydropower – relies on fast-moving water in a large river or rapidly descending water from a high point. The water coverts the force of the water into electricity by spinning turbine blades of a generator.

c. solar – from the sun's energy. The solar, or photovoltaic (PV), cells are prepared using silicon or other materials that transform sunlight directly into electricity.

d. geothermal – is energy from the earth's crust. The earth's core is almost as hot as the sun resulting from the slow decay of radioactive particles in rocks at the centre of the planet. When deep wells are drilled, very hot underground water is brought to the surface as a hydrothermal resource, which is pumped to create electricity using a turbine.

e. wind – wind powered energy, where the wind energy turns blades of a turbine to feed an electric generator to produce electricity.

4.7.3 Implementation issues of renewable energies

In Africa, 48 countries submitted their NDCs and 81% of these quantified their renewable energy targets. Fifteen countries in Africa have quantified renewable energy targets for direct heat, transport (13) and energy sector targets (2) whilst 39 have quantified renewable power targets (The International Renewable Energy Agency (IRENA) 2021). Renewable energy technologies, along with batteries and other enabling

technologies, have been proved to be effective and affordable for a growing range of applications in all countries (IRENA 2020). IRENA (2020) suggested the following five emission reduction measures to reduce emissions in industry and transport sectors:

- reduced demand and improved energy efficiency;
- direct use of clean, predominantly renewable, electricity (from solar, wind, ocean, geothermal energy);
- direct use of renewable heat and biomass (from biomass);
- indirect use of clean electricity via synthetic fuels and feedstocks displacing fossil fuel sources; and
- use of CO2 removal measures.

In terms of energy, an increase of renewable energies in the energy mix could reduce emissions from fossil energy-intensive materials. While renewable energy can be a mature and cost-effective climate change mitigation technology, its role in NDCs can be more strengthened to realise objectives of the Paris Agreement of 2015. Most of the energy used in industry is normally obtained from fossil fuels although energy use is not the only source of GHG emissions because CO2 emissions also come from production processes and the life cycle of products (IRENA 2020).

4.7.4 Valorisation of bioenergy

Plant biomass is a highly abundant renewable resource that can be converted into several types of high-value-added products, such as biofuels, chemicals and advanced materials. The increasing number of biomass species and processing techniques has enhanced the application of plant biomass together with industrial application of some of the products (Ning et al. 2021). Volarisation is the process of creating value from biomass and wastes to create energy and other useful materials for new economic purposes via innovative products or processes, with particular focus on environmental indicators and sustainability goals (Nzihou 2010).

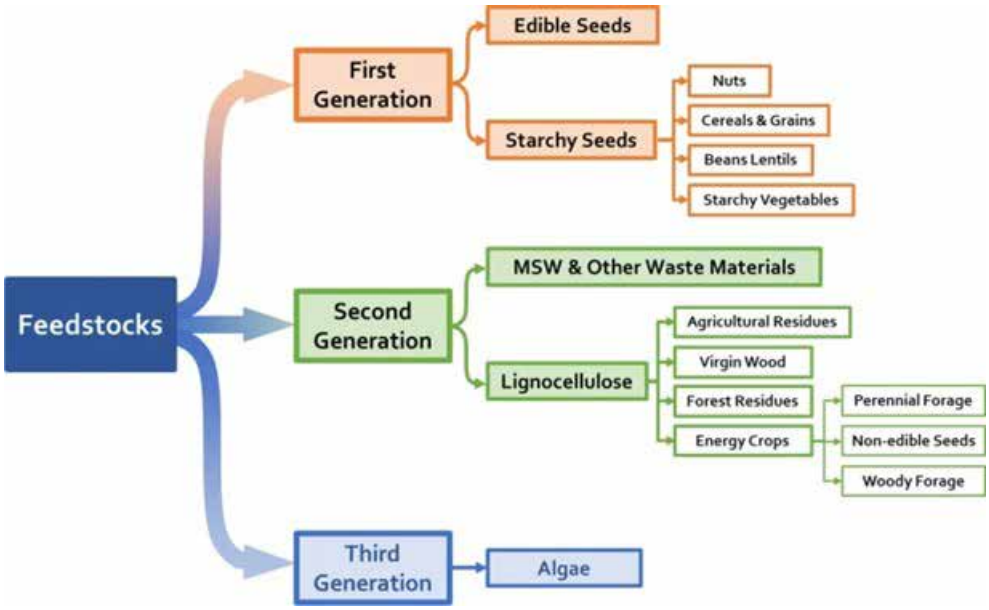

Figure 14: Plant biomass resources used in volarisatiom (Ning et al 2021)

Organic waste materials, including agricultural residues, can be valorised to produce green fuels and value-added products through thermochemical or biological conversion processes, each with its own shortfalls. The processes can however, be integrated to facilitate utilisation of by-products from one process as inputs for subsequent processes, generate different value-added products, improve material management (Patinvoh et al. 2017), optimise resource utilisation and minimising production cost and environmental emissions (Okolie et al. 2022).

Further reading

Ning P, Yang G, Hu L. et al. 2021. Recent advances in the valorization of plant biomass. Biotechnol Biofuels 14: 102 . https://doi.org/10.1186/s13068-021-01949-3

Box 4.2 Use of Bioenergy in Africa

In Africa, biofuels are mainly from first generation biofuels mainly for ethanol production from sugar cane. Some African countries have biofuel blending mandates, e.g. Ethiopia (E10), Kenya (E10), Malawi (E20), South Africa (E5) and Zambia (E10, B5), Zimbabwe (E20) (Mitchell 2011, REN21 2012, 2019).

Ethiopia's national biogas program planned to build 14 000 domestic biogas digesters and the result was the building of over 17 000 bio digesters (Kamp and Bermúdez Forn 2016) and a 5% blending of petrol and ethanol.

In Kenya, Uganda and Tanzania, charcoal making supports about 500 000 full-time and part-time producers. Wood fuel demand is double the supply, with forest cover decreasing by 2% annually, creating a need for incentives for tree planting. Charcoal remains preferred choice over briquettes despite higher price and more pollution and therefore, afforestation for sustainable charcoal production is inevitable (EEP Africa 2013).

In text question (5 minutes))

i. Give examples of practices that reduce emission in the agricultural sector.
ii. What are the existing options for renewable energy?
iii. Outline the advantages and disadvantages of using biofuels?
iv. Discuss the nexus between forest and non-forest based climate change mitigation options.
v. Explain the factors that will influence successful implementation on non-forest based climate change mitigation options. How should challenges be overcome

Summary

In this chapter, we learnt about non-forest based climate change mitigation including smart agricultural initiatives such as intensification, manure management, fertiliser management, conservation farming, reducing emissions from livestock systems, use of biochar and climate smart consumption. Biofuels can be an option for reducing GHG emissions and there are four types of biofuels ranging from first to fourth generation biofuels. Although the use of biofuels is important in all sectors, the transport sector has advanced using either the first (ethanol) or the second (biodiesel) generation fuels.

Alternative livelihoods and substitution can be used as climate change mitigation measures as they encourage conservation of forests and substitute high energy consumption respectively. Renewable energy is energy from sources that are naturally replaced but are essentially inexhaustible in time but limited in terms of the amount of energy that is available per unit time.

There are several types of renewable energy including solar, wind, geothermal, hydropower and biomass. The biomass can be converted into several types of high-value-added products, such as biofuels, chemicals and advanced materials using thermochemical and biological conversion methods. First, second and third generation biofuels can be effectively transformed into other useful products. However, in Africa wood fuel still remains a major source of cooking energy.

Chapter 5: Monitoring Reporting and Evaluation Of Climate Change Mitigation Initiatives And Other Approaches

5.1 Chapter Overview

Monitoring and evaluating practices and projects can help countries assess progress towards climate change. The processes help to identify which strategies work and which do not work, as well as reasons behind this. This chapter is designed to enhance the skills of learners in monitoring and evaluating mitigation projects and practices.

Learning outcomes

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

i. Describe concepts for monitoring, reporting and evaluation in the context of mitigation to climate change initiatives and other approaches;
ii. Apply recommended methods for monitoring, reporting and evaluation of mitigation activities to climate change initiatives and other approaches; and
iii. Choose appropriate types of evaluation of mitigation activities related to climate change initiatives and other approaches.

5.2 Concepts and purpose of monitoring for climate change mitigation initiatives and other approaches

Concepts of monitoring and evaluation are centred on several components (STAP 2017):

a. **Monitoring** is a continuous function that uses systematic collection of data on specified indicators to provide management and the main stakeholders of an on-going development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds (OECD 2009). This entails systematic and continuous collection of quantitative and/or qualitative data on the progress of a project or program over time.

b. **Reporting,** alongside monitoring, is often done at annual (or more/less frequent) intervals, except stock taking of progress and support for routine management and accountability purposes.

c. **A results framework**—often depicted as a theory of change, logic model, or log frame—identifies the intended results an intervention aims to achieve and the logical cause-and-effect relationship between the intervention's inputs, activities, and these results.

Activity 5.1 (Brainstorming) (10 minutes)

- Explain the importance of monitoring and evaluation in climate change mitigation?

a. **A Theory of Change** (ToC) framework is increasingly favoured for M and E initiatives. UNICEF (2014) explained that a 'theory of change' explains how activities are understood to produce a series of results that contribute to achieving the final intended impacts. The ToC can be developed for any level of intervention – an event, a project, a programme, a policy, a strategy or an organisation.

a. **Indicators** are markers of progress toward the intended results, as outlined in the results framework and are used to demonstrate the status of an activity, project, or program.

a. **Evaluation** is the systematic assessment of the operation and/or outcomes of a program or policy, compared to a set of explicit or implicit standards, as a means of contributing to the improvement of the program or policy (Weiss 1998). The aim is to determine the relevance and fulfilment of objectives, efficiency, effectiveness, impact and sustainability of the project (OECD 2002). The definition of evaluation emphasises that one acquires and assesses information rather than just assessing worth or merit. All evaluation work involves gathering and examining data, making conclusions about the validity of the information and inferences derived from it (Suulola nd).

Other terms involved in M and E are baseline, assumptions and means of verification which are normally part of the logical framework. The logical framework is an approach used to conceptualise projects that can be used as an analytic tool to be clearly communicating a complex project on a single sheet of paper (World Bank 1996). Ssekamatte (2018) stated that the critical roles of M & E in any intervention include; enhancing learning, supporting decision-making, being an accountability tool and assisting organisations to improve.

5.3 Purpose and types of evaluation

Evaluation is carried out for several reasons (Suulola nd), including the following:

- to influence decision-making or policy formulation through the provision of empirically-driven feedback;
- improving program design and implementation by periodically assessing and adapting activities to ensure they are as effective as they can be;
- helping in the identification of areas that need improvement and ultimately help realise goals more efficiently; and
- demonstrating the program impact (success or progress).

There are several different types of evaluations depending on what is being evaluated and the purpose of the evaluation. Evaluations can generally be classified as either formative or summative evaluations (Suulola nd).

a. **Formative** evaluations - used mainly to provide information that can help improve the initiative through examination of the delivery of the initiative, its implementation, procedures, personnel, etc. There are two types of formative evaluation:

b. **Needs assessmen**t- establish who needs the program, extent of the need and what can be done to best meet the need;

c. **Process or implementation evaluation**- examines the process of implementing the program and determines whether the program is operating as planned;

d. **Summative evaluations** - examines the outcomes of an initiative and provides information that will assist in making decisions regarding the adoption, continuation or expansion of an initiative and can assist in judgments of the overall merit of the initiative based on given criteria;

e. **Outcome evaluation**- investigates to what extent the program is achieving its outcomes. These outcomes are the short-term and medium-term changes in program participants that result directly from the program;

f. **Impact evaluation** - determines any broader, longer-term changes that have occurred as a result of the program. These impacts are the net effects, typically on the entire school, community, organization, society, or environment.

Activity 5.1 (Brainstorming) (20 minutes)

- Describe any elements that that you think form the core of GHG reporting.

5.4 Methods of monitoring and evaluation in line with and UNFCC recommendations and guidelines

5.4.1 Methods of monitoring, evaluation and reporting

We have already learnt that the agriculture, forestry and other land uses (AFOLU) sector is the largest emitting sector after the energy sector. The GHG emissions from the AFOLU sector account for 24 % of the total emissions (IPCC 2014). According to the Bali Action Plan (Decision 1/CP.13), both developed and developing country Parties agreed to enhance their action on climate change mitigation by implementing "measurable, reportable and verifiable nationally appropriate mitigation actions". In chapter 3.4, we learnt that the reporting to UNFCCC should follow guidelines of the Paris agreement's enhanced transparency framework to build mutual trust and confidence and promote its effective implementation of the UNFCCC.

For climate change initiatives, monitoring entails the need for periodic information on the results of any initiatives obtained through national policies and measures, guided by Article 4.2, paragraphs a) and b) of the Convention:

- "In order to promote progress to this end, each of these Parties shall communicate, within six months of the entry into force of the Convention for it and periodically thereafter, and in accordance with Article 12, detailed information on its policies and measures referred to in subparagraph (a) above, as well as on its resulting projected anthropogenic emissions by sources and removals by sinks of greenhouse gases"

Measurement, Reporting, Verification (MRV) - can be interpreted as the means for addressing a country's commitments to collect and share information on the progress of the implementation of provisions and/or commitments of Parties, according to Article 4.1 (a) of the Convention i.e. to:

"Develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties".

Estimates are to be done following the guidance on consistent representation of land in the Intergovernmental Panel on Climate Change Good Practice Guidance for Land Use, Land-Use Change and Forestry (2006). UNFCCC (2009) provided initial methodological guidance in relation to MRV for REDD+ at COP 15, Decision 4/CP.15, paragraph 1(d) and requested Parties to:

"establish, according to national circumstances and capabilities, robust and transparent national forest monitoring systems and, if appropriate, sub-national systems as part of national forest monitoring systems that:

- use a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes (Monitoring and Measurement);
- provide estimates that are transparent, consistent, as far as possible accurate, and that reduce uncertainties, taking into account national capabilities and capacities (Reporting);
- are transparent and their results are available and suitable for review as agreed by the Conference of the Parties (Verification)".

- **Verification:** refers to establishing whether the measured GHG reductions occurred, similar to an accounting audit performed by an objective, accredited party not directly involved with the project. Verification can occur without certification.
- **Certification**: refers to certifying whether the measured GHG reductions occurred, and is expected to be the outcome of a verification process. The value-added function of certification is in the transfer of liability/responsibility to the certifier.

(STAP 2017).

There are several MRV schemes and these include the following:

a. National Communications – reporting of climate change mitigation and adaptation and provision of information on programmes comprising measures to mitigate climate change, meteorological information, adaptation and GHG emissions;

b. GHG inventories – reporting GHG emissions and removals with information on GHG emissions by sources and removals by sinks by sectors and categories;

c. Biennial Update Reports (BURs) - climate change mitigation, adaptation and support. Includes information on mitigation actions planned and under implementation, including national GHG inventories;

d. Reporting for CDM and other carbon market projects showing emission reductions from projects;

e. National Forest Monitoring Systems (NFMS)- information on forest cover and associated carbon stocks and their changes;

f. Policy monitoring and evaluation - depends on the policy objective, therefore depends on policy sector; and

g. Global Stock Take- a process for taking stock of the implementation of the Paris Agreement with the aim to assess the world's collective progress towards achieving the purpose of the agreement and its long-term goals in line with Article 14 of the agreement

In all the initiatives, reporting becomes an essential component of the UNFCCC because it promotes consistent, transparent, comparable, accurate and complete information that facilitates a thorough review and assessment of the implementation and monitoring of the progress of the Convention. The UNFCCC has developed guidelines for reporting progress by Parties where Annex I are required to prepare and submit national communications every four years and biennial reports every two years (UNFCCC 2020).

Box 5.1 Implications of MRV for REDD+ initiatives

Parties aiming to undertake REDD+ activities are encouraged to:

- Set up a robust and transparent NFMS comprised of both a monitoring function and an MRV function;
- Ensure that REDD+ activities, policies and measures are results-based, by using an NFMS;
    - measuring the anthropogenic sources and removals (by sinks) of GHG emissions in the forest sector, including changes in forest carbon stocks, and changes in forest area;
    - minimising uncertainty by providing transparent, coherent, comparable, consistent and accurate estimates of GHG emissions and removals associated with REDD+ activities;
    - maximising transparency, by making the results of these measurements available for international appraisal, as agreed by the COP;
- Follow the most recent methodological recommendations provided by the IPCC, as adopted or encouraged by the COP.

5.4.2 Biennial update report (BUR)

BURs are reports that are submitted by non-Annex I Parties, with updates of national GHG inventories, including a national inventory report and information on mitigation actions, needs and support received. The reports provide updates on actions carried out by a Party to implement the Convention, including the status of its GHG emissions and removals by sinks, as well as on the actions to reduce emissions or enhance sinks (UNFCCC 2022b). Key elements of the BUR are shown in figure 15. The BUR is a form of MRV scheme.

The GEF provides resources to cover the requirements for both national communications and BURs on an agreed full cost basis following its operational procedures for financing national communications and the policy guidelines for funding BURs. The funds can be accessed by Non-Annex I Parties either through a GEF Implementing Agency, (which supports enabling activities – for example, national communications and BUR preparation) or directly from the GEF secretariat.

The UNFCCC COP decision has led to the introduction of the Biennial Transparency Report (BTR) Guidance and Roadmap Tool, jointly developed by the Partnership on Transparency in the Paris Agreement (PATPA) and the Food and Agriculture Organization of the United Nations (FAO) that guides developing countries in planning the preparation process of their first BTR as well as preparing a roadmap for implementing it. Led through six main steps, users of this hands-on and highly interactive tool will learn about key elements to be considered when planning for a BTR and good practices and recommendations for improving the quality of the process over time. The tool is meant to facilitate long-term planning and help in structuring and elaborating a roadmap for the BTR process. This will replace BUR and the first initial BTR will coincide with GST in 2024.

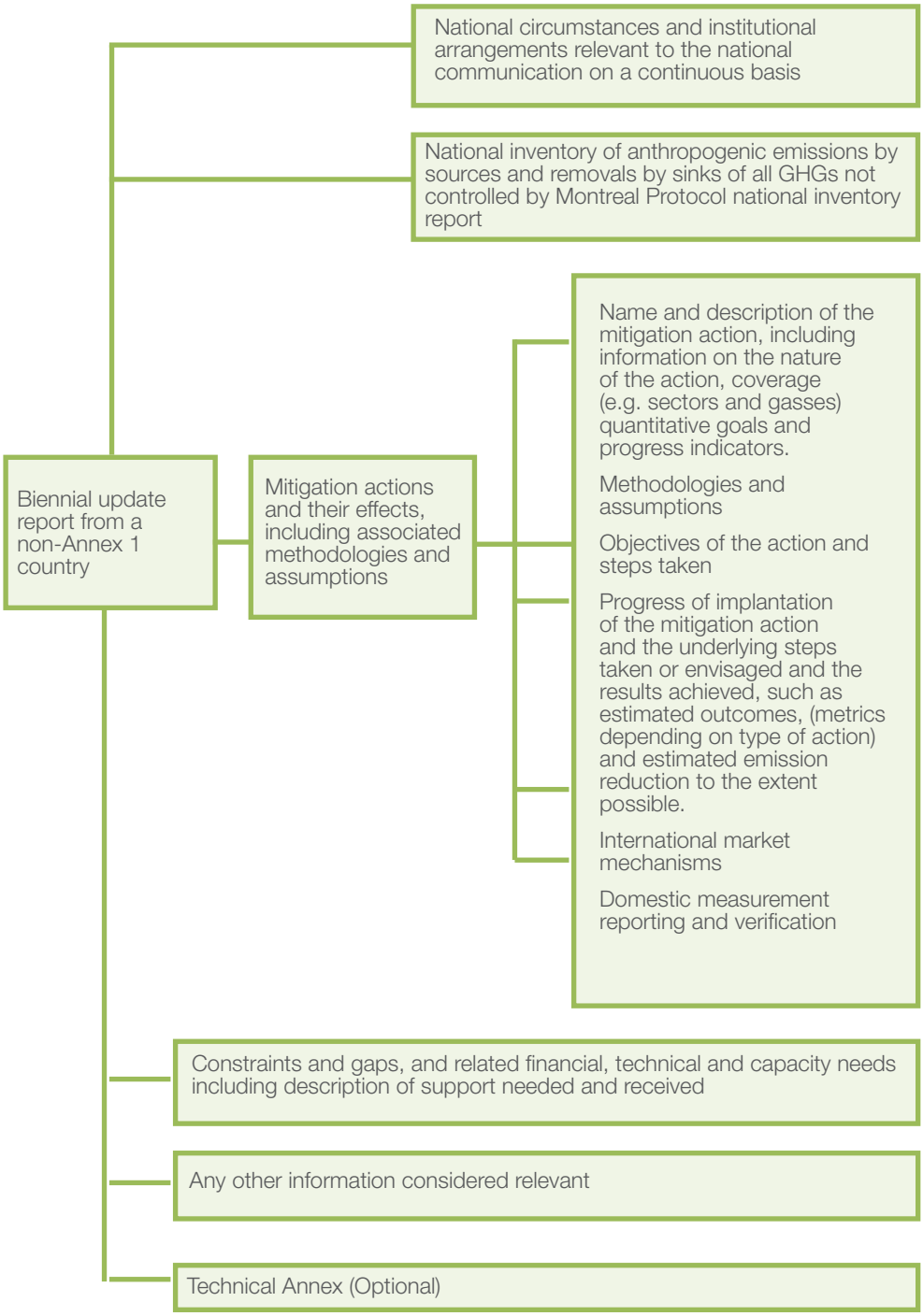

Figure 15: Key elements of BUR scheme (UNFCCC 2020c)

5.5 Reporting process at project level

The information reported to the UNFCCC secretariat must be documented following the reporting guidelines required by the UNFCCC, as decided by the COP. When developing and reporting GHG estimates, there is need to follow principles of Accuracy, Transparency, Consistency, Comparability and Completeness. These principles are also relevant for the verification and assessment process that is independent of the GHG inventory. The IPCC developed guidance and guidelines to form a methodological framework for the MRV function of the NFMS, although they could be applied to the monitoring function as well to ensure consistency in estimations, for example to directly estimating emissions reductions for a demonstration activity rather than relying only on proxy indicators or measurements.

Key concepts and elements of the methodological guidance and guidelines of the IPCC for the development of GHG inventories should be considered when developing the MRV function of NFMS for REDD+ activities under the UNFCCC. The UN-REDD NFMS Strategy is built on three 'pillars' that support the development of REDD+ NFMSs under the UNFCCC. This includes following the IPCC's Good Practice Guidance (IPCC, 2003) or the Guidelines for National GHG Inventories (IPCC, 2006), with the methodological approach involving a combination of information on the extent of human activities (referred to as activity data) and coefficients that quantify emissions or removals per unit activity (referred to as emission factors) (equation 1). These form the three pillars of national forest monitoring.

Emission Estimate = Activity Data (AD) x Emission Factor (EF). [I]

5.5.1 Activity data

The IPCC's Good Practice Guidance for Land Use, Land Use Change and Forestry (GPG LULUCF) (IPCC 2003), defined AD as data showing the magnitude of human activity causing emissions or the removals taking place during a particular period of time. In the LULUCF sector, examples of AD are:

- data on land area;
- management systems;
- liming; and
- fertiliser use.

There are three approaches proposed by the IPCC to generate AD when referring to land identification, which are not presented hierarchically and are not mutually exclusive (IPCC 2003, 2006). National entities responsible for GHG inventories are required to select an approach based on their national circumstances and capabilities. There are three approaches that can be used, namely:

- first approach identifying total change in area for each individual land use category within a country, but does not provide information on the nature and area of conversions between land uses;
- the second approach introduces some tracking of land-use conversions between categories though it's not spatially explicit; and
- the third approach extends the second approach by allowing land use conversions to be tracked on a spatially explicit way.

These three approaches are briefly explained below (IPCC 2003, 2006);

Approach 1- represents land use area totals within a defined spatial unit, which is often defined by administrative borders, such as a country, a province or municipality. Only net changes in land use area can be tracked within the boundaries of the spatial unit through time following this approach. Consequently, the geographical location of each land use change is not known, and the exact changes that occur between land uses cannot be ascertained.

Approach 2- provides an assessment of both the gross and net losses or gains of the surface area for the categories of specific land uses and allows the determination of areas where these changes take place.

This approach includes information on the conversions between categories, but tracks these changes without spatially-explicit data (i.e. the location of specific land uses and land-use conversions are not known).

Approach 3 - is characterised by spatially explicit observations of land use categories and land use conversions, often through sampling at specific geographical points and/or complete ('wall-to-wall') mapping. Approach 3 employs the use and analysis of satellite data.

5.5.2 Emission Factor (EF)

An EF is either the average emission rate of a given GHG for a given source, relative to units of activity, or the average carbon stock increase, in the case of net removals. Estimations of emissions and removals can be obtained in different ways. The methodological approaches have been classified in three different 'Tiers', which differ according to the increasing quantity of required information and the extent of complexity (IPCC, 2003, 2006). Tier 1 is the basic method, Tier 2 intermediate and Tier 3 most demanding in terms of complexity and data requirements. Tiers 2 and 3 are often referred to as higher tier methods that are usually considered as more accurate. These are described below:

- Tier 1- this approach uses default EF data that are provided by the IPCC (including on the Emissions Factor Database (EFDB)). This tier level is appropriate for countries where national data are scarce or absent and default values for EFs are used.
- Tier 2 - can use a similar methodological approach as Tier 1 but applies EFs that are specific to the country or the region for the most important land use categories, usually allowing the use of more disaggregation on the AD.
- Tier 3 -higher order methods are used, including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by high-resolution AD and disaggregated at the sub-national to fine-grid scales. These higher-order methods provide estimates of greater certainty than lower tiers and, for the LULUCF sector, have a closer link between biomass and soil dynamics.

Box 5.2 NFMS in Congo

The NFMS in the Congo complies with the IPCC guidelines and directives. They completed their first comprehensive national forest inventory, in addition to conducting a historical analysis of forest cover change. These two projects enabled establishment of robust activity data and emission factors for the construction of its FREL as well as the regular monitoring of emissions from forests on its territory. The NFMS was institutionalised and REDD + monitoring and MRV (satellite land monitoring system, national forest inventory, GHG inventories) produced. The UN-REDD measures Historical analyses of deforestation have been published and the methodology for monitoring deforestation is in place using the Terra Mayombe platform. The NFMS includes a Satellite Land Tracking System and the National Forest Inventory. The NFMS also includes a national GHG inventory. As the FREL document shows, the NFMS is capable of estimating anthropogenic forest GHG emissions by source and removal through sinks, forest carbon stocks and area change in forests as a result of the implementation of REDD + activities. Maps and a nationwide forest inventory covering all the forests of the countries, including natural forests, are available (World Bank 2021b).

In text question (15 minutes))

i. Distinguish between monitoring and evaluation.

ii. What is the relationship between MRV and NFMS?

iii. Explain how emission are estimated in the AFOLU sector.

iv. What is the role of the Enhanced Transparency framework in climate change mitigation?

Summary

This chapter we learnt about concepts of monitoring and evaluation and associated components. Monitoring is a continuous process whilst evaluation can be done before, at mid-term and at end of project. We learnt about the reasons why monitoring and evaluation are done and that evaluation can be either formative or summative. Another key component is the issue of reporting which is normally the product of a monitoring and/or evaluation process. Under the UNFCCC process both developed and developing country Parties enhance their action on mitigation of climate change, by implementing nationally appropriate mitigation actions that are measurable, reportable and verifiable. The MRV can be interpreted as the means for addressing a country's commitments to collect and share information on the progress of the implementation of provisions and/or commitments of Parties.

There are several reporting schemes that were discussed including BUR and importance of national forest monitoring systems. Reporting at project level includes the reporting of emissions based on activity data (either approaches 1, 2 or 3) and emission factors generated using either tier 1, 2, or 3. The performance indicator specific to forestry sector were discussed. The chapter concluded with a case study on NFMS. .

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Glossary of Terms

This glossary is compiled according to the Intergovernmental Panel on Climate Change, United Nations Environment Programme, United Nations Framework Convention on Climate Change UN-REDD and World Resources Institute.

Anthropogenic methane: Methane emissions derived from human activities. Anthropogenic emission sources include coal mining, agricultural practices, wastewater treatment, certain industrial processes and oil and gas systems, among others.

Baseline scenarios are not intended to be predictions of the future, but rather counterfactual constructions that can serve to highlight the level of emissions that would occur without further policy effort. Typically, baseline scenarios are compared to mitigation scenarios that are constructed to meet different goals for greenhouse gas emissions, atmospheric concentrations or temperature change. The term 'baseline scenario' is used interchangeably with 'reference scenario' and 'no policy scenario' In much of the literature, the term is also synonymous with the term 'business as usual (BAU) scenario', although the term 'BAU' has fallen out of favour because the idea of 'business as usual' in century long socioeconomic projections is hard to fathom.

Baseline/reference: The state against which change is measured. In the context of climate change transformation pathways, the term 'baseline scenarios' refers to scenarios that are based on the assumption that no mitigation policies or measures will be implemented beyond those that are already in force and/or are legislated or planned to be adopted.

Carbon border adjustment mechanisms: Mechanisms that act to equalise the price of carbon between domestic products and imports to eliminate financial incentives in order to relocate production outside of regions with strong climate controls.

Carbon dioxide emission budget (or carbon budget): For a given temperature rise limit, for example a 1.5°C or 2°C long-term limit, the corresponding carbon budget reflects the total amount of carbon emissions that can be emitted for temperatures to stay below that limit. Stated differently, a carbon budget is the area under a CO2 emission trajectory that satisfies assumptions about limits on cumulative emissions estimated to avoid a certain level of global mean surface temperature rise.

Carbon dioxide equivalent (CO2e): A way to place emissions of various radiative forcing agents on a common footing by accounting for their effect on climate. It describes, for a given mixture and amount of greenhouse gases, the amount of CO2 that would have the same global warming ability, when measured over a specified time period. For the purpose of this report, greenhouse gas emissions (unless otherwise specified) are the sum of the basket of greenhouse gases listed in Annex A to the Kyoto Protocol, expressed as CO2e assuming a 100-year global warming potential.

Carbon markets: A term for a carbon trading system through which countries may buy or sell units of greenhouse gas emissions in an effort to meet their national limits on emissions, either under the Kyoto Protocol or other agreements, such as that among member states of the European Union. The term comes from the fact that CO2 is the predominant greenhouse gas, and other gases are measured in units called carbon dioxide equivalent.

Carbon neutrality: This is achieved when an actor's net contribution to global CO2 emissions is zero. Any CO2 emissions attributable to an actor's activities are fully compensated by CO2 reductions or

removals exclusively claimed by the actor, irrespective of the time period or the relative magnitude of emissions and removals involved.

Carbon offset: See Offset. Carbon price: The price for avoided or released CO2 or CO2e emissions. This may refer to the rate of a carbon tax or the price of emission permits. In many models that are used to assess the economic costs of mitigation, carbon prices are used as a proxy to represent the level of effort in mitigation policies.

Clean development mechanism (CDM): A mechanism under the Kyoto Protocol, the purpose of which, in accordance with article 12 of the Protocol, is to assist non-Annex I parties in achieving sustainable development and in contributing to the ultimate objective of the United Nations Framework Convention on Climate Change, and to assist Annex I parties in achieving compliance with their quantified emissions XII Emissions Gap Report 2021: The Heat is on limitation and reduction commitments under article 3 of the Protocol.

Conditional nationally determined contribution (NDC): An NDC proposed by some countries that are contingent on a range of possible conditions, such as the ability of national legislatures to enact the necessary laws, ambitious action from other countries, realization of finance and technical support, or other factors.

Conference of the Parties (COP): The supreme body of the United Nations Framework Convention on Climate Change. It currently meets once a year to review the Convention's progress.

Double counting: Double counting involves two countries taking credit for the same emissions reductions, thereby giving the impression that the world has reduced emissions more than it actually has. For example, emissions reduction credits from one country might be sold to another country, but the reductions may still be counted towards the achievement of the NDC of the country where the credits originated.

Emission pathway: The trajectory of annual greenhouse gas emissions over time. Emissions trading: One of the three Kyoto mechanisms, by which an Annex I party may transfer Kyoto Protocol units to, or acquire units from, another Annex I party. An Annex I party must meet specific eligibility requirements to participate in emissions trading.

EU Emissions Trading System (ETS): The EU ETS is a trading system for carbon emissions and the first international emissions trading system in the world. The EU ETS covers the following sectors and gases: electricity and heat generation, energy-intensive industry sectors (including oil refineries, steel works and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals, commercial aviation within the European Economic Area), nitrous oxide from production of nitric, acidic and glyoxylic acids and glyoxal, and perfluorocarbons from production of aluminium. Global warming potential: An index representing the combined effect of the differing times greenhouse gases remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation.

Forest transition curve: The change in forest cover over time as the value of land uses changes relative to the competing uses, usually resulting in rapidly decreasing forest area during early industrialization and development, followed by slow expansion of forest area to lower than original levels.

Greenhouse gas removal: Withdrawal of a greenhouse gas and/or a precursor from the atmosphere by a sink. Integrated assessment models: Models that seek to combine knowledge from multiple disciplines in the form of equations and/or algorithms in order to explore complex environmental problems. As such, they describe the full chain of climate change, from production of greenhouse gases to atmospheric

responses. This necessarily includes relevant links and feedbacks between socioeconomic and biophysical processes.

Greenhouse gases: The atmospheric gases responsible for causing global warming and climatic change. The major greenhouse gases are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). Less prevalent, but very powerful, GHGs are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).

GtCO2e GHG: Billion tons (gigatons) of carbon dioxide equivalent greenhouse gas emissions.

Intended nationally determined contribution (INDC): INDCs are submissions from countries describing the national actions that they intend to take to reach the Paris Agreement's long-term temperature goal of limiting warming to well below 2°C. Once a country has ratified the Paris Agreement, its INDC is automatically converted to its NDC, unless it chooses to further update it. Katowice Climate Package: The Katowice Climate Package, also known as 'the Katowice outcome', is a complex package containing operational guidance on information provision, communication and rules for the functioning of the climate transparency framework, the global stocktaking of overall progress and the evaluation of progress, and the provision of prior information on financial assistance. The package sets out the essential procedures and mechanisms that operationalised the Paris Agreement. The guidelines of the package aim to build greater trust and strengthen international cooperation.

Kyoto Protocol: An international agreement, standing on its own, and requiring separate ratification by governments, but linked to the United Nations Framework Convention on Climate Change. The Kyoto Protocol, among other things, sets binding targets for the reduction of greenhouse gas emissions by industrialised countries.

Land use, land-use change and forestry (LULUCF): A greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human induced land use, land-use change and forestry activities.

Leakage: A phenomenon whereby the reduction in emissions (relative to a baseline) in a jurisdiction/sector associated with the implementation of mitigation policy is offset to some degree by an increase outside the jurisdiction/sector through induced changes in consumption, production, prices, land use and/or trade across the jurisdictions/sectors. Leakage can occur at a number of levels: project, state, province, nation or world region. XIII Least-cost pathway: A scenarios identifying the least expensive combination of mitigation options to fulfil a specific climate target. A least-cost scenario is based on the premise that, if an overarching climate objective is set, society wants to achieve this at the lowest possible costs over time. It also assumes that global actions start at the base year of model simulations (usually close to the current year) and are implemented following a cost-optimal (cost-efficient) sharing of the mitigation burden between current and future generations depending on the social discount rate.

Likely chance: A likelihood greater than 66 per cent chance. Used in this assessment to convey the probabilities of meeting temperature limits. Mitigation: In the context of climate change, mitigation relates to a human intervention to reduce the sources, or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings and expanding forests and other 'sinks' to remove greater amounts of CO2 from the atmosphere.

Measurement, reporting and verification (MRV): The collection of data and information at a national (or sub-national) level, and performance of the necessary calculations for estimating emission reductions or enhancement of carbon stocks and associated uncertainties against a reference level.

Nationally determined contribution (NDC): Submissions by countries that have ratified the Paris Agreement which presents their national efforts to reach the Paris Agreement's long-term temperature

goal of limiting warming to well below 2°C. New or updated NDCs were expected to be submitted in 2020 and should be submitted every five years thereafter. NDCs thus represent a country's current ambition/target for reducing emissions nationally.

Offset (in climate policy): A unit of CO2e emissions that is reduced, avoided or sequestered to compensate for emissions occurring elsewhere. Recovery-type measure: Fiscal, monetary or regulatory intervention by a government to reinvigorate economic activity in response to a crisis.

REDD credits: Emission reductions and enhancements in forest carbon stocks measured in tCO2e that are converted into tradable carbon units.

REDD: Reduced emissions from deforestation and forest degradation.

REDD+: REDD plus conservation, sustainable management of forests and enhancement of forest carbon stocks.

Reference emission level: The amount of gross emissions from the forest sector from a geographical area estimated within a reference time period. RED: Reduced emissions from deforestation.

Reference level (RL): The amount of net/gross emissions and removals from the forest sector from a geographical area estimated within a reference time period.

Rescue-type measure: Immediate fiscal, monetary or regulatory intervention by a government to protect citizens' lives and socioeconomic well-being and/or to provide emergency support to businesses and the economy in response to a crisis.

Scenario: A description of how the future may unfold, based on 'if-then' propositions. Scenarios typically include an initial socioeconomic situation and a description of the key driving forces and future changes in emissions, temperature or other climate change-related variables.

Sink: a forest, ocean, or other natural environment viewed in terms of its ability to absorb carbon dioxide from the atmosphere.

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

Technical REDD+ potential: Biophysical potential of the forest sector to remove and store greenhouse gases in biomass and other carbon pools as estimated in academic literature. The technical REDD potential does not include discounts for political and capacity constraints (i.e. feasible REDD potential).

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A platform for stakeholders in African forestry

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