CLIMATE CHANGE AND FORESTRY

PRACTICES FOR TECHNICAL LEVEL FORESTERS

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CHAPTER FIVE

Forests and Climate Change Mitigation

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Overview

Forest ecosystems are increasingly being recognized for their important role in climate change mitigation because of their ability to regulate the carbon cycle. As a result, national and global initiatives such as afforestation/reforestation under CDM and REDD+ have been initiated to enhance the role of forests in climate change mitigation. Understanding the relationship between forests and climate change mitigation is necessary to enable the meaningful participation of forest practitioners in forest carbon projects and programmes. This chapter explores and highlights aspects of climate change mitigation as linked to forestry by explaining the meaning of climate change mitigation while also introducing various types of GHG sinks. Also covered in the chapter are relevant national strategies and policies in addition to available forest and non-forest based options for participating in mitigation activities. The chapter ends by giving an overview of M & E methods available for mitigation projects.

Climate Change Mitigation

Climate Change Mitigation refers to efforts to reduce or prevent emission of GHGs (Chandler *et al.*, 2002; OECD, 2008). Mitigation can mean using new technologies and renewable energies, making equipment more energy efficient, changing practices on fuel utilization or consumer behaviour. According to IPCC (2001), mitigation is a human activities or intervention that leads to the reduction of the sources or enhance the sinks of GHGs. Mitigation may in addition to reducing emissions also encompass attempts to remove already existing GHGs from the atmosphere. In forestry, climate change mitigation focuses on reducing emissions from forest degradation and deforestation. It is important to link climate change mitigation with forestry since forest resources are a source and sink of CO_2 (one of the important GHGs responsible for global warming). Unlike adaptation, climate change mitigation requires developed countries to play a bigger role in reducing their emissions, which historically have contributed to the majority of increased concentration of GHGs in the atmosphere.

GHGs Sinks

A sink is a reservoir or a pool that takes up a chemical element or compound from part of its natural cycle. A forest is an important carbon sink due to its ability to store large amounts of atmospheric CO_2. The potential of forests to act as sinks can be realized through conservation and restoration of natural forests, afforestation, reforestation and agroforestry interventions. The process of forests storing atmospheric CO_2 is referred to as carbon sequestration. Carbon sequestration is made possible through photosynthesis, where in the presence of sunlight, plants including trees take up atmospheric CO_2 and sequester or store it in their living tissues as biomass. Tropical forest systems found in warm climates, sequester carbon faster and store more carbon than temperate and boreal forests located in cooler climates. This is because in the warmer climates there is more solar energy input for photosynthesis reaction than it is in the cooler climates. Indeed, tropical forests are responsible for approximately 33% of terrestrial ecological net primary productivity and hold nearly 25% of the aboveground terrestrial carbon (UNEP, 2014). While still significant, mid- and high-latitude forests have relatively slower rates of carbon uptake and lower per area carbon stock.

Another GHG is CH_4, whose main sink is a reaction with OH radicals found in the atmosphere. However, this sink is not reliable since only a portion of it reacts with CH_4. Another sink is soils. However, changes in land use, i.e. the use of nitrogen fertilizers (Mosier *et al*., 1991) decreases the CH_4 uptake by soils. The main sinks for N_2O are stratospheric photo-dissociation and stratospheric photo oxidation. This sink accounts for 90% of total loss of N_2O. Soil is another sink of N_2O although its contribution is very small. There is no removal system (i.e. sinks) for the CFCs in the lower atmospheres; instead, they are transported to the stratosphere where they are dissociated by ultraviolet (UV) radiation and they release free chlorine atoms which cause significant ozone depletion. But CFCs in the atmosphere are very small and therefore do not contribute significantly to the enhancement of the GHG effect (Thomson *et al*., 2012).

Mitigation Options for Climate Change

The major land use options relevant to Tanzania for climate change mitigation include REDD+, improving supply and distribution of energy efficient technology, afforestation, improving crops and grazing. There are several other options for climate change mitigation, including making older equipment more energy efficient. For example, improvements in the design of cooking stove, or by switching e.g. from fuelwood to solar, may lead to a decrease in the use of fuelwood and thereby reduce deforestation and increase CO_2 uptake. Mitigation options may also include creating new sinks through agroforestry or sustainable agriculture.

Mitigation benefits to the entire globe, although its effectiveness requires targeting a sufficient number of major greenhouse gas emitters at a local or regional scale. The benefits of mitigation carried out today will only be evidenced several decades into the future because of the long residence time of GHGs in the atmosphere,

Exploring National Strategies and Policies to Mitigate Climate Change

After understanding that Tanzania is vulnerable to increased climate change and variability, the country developed a strategic and institutional framework to enhance its governance, technological and infrastructural capacities to participate in international climate change initiatives. The concept of climate change is new and still developing in the country, and therefore policies (e.g. National Forest Policy) and legislations are still under review. The National Climate Change Strategy (NCCS) was finalized in 2012 and it presents Tanzania with an opportunity to engage in climate change mitigation actions. In such a situation, the NCCS has created an environment in which the country can participate effectively in global efforts to reduce GHGs emissions within the context of sustainable development. Some of the developed strategies to mitigate the climate change are elaborated in the following sections.

Forests based mitigation mechanisms

Many forest activities can contribute to climate change mitigation. Such activities include increasing carbon stocks through forest plantations or agroforestry; conserving existing carbon stocks by reducing deforestation; reducing emissions caused by forest activities through using less energy or fertilizers in forest operations, in addition to substituting biomaterials and bioenergy (materials based onrenewable, biological products) for GHG-intensive non-renewable materials or energy. On-farm tree planting, reforestation, sustainable forest management (even when practiced under the context of PFM), and urban forestry could all be considered as forest-based mitigation mechanisms. Major examples of forest based mitigation mechanisms are REDD+ and CDM.

REDD+ as a climate change mitigation initiative

The 13th Conference of Parties (COP-13) and the 3rd Meeting of the Parties to the Kyoto Protocol of the UNFCCC held in Bali, December 2007 agreed to promote collaboration between countries in order to implement activities that can contribute to Reducing Emissions from Deforestation and Forest Degradation (REDD+) in Developing Countries. The Conference of Parties (CoP-13) formally initiated negotiations to provide incentives and policy approaches for reducing emissions from deforestation and forest degradation, supporting conservation and sustainable management of forests, and enhancement of forest carbon stocks in developing countries (REDD+)(UNFCCC, 2008).

Implementation of REDD+ as a forest based mitigation mechanism, is expected to deliver monetary and other benefits as incentives for implementing natural forest conservation. Monetary benefits are payments made when a REDD+ programme achieves emission reduction targets; and the payments are given to forest and land-owners including states, communities and individuals for their effort to reduce deforestation and forest degradation. REDD+ is expected to generate a substantial, new financial income stream for developing countries. REDD+ is also expected to lead to social benefits, such as improved livelihoods, clarification of land tenure, and stronger governance. Also , while protecting forests, REDD+ implementation can promote other benefits such as biodiversity conservation and secure provision of ecosystem services such as water regulation, timber production, erosion control, aesthetic and recreational services, secured supplies of Non Timber Forest Products (NTFPs), and employment and income generation opportunities.

Initially, the concept of reducing emissions from deforestation and forest degradation (REDD) considered forests for their climate service, with less recognition of other long term benefits arising from forest ecosystems, biodiversity being one example. Therefore, a plus (+) was added to include sustainable management of forests, enhancement of carbon stocks and conservation of forest carbon stocks. This means that long-term accounting of land-use emissions should be done on a land basis (which measures the total emissions and sinks on a given area of land) instead of an activity basis (which measures only emissions and sinks from certain land-use activities) (Holloway and Giandomenico, 2009). This is because land-based accounting reflects land's true effect on the environment more accurately.

Clean development mechanisms (CDM)

The Kyoto Protocol, also known as the Kyoto Accord, is an international treaty among industrialized nations that sets mandatory limits on greenhouse gas emissions. The Clean Development Mechanism (CDM) is defined in Article 12 of the Protocol. The CDM allows only afforestation and reforestation projects, such as agroforestry, to be eligible forestry projects. Eligible forestry projects must be implemented on land that had not been forested after December 31, 1989, for reforestation projects. CDM is a project-based, flexible offset mechanism under the Kyoto Protocol that allows crediting (issuing) of emissions reductions from GHGs abatement (reduction) projects in developing countries. The CDM allows emissions reductions projects in developing countries to earn Certified Emission Reductions (CERs), each equivalent to 1 tonne of CO_2. CERs can be traded and sold and used by industrialized countries to meet part of their emission reduction targets under the Kyoto protocol. The aim of CDM is to help host countries to achieve sustainable development and reduce emissions, while giving industrialized countries some flexibility in how they meet their emissions targets (Zomer *et al.*, 2007).

In order to host CDM projects, potential host countries must fulfill a number of basic participation requirements, which govern involvement in the CDM. CDM requirements include being a Party to the UNFCCC and the Kyoto Protocol; establishing a Designated National Authority - DNA, capable of approving proposed projects; developing CDM project approval criteria; and issuing Letters of Approval (LoAs) for projects that have been approved.

Non-forest based climate change mitigation mechanisms

There are measures outside the forestry sector that can contribute significantly to climate change mitigation. Major non-forest based mitigation measures are in the energy, transport, industrial and agriculture sectors.

Energy sector

Mitigation measures in the energy sector include: increasing the efficiency of bioenergy sources such as fuelwood and biofuels; switching to lower intensity carbon fuels such as converting from fossil fuels to biofuel, ethanol and natural gas; reducing losses in the transmission and distribution of electricity and fuel; and increasing use of renewable energy forms such as biofuels, solar and hydropower. For Tanzania the options are to use biofuels (charcoal and fuelwood) more efficiently; using natural gas instead of petroleum; improving electricity transmission efficiency; and promoting hydroelectric transmission over natural gas, solar panels and wind turbines.

Transportation sector

Mitigation measures in the transport sector can include fuel efficiency improvements (i.e. changes in vehicle and engine design) and alternative low-carbon fuel sources (i.e. biofuels and compressed natural gas). Another option is the expansion and improvement of public transport infrastructure. Generally, buses and trains operate with much lower emission per passenger than cars or airplanes (UNFCCC, 2008). An example from Tanzania is the development, and potential expansion of, the BRT (Dar-es-Salaam rapid transit bus system), which is designed to reduce car traffic in favour of bus based public transportation.

Industrial sector

Mitigation measures in the industrial sector include process changes to directly reduce CO_2 emissions, material-efficient product design, cogeneration, material substitution, and product and material recycling. In light industries, mitigation options include efficient lighting, efficient motor and drive systems, process controls and saving energy in space heating. Other mitigation measures include policies and strategies which promote processing of items such as agriculture products and other raw materials so as to reduce the volume of materials transported from sources to consumers. For example, when fruits are processed into juice, the bulky by-products will not be transported, translating into reduced fuel burning that could have been used to transport them.

Agriculture sector

In the case of Tanzania, agriculture is the single biggest source of emissions due to clearing forested land for cultivation. Therefore, agriculture and other land use sectors have potential to make significant contributions to the mitigation of climate change and the reduction of GHGs emissions. Mitigation measures in the agricultural sector include improving rice cultivation and animal husbandry to minimize CH_4 emissions; decreasing the use of artificial fertilizer to minimize N_2O emissions and improving cultivation methods, such as the no-till approach to increase carbon storage in soil (Castro, 2014). Other mitigation measures under agriculture can be: climate smart agriculture (e.g. climate-friendly agricultural practices with focus on increasing carbon content in the soil), appropriate use of chemical fertilizers, especially avoiding those responsible for N_2O emissions; managing livestock systems to reduce CH_4, low-emission farming systems (e.g. conservation agriculture, agroecology and organic farming); climate-conscious consumption that reduces food losses; curbing meat consumption; and the use of bio-char (AFF, 2014).

Monitoring, Evaluation and Reporting of Climate Change Mitigation Strategies

Meaning and purpose

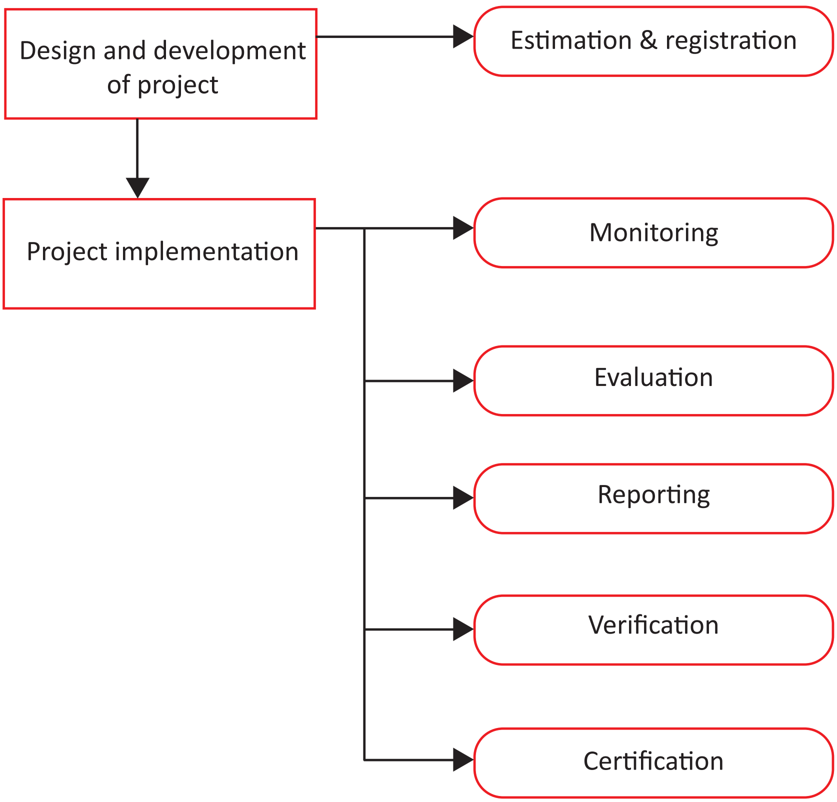
Monitoring refers to the measurement of carbon stock, GHGs emissions, and socio-economic and environmental benefits and costs that occur as a result of a project. Monitoring does not involve calculation of GHGs reduction, nor does it involve comparisons with previous baseline measurements.

Evaluation refers to a more in-depth and rigorous analysis of a project compared to monitoring emissions. Project evaluation usually involves comparisons requiring information from outside the project in time, area, or population (De Jong *et al*., 1997). Calculation of GHGs reductions is conducted at this stage. Project evaluation is used to determine the official level of GHGs emissions reductions that should be assigned to the project.

Reporting is concerned with measuring GHG and non-GHG impacts of a project. In some cases, reporting may be on estimated impacts prior to project implementation). Reporting occurs throughout the process and a final report once the project has ended.

The purpose of monitoring and evaluation (M&E) of a mitigation strategy or project is to accurately determine impact on GHG emissions and to ensure that a country's obligations to mitigate climate change are met. The implementation of monitoring, evaluation and reporting of climate change mitigation is supported by guidelines. The guidelines are intended to increase the reliability of data when estimating GHG impacts; provide real-time data so that plans can be revised mid-course; introduce consistency and transparency across project type; enhance project credibility with stakeholders; reduce costs by providing consensus methodologies; and reduce financing cost by allowing project bundling and pooled financing. Stages at which monitoring, evaluation and reporting are taking place in a project cycle are shown in Figure 5.1.

Figure 5.1 Monitoring, Evaluation and Reporting in a Project Cycle



Methods of monitoring, evaluation and reporting

The measurement of a forestry project's carbon fixation necessitates specialised tools and methods drawn largely from experience with forest inventories and ecological research. This implies that monitoring systems should be built upon standard forestry approaches to biomass measurement and analysis, and should apply commonly accepted principles of forestry inventory, soil science and ecological surveys.

Monitoring and evaluation methods in forestry project

Three general M&E techniques are used to monitor carbon sequestered through forestry projects (MacDicken, 1997):

- Modelling;
- Remote sensing; and
- Field/site measurements, including biomass survey and destructive sampling.

Modelling

Modelling the impacts of certain forestry practices on carbon flows into and out of forest carbon sinks can be used for estimating annual flows of carbon. The models are used to predict future carbon flows, but they do not measure the actual changes. The modelled estimates of carbon storage over time must be checked using remote sensing with ground truthing or field/site measurement. Models start from an estimate of carbon stock for a specific forest type at a specific site. Then, based on information from forest practices, the models develop estimates of annual carbon flows. This approach relies on a series of highly simplified assumptions to estimate total carbon sequestration. For example, assumptions may include: the number of trees planted in either woodlots or agroforestry systems, initial stocking rates, mean annual stem volume increments, a biomass multiplier factor and harvest rates. The assumptions are then entered into a model to estimate the amount of sequestered carbon. The models need to be corrected or calibrated with measured data periodically. (Vine *et al.*, 2000).

Remote sensing

Remote sensing (along with ground-based measurements) can be used to: monitor land area changes, map vegetation types, demarcate strata for sampling and assess leakage and base case assumptions. Remote sensing is defined as the acquisition of data about an object or scene by a sensor that is far from the object (Richards, 2013; Woodcock and Strahler, 1987). Aerial photography, satellite imagery and radar are all forms of remotely sensed data. Usually, remote sensing can be done using satellite imagery or aerial photography. (Dale et al., 1999 & Hyyppä et al., 2000).

Field/site measurements

Field/site measurements include two types of techniques namely (i) biomass surveys and (ii) destructive sampling which can be used in monitoring carbon in forestry projects.

Biomass surveys include one or more of the following methods: research studies, surveys, monitoring wood production and end products, and forest inventories. Research studies use intensive data collection and analysis to test research hypotheses. Surveys of project field activities are conducted to see what was actually implemented in the project. This type of monitoring provide useful data for the evaluation of GHG reduction and sequestration projects, especially if the surveys were combined with other approaches. The monitoring of wood production and end product data is needed to follow historical and trend data for the development of accurate baselines.

Destructive sampling is the oldest methodology for estimating biomass density at a site. It involves selection of representative sites in the ecosystem (usually a few square meters each, and in a few rare cases, as much as one hectare each). All the vegetation is uprooted and the relevant parameters measured, e.g. volume; weight at different moisture contents; proportions of various components like branches, stem and roots; and chemical composition of the biomass. Detritus is also collected and similarly analyzed. In addition, tree biomass allometric models, which relate tree measurements, may be developed i.e. Dbh and total tree height, with tree above- and below-ground biomass. Such relationships may be used to determine tree biomass of live trees (e.g. Mugasha et al., 2013).

Reporting process

Reporting occurs throughout the project, from implementation to certification. Normally, there are monitoring, evaluation and reporting formats that evaluators follow when reporting carbon emissions reduction (Vine and Sathaye, 1999). Several types of reporting might occur in climate change mitigation projects:

- Impacts of a particular project could be reported at the project level and at the programme level (where a programme consists of two or more projects);
- Impacts of a particular project could be reported at the project level and at the entity level (e.g. a utility company reports on the impacts of all of its projects); and

- Impacts of a particular project could be reported by two or more organizations as part of a joint venture (partnership) or two or more countries.

Chapter Summary

Climate change mitigation is linked to the forestry sector because the sector sequesters CO_2, which is one of the main GHGs. It is evident that forests are the main GHG sinks while the other important GHGs (CH_4 and N_2O) are taken care of by reactions and dissociations. It is imperative to cut or prevent the emission of GHGs in order to limit the magnitude of future warming. There are several options for climate change mitigation including technologies which are energy efficient, REDD+ and CDM. M&E is needed to accurately determine their impact on GHG emissions and other attributes, and to ensure that the country obligations to mitigate climate change are met and reported.

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