2. Climate change and forests

CLIMATE CHANGE PROCESSES AND PROJECTIONS

The Earth's climate changes continually under the influence of a range of natural forces. Currently, however, observed significant and rapid changes in climate patterns worldwide are being driven by global warming caused by human activities that emit heat-trapping gases known as greenhouse gases (GHGs). Global warming is associated with increased climate variability and consequently an increased frequency of extreme events such as heat waves, severe droughts and intense storms, and it is also associated with rising sea levels. Climate change and increased climate variability are expected to have widespread economic, social and environmental repercussions. For forest managers, adapting to and mitigating climate change is likely to require major adjustments in management practices.

Forests and the global carbon cycle

Carbon dioxide (CO_2) is a key GHG, and changes to the global carbon cycle that affect the atmospheric concentration of CO_2 are crucial to the global climate. Forests play important roles as both sinks and sources of CO_2 (Box 2). Forest vegetation and soils contain about half the planet's terrestrial carbon, and terrestrial ecosystems have the potential to sequester more CO_2 than at present.

Forests absorb CO_2 through photosynthesis, store it as carbon[1] and release it through respiration, decomposition and combustion. The **carbon sink** function of a forest increases with the forest's rate of growth and the permanence with which it retains carbon.

BOX 2
Carbon sinks and sources

A **carbon sink** is a reservoir that takes up – sequesters – carbon from the atmosphere in the form of CO_2. When forests grow, they act as carbon sinks. Globally, forests are responsible for a large proportion of removals of CO_2 from the atmosphere.

A **source** of GHG emissions is any process or activity that releases GHGs into the atmosphere. Deforestation and forest degradation are major sources of GHG emissions because they cause the release, to the atmosphere, of the carbon stored in forests in the form of CO_2 and other GHGs, such as methane.

[1] The UNFCCC distinguishes five carbon pools in forests: aboveground living biomass, belowground living biomass, litter, dead wood, and soil.

Vigorous young forests may sequester a great deal of carbon as they grow. In contrast, the vegetation and soils of old-growth forests typically store large quantities of carbon but add to these stocks only slowly, if at all.

Forests are also **sources** of GHG emissions, mainly CO_2. Deforestation and forest degradation account for an estimated 17 percent of global GHG emissions.[2]

Climate change and increased climate variability have both direct and indirect effects on forests and forest-dependent people. For example, increased winter temperatures combined with fire suppression have led to massive population increases of the mountain pine beetle in Canada, resulting in the premature deaths of millions of trees. Similarly, a disturbing synergy between forest degradation caused by poor logging practices, forest fragmentation and increasingly severe droughts has rendered many Amazonian and Southeast Asian forests more fire-prone. In both boreal and tropical regions, climate change is increasing forest susceptibility to stresses that have long been present but previously posed a lesser threat. When forests and associated social systems are unable to cope with the direct and indirect stresses associated with climate change, they are said to be vulnerable to it.

The rate of climate change varies at both small and large geographical scales and generally increases with distance from the equator. Locally, the rates and directions of climate change vary with topography and proximity to large water bodies. Forest species and forest communities vary in their resistance and resilience to climate change and in their adaptive capacity. To cope with climate change, species will need to adapt to the changed conditions or migrate to areas where suitable conditions prevail. The ability of a species to migrate will depend on its capacity to disperse and on the connectivity of suitable habitat. The risks of species loss and ecosystem disruption will vary geographically and over time. It is concerning that neither climate nor species respond linearly to changing conditions but, rather, tend to react abruptly at certain thresholds or tipping points. Forest managers should keep this in mind while recognizing that thresholds are hard to predict.

Societies, and communities within them, differ in the extent to which they are vulnerable to climate change. The most vulnerable are those that are already stressed by poverty, have limited options for employment or income generation, and depend directly on rainfed agriculture or forests for their livelihoods.

ADAPTATION AND MITIGATION IN FORESTRY

Adaptation and **mitigation** are the two main responses to climate change. They are two sides of the same coin: mitigation addresses the causes of climate change and adaptation its impacts (Box 3).

In the forest sector, adaptation encompasses changes in management practices designed to decrease the vulnerability of forests to climate change and interventions intended to reduce the vulnerability of people to climate change.

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[2] IPCC (2007) *Climate change 2007: synthesis report. Contribution of working groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. R.K. Pachauri & A. Reisinger, eds. Geneva, Switzerland, Intergovernmental Panel on Climate Change.

BOX 3
Adaptation and mitigation

Climate change **adaptation** actions consist of adjustments in natural or human systems in response to the actual or expected impacts of climate change to avoid harm or exploit opportunities.

Climate change **mitigation** actions are measures to help stabilize or reduce the concentration of GHGs in the atmosphere. They include actions to reduce human-induced GHG emissions or increase removals of GHGs from the atmosphere.

In short, adaptation addresses the risks and effects of climate change, while mitigation addresses human-induced causes of climate change.

Mitigation strategies in the forest sector can be grouped into four main categories: reducing emissions from deforestation; reducing emissions from forest degradation; enhancing forest carbon sinks; and product substitution. Substitution comprises the use of wood instead of fossil fuels for energy and the use of wood fibre in place of materials such as cement, steel and aluminium that involve the emission of larger quantities of GHGs.

Climate change mitigation measures, including in forests, are urgently needed to help reduce anthropogenic human-induced interference with the climate system, but such measures will only begin to have an effect on global mean surface temperature decades from now. For this reason, adaptation measures in forests to secure the continued delivery of forest goods and ecosystem services will be required for many years to come.

WHAT DOES CLIMATE CHANGE MEAN FOR FOREST MANAGERS?

Climate change jeopardizes the capacity of forest managers to achieve their objectives and to help meet the forest-related needs of society. Forest managers will need to adjust their management objectives and practices to reduce vulnerability and to facilitate adaptation to climate change, both of forests and of the people who depend on the goods and ecosystem services that forests provide. Forest managers should aim to optimize the potential benefits of climate change by taking advantage of policy incentives and financial support mechanisms for climate change adaptation and mitigation.

Managers aiming to minimize the impacts of climate change must deal with uncertainties in the extent and nature of climate change and climate variability, differences in the time scale of impacts, and the costs associated with changing management practices. While global climate models can project broad patterns of climate change at the global and regional levels with some certainty, projections of climate change at the subnational and especially local levels are likely to be less accurate. Climate variability and extreme climatic events are very difficult to predict with confidence. This uncertainty poses

challenges for forest managers aiming to undertake adaptation and mitigation measures. Forest managers may need to "hedge their bets" by managing for a wide range of change and adopting "no regrets" options that are consistent with good practice and will yield climate change adaptation and mitigation benefits.

Increasingly, forest managers need to be aware of the current and potential impacts of climate change. Some effects will be direct, such as on water availability and the rate of tree growth. Other effects will be the result of modified disturbance regimes (e.g. fire, pests and storms), or will be driven by economic and social changes caused by climate change, such as population movements and changes in markets (e.g. increased demand for biofuels to replace fossil fuels).

The Fouta Djallon Highlands in the centre of Guinea. Effective adaptation and mitigation strategies are required in response to climate change impacts in mountain regions.

Forest managers will also need to be aware of the incentives available to undertake climate change adaptation and mitigation measures. These may be policy incentives instituted by government, or market incentives, such as carbon credits or demand for bioenergy. Forest managers will need to understand the evolving climate-related policy, legal and regulatory environment, which is likely to change, in order to comply with new laws and regulations and to capitalize on financial opportunities.

As climatic conditions move beyond historical ranges, adaptation and mitigation will require the adjustment of management objectives, approaches and monitoring systems. Fortunately, SFM (discussed in greater detail in Chapter 3) is consistent with climate change adaptation and mitigation and provides a comprehensive framework that can be adapted to changing circumstances. Forest managers will need to factor climate change into their planning and to adjust their management practices accordingly. They will also need to put greater emphasis on risk management and to weigh the costs of changes in forest management against the likely benefits, keeping in mind that the costs of climate change adaptation measures are likely to increase, the longer they are delayed.

A rural landscape in Ecuador. Some impacts of climate change require managers to look beyond their management units. Adopting a landscape approach can help to identify forest adaptation and mitigation measures that will provide the best economic, social and environmental outcomes.