Climate Change Adaptation and Mitigation

Basic knowledge

The Climate Change Adaptation and Mitigation Module aims to assist forest managers in assessing and responding to climate-change challenges and opportunities. It provides both basic and more detailed information on key issues to be considered in assessing climate-change vulnerability and risks and adaptation and mitigation options. The module provides links to important tools and to cases in which these tools have been applied in forestry to adapt to, and mitigate the impacts of, climate change.

The effects of climate change and climate variability on forest ecosystems are evident around the world and further impacts are unavoidable, at least in the short to medium term. The potential impacts vary across regions, with some forest types more vulnerable than others; they include both increased and decreased plant growth, an increased frequency and intensity of fire and disease, and an increase in the severity of extreme weather events such as droughts, rainstorms and wind. In some cases, climate change is impairing the ability of forests to deliver critical wood and non-wood products and environmental services, such as watershed protection, to the detriment of the livelihoods of forest dwellers, forest-dependent communities and others who benefit from forests.

Meeting the challenges posed by climate change requires adjustments to forest strategies and to forest management plans and practices. Delays in taking action will increase the cost and difficulty of making those adjustments.

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 addresses its impacts.

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.

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, the production of which involve the emission of large quantities of greenhouse gases.

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

Climate change and SFM

As climatic conditions move beyond historical ranges, climate-change adaptation and mitigation will require the adjustment of management objectives, approaches and monitoring systems. Fortunately, SFM is consistent with both 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 to reduce vulnerability and to facilitate adaptation to climate change.

Forest managers 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. 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.

Climate change poses crucial challenges but may also create new opportunities for the forest sector. Forest managers (and other stakeholders) will need to take these into consideration. They will also need to consider responses to climate change in the context of the multiple goods and environmental services that forests provide to meet the diverse needs of a wide range of stakeholders.

Climate change adaptation and mitigation contributes to SDGs:

Related modules

- Forest and water
- Forest management planning
- Forest pests
- REDD+
- Reducing deforestation
- Reducing forest degradation
- Vegetation fire management

In more depth

Predicted impacts of climate change on forests

Forests are highly sensitive to climate change. In particular:

- Sustained increases of as little as 1°C in mean annual air temperature can be sufficient to cause changes in the growth and regeneration capacity of many tree species. In several regions, this can significantly alter the function and composition of forests; in others, it can cause forest cover to disappear completely.
- Suitable habitats for many species or forest types are likely to shift faster with climate change than the maximum natural rate at which many species can migrate and establish. Consequently, slow-growing species, such as late-successional species, or those with restricted seed dispersal, will be replaced by faster-growing, highly adaptable or more mobile species.
  Forests are particularly vulnerable to extremes of water availability (either drought or waterlogging) and will decline rapidly if conditions move toward either of the extremes.
- A substantial fraction of existing forests will experience climatic conditions in which they do not currently exist; eventually, shifts in vegetation type will need to occur. It is projected that 33 percent of the currently forested area could be affected by such changes, and one model projects that up to 65 percent of forests in the boreal zone will be affected.
- Although net primary productivity may increase in some areas (due to elevated concentrations of carbon dioxide and, in some regions, increased moisture availability), this may not lead to a consequent increase in forest biomass because of more frequent outbreaks and extended ranges of pests and an increasing frequency and intensity of fires.
- Mature forests are a large store of terrestrial carbon. Because the maximum rate at which carbon can be lost is greater than the rate at which it can be gained, large amounts of carbon may be released transiently into the atmosphere as forests change in response to changing climatic conditions and before new forests replace the former vegetation. The loss of aboveground carbon alone has been estimated at 0.1–3.4 Gt per year, or a total of 10–240 Gt.

Important considerations before responding to climate change
As integral parts of broader landscapes, forests and trees contribute to the stability and vitality of ecosystems and to meeting societal needs. Integrated approaches to landscape management can increase synergies among multiple land-use objectives. By considering the perspectives, needs and interests of all stakeholders, including local communities and individual land users, landscape approaches can be instrumental in the development of sustainable land-use and livelihood strategies. Stakeholder dialogue is especially important as adjustments are made to land uses and management.

Gender is another important element to take into consideration as climate change affects women and men differently. Women rely on natural resources more than men for their everyday livelihoods, and they have fewer means of coping with climate risks such as natural disasters. Women are less likely to have access to resources such as credit and cash, making the adaptation to climate change more challenging for them.

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

Partnerships and participatory approaches recognize the importance of involving all forest stakeholders in the management or co-management of forest resources. Forest stakeholders comprise all people who depend on or benefit from forests and those who decide on, control or regulate access to forests including women, youth and indigenous groups.

Partnerships and participatory approaches can operate at a range of levels, from national to local, and may include state and local authorities, forest extension agencies, forest-dependent communities, non-governmental organizations (NGOs), private-sector entities, research and academic organizations, and forest managers. Partnerships and participatory approaches will be essential for successful management responses to climate change.

Effective responses to some climate-change impacts will require action at a landscape, regional or national level. Climate-change impacts are cross-sectoral, which means that preparing for them requires coordination among government agencies, NGOs and other stakeholders in multiple sectors, such as natural resources, public health and safety, emergency and disaster risk management, recreation, and economic development.

New knowledge, skills and expertise may be needed to enable timely and well-informed decision-making and action. Forest managers and other stakeholders should have sufficient knowledge and expertise to undertake climate-change vulnerability and risk assessments; design and revise management plans; implement actions to adapt to and mitigate climate change; and monitor the impacts of climate change and

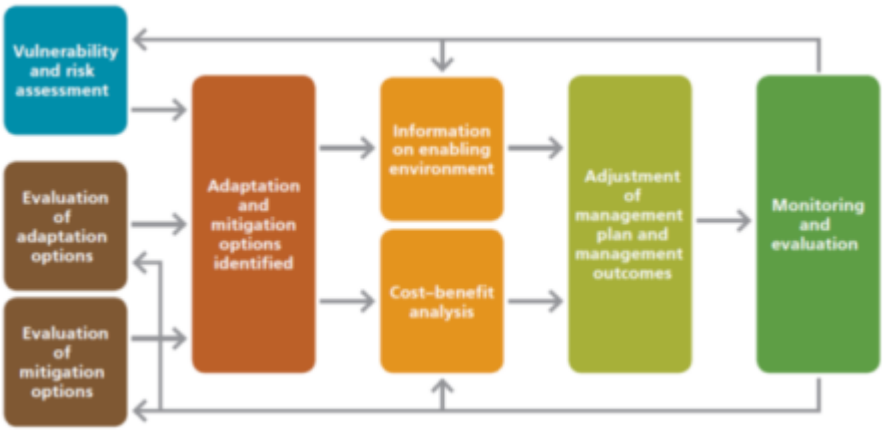
the outcomes of climate-change actions.

Integrating climate change into forest management

Forest managers should assess the costs, benefits, tradeoffs and feasibility of climate-change adaptation and mitigation actions and consider how these might affect – positively or negatively – the achievement of management objectives. The general process for undertaking such an assessment (as shown in a simplified form in Figure 1) involves the following steps:

- assess the risk that climate change poses to the achievement of the management objectives of the FMU (i.e. the delivery of desired forest products and environmental services);
- identify the forest-dependent people and forest areas that are most vulnerable to the likely impacts of climate change;
- identify forest management measures that would reduce the vulnerability of forest-dependent people and forest areas to climate change or would increase their adaptation capacity, and estimate the cost of implementing those measures in the FMU (i.e. adaptation measures);
- gather information on policies, institutions, financial and technical incentives, the availability of support for undertaking adaptation measures, and the requirements for obtaining access to such incentives and support;
- identify the available options at the FMU level for contributing to climate-change mitigation, including the actions to be taken, the schedule for taking such actions, the costs involved and the mitigation benefits that could be expected to materialize;
- gather information on policies, financial and technical incentives and the availability of support for undertaking mitigation actions and the requirements to gain access to such incentives and support;
- conduct a cost–benefit assessment to identify the most cost-effective adaptation and mitigation measures, taking into consideration synergies and tradeoffs between them;
- adjust the forest management plan and other planning tools to accommodate the adaptation and mitigation measures and to incorporate the knowledge gained through the assessments of vulnerability, risk and options for mitigation;
- identify capacity development needs and opportunities to implement adaptation and mitigation measures;
- adjust management practices to achieve the specified adaptation and mitigation goals;
- adjust forest monitoring and evaluation procedures to allow for additional requirements related to the specified adaptation and mitigation measures; and
- develop mechanisms to ensure the continual adaptation of forest management in the light of monitoring and evaluation.

Fig. 1 The process for integrating adaptation and mitigation measures into forest management plans and practices



Assessments of vulnerability and risk and adaptation and mitigation options

The scope and scale of assessments of vulnerability, risk and adaptation and mitigation options carried out by the forest manager will depend on the following factors:

- the focal area of the assessments;
- the time available for the assessments;
- the questions to be addressed by the assessments and the decisions the assessments should support;
- the funds available for the assessments;
- the level of support from stakeholders; and
- the value of the resources that may be at risk.

Vulnerability and risk

The goal of vulnerability and risk assessments is to identify who (i.e. which groups in a population) and what (i.e. which ecological systems and human-created infrastructure) are vulnerable to climate-change impacts and the risks of negative impacts. Climate-change vulnerability assessments for forests and forest-dependent communities can involve a range of approaches and sources of information, such as local knowledge, expert opinion and detailed data collection and technical analyses. The first step of any such assessment is to identify the likely impacts on ecosystems and their ramifications for human well-being. Once the likely impacts have been identified, the vulnerability of forests and forest-dependent communities to them can be assessed and appropriate actions taken.

At the national level, government agencies and research institutions that collect and analyse climate-related information are likely to be involved in downscaling global and regional climate models to national and subnational levels. They are also likely to carry out vulnerability assessments for various sectors (e.g. agriculture and forestry) and population groups. Forest managers should obtain available information from relevant government agencies and research institutions or other sources, including local meteorological data. They should also gather information about the impacts of climate change on forests from their own field observations and forest inventories, other monitoring systems, and local residents. The collected information can be used to make predictions about impacts on product yields and the provision of environmental services.

A vulnerability assessment generally involves a climate sensitivity analysis and an evaluation of the capacity of ecosystems and communities to adapt to climate change. To analyse the sensitivity of forests and forest-dependent communities to changing climatic conditions, the forest manager, in partnership with other stakeholders, should determine:

- the current and expected stresses on the forest area;
- the known climatic conditions, and how these affect the forest area;
- the projected change in climatic conditions and the likely impact(s) of these changes on forests; and
- the expected changes in stresses on forests as a result of the likely impacts of climate change.

To evaluate the capacity of a forest area and forest-dependent communities to adapt to climate change, the forest manager, in partnership with other stakeholders, should consider:

- the current capacity of a forest or forest-dependent community to adapt to climate change;
- constraints on the capacity of a forest or forest-dependent community to accommodate changes in climatic conditions;
- whether the projected rate of climate change is likely to be faster than the capacity of a forest or forest-dependent community to adapt; and
- ongoing efforts in the locality to address the impacts of climate change on forests and forest-dependent communities.

The final step in a vulnerability and risk assessment is to combine the findings of the climate sensitivity analysis and the evaluation of capacity to adapt, with the aim of determining the extent to which forests and forest-dependent communities are vulnerable to climate change. The vulnerability assessment can be qualitative (e.g. “high”, “medium” or “low”) or quantitative, depending on the information and resources available.

The vulnerability assessment should not be considered static because existing vulnerabilities will change and new vulnerabilities will emerge as a result of:

- climate-change impacts on the frequency, intensity, duration and extent of specific climatic events;
- the emergence of threats, such as new invasive species or diseases;
- new information on how climate change may affect forests;
- the implementation of adaptation and mitigation actions; and
- changes in the forest-dependent community’s size, economy, preferences or other factors that might influence its vulnerability to climate change.

Assessment of adaptation options

After completing assessments on how changing climatic conditions will affect forest ecosystems and forest-dependent communities, the next step is to examine management options that would reduce vulnerability, increase resilience, and enable adaptation to climate change and climate variability.

Many of the actions that a forest manager might take to help forests and forest-dependent communities adapt to climate change involve substantial amounts of uncertainty. Several criteria exist for evaluating adaptation options. These include:

- timing/urgency for action – those actions for which further delay could increase vulnerability or lead to increased costs at a later stage;
- cost – the general cost of proposed actions, including human and other resources, and, where relevant, economic costs and benefits;
- co-benefits – whether the actions would have negative or positive impacts on other aspects of forest management, sectors or systems, or on vulnerable populations;
- efficiency and effectiveness – the extent to which the measure is able to effectively reduce the risk;
- "no regrets" – those approaches that will have a positive impact, even if climate change impacts do not occur. Such measures are especially useful when there is still a high level of uncertainty about the type or degree of climate-change impacts;
- flexibility or robustness – measures that allow for adjustment or change in the future if climate-change impacts differ from those expected;
- feasibility – the economic, social, technological and environmental feasibility of implementing an action (including enabling conditions such as laws and policies for the successful implementation of the action);
  participation – the stakeholders who should be involved to ensure the successful implementation of the option; and
- monitoring – the indicators of success for the option, and how these will be monitored.

Assessment of mitigation options

Forest managers must weigh the costs of climate-change mitigation against the benefits and identify the negative and positive impacts on the achievement of other forest management objectives. Forest managers should aim to maximize the economic and social benefits and minimize the social and environmental costs of adjusting forest management plans for climate-change mitigation.

In 2010, the Conference of the Parties to the UNFCCC adopted a decision on reducing emissions from deforestation and forest degradation and on the conservation of forests, sustainable management of forests, and enhancement of forest carbon stocks, usually known as REDD+. REDD+ is designed as a national (or in some cases subnational) mechanism that would provide positive incentives to countries achieving verified emissions reductions or carbon removals in forests at the national level. The accessibility of benefits from REDD+ activities to individual forest managers would depend on the arrangements in place in the country for REDD+ benefit-sharing.

Mitigation options available to forest managers can be grouped into four general categories:

- reducing emissions from deforestation by maintaining the area under forest and by promoting forest conservation and protection;
- reducing emissions from forest degradation by maintaining or increasing carbon density at the stand and landscape scales, managing timber production forests and restoring degraded forests;
- enhancing forest carbon sinks by increasing the area under forest through afforestation and reforestation; and
- product substitution e.g. displacing fossil fuels with woodfuels.

The designation of forests for conservation (specifically as parks and other protected areas) or protection (specifically for the protection of soil and water resources), where timber extraction is prohibited or limited, cannot be considered a mitigation action unless such forests would otherwise have been cleared or degraded.

To assess mitigation options, forest managers need information on at least the following:

- national policies and regulations related to incentives to undertake (and potential disincentives for not undertaking) mitigation actions;
- mitigation options that are feasible, given existing forest cover and current forest management objectives;
- the potential for greenhouse gas emissions reductions (i.e. the potential to maintain or increase forest carbon stocks) over time as a result of adjusting forest management plans or practices;
- requirements for measuring forest carbon and verifying mitigation;
- requirements for ensuring that no "leakage" is occurring (i.e. changes in the management of an FMU to effect climate-change mitigation that result in greenhouse gas emissions elsewhere);

- the capacity to provide evidence that the forest manager would not have undertaken the mitigation measure anyway (i.e. that it was “additional” to business-as-usual in managing the forest);
- the actual and opportunity costs, and the benefits, of implementing and monitoring the mitigation actions; and
- the likely positive and negative economic, social and enviromental side-effects of implementing the mitigation actions.

E-learning

A guide to developing a resilient watershed management plan

This course presents the basic principles and concepts related to resilient watershed management, and, through the description of a case study, practically illustrates the process for formulating a resilient watershed management plan, from the analysis of the enabling environment to the definition of the risk management measures to implement.

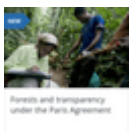
Climate-smart forestry

This course explores the role of forests and trees in Climate-Smart Agriculture (CSA). It takes into consideration the ecosystem services and goods that forests provide, and the importance of forests for the food security of forest-dependent people. It explores the complex relationship...

Estimating GHG emissions and carbon sequestration in agriculture, forestry and other land use with EX-ACT

Are you aware that AFOLU contributes to carbon sequestration as co-benefits through productive and sustainable landscape management? At the same time, Agriculture, Forestry and Land Use Change (AFOLU) is the second largest emitter of greenhouse gas (GHG) emissions worldwide...

Forests and transparency under the Paris Agreement



The objective of this course is to learn about the Enhanced Transparency Framework (EFT) under the Paris Agreement. It will be useful to those wishing to understand the importance of forest-related data collection, analysis and dissemination in meeting the Enhanced

Transparency Framework...

Massive open online course (MOOC) on nature-based solutions for disaster and climate resilience

Do you want to find out how nature can help in protecting people from disasters and solving the climate crisis? Then this free online course is for you! Learn what young people and teachers, policy makers, practitioners, businesses and engineers can do to get involved in our race against the climate emergency.

Sharing the experience on “Forest and land monitoring for climate action – SEPAL” facilitated course

The overall objective of this course is to support knowledge and skills development to operationally apply high-resolution satellite imagery to critical forest and land monitoring in tropical forest countries. More specifically, the course focuses on how the System for Earth Observation Data Access...

Sharing the "Forests and Transparency under the Paris Agreement" MOOC multilingual experience

This Massive Open Online Course (MOOC) was based on the FAO e-learning course “Forests and transparency under the Paris Agreement” available on the FAO e-learning Academy. In this course participants learnt about the importance of forest-related data collection, analysis...

The national greenhouse gas inventory for land use

This course provides the necessary knowledge to build a sustainable National Greenhouse Gas Inventory (NGHGI) and assess greenhouse gas (GHG) emissions and removals from the land use sector. It focuses on the biological and physical process that lead to GHG fluxes from...

Further learning

CPF. 2012. *SFM and adaptation to climate change.*

FAO. 2012. *Forest management and climate change: stakeholder perceptions.* Forests and Climate Change Working Paper 11. FAO, Rome.

FAO. 2012. *Forest management and climate change: a literature review.* Forests and Climate Change Working Paper 10. FAO, Rome.

FAO. 2011. *Climate change for forest policy-makers. An approach for integrating climate change into national forest programmes in support of sustainable forest management.* FAO, Rome.

FAO. 1997. *Estimating biomass and biomass change of tropical forest: a primer.* FAO, Rome.

Mery, G., Katila, P., Galloway, G., Alfaro, R.I., Kanninen, M., Lobovikov, M. & Varjo, J. (eds). 2010. *Forests and society: responding to global drivers of change.* IUFRO.

Furniss, J.M, Staab, B.P, Hazelhurst, S., Clifton, C.F. et al. 2010. *Water, climate change, and forests: watershed stewardship for a changing climate.* US Department of Agriculture, Forestry Service.

ICIMOD. 2009. *Mountain biodiversity and climate change.*

Koskela, J., Buck, A. & Teissier du Cros, E. (eds). 2007. Climate change and forest genetic diversity: implications for sustainable forest management in Europe. Biodiversity International, Rome.

Luttrell, C., Schreckenberg, K. & Presket, L. 2007. *The implications of carbon financing for pro-poor community forestry*. Overseas Devlopment Institute.

Loo, J., Fady, B., Dawson, I., Vinceti, B. & Baldinelli, G. 2011. Climate change and forest genetic resources: state of knowledge, risks and opportunities. Background Study Paper no. 56. FAO, Rome.

Messier, C., Puettmann, J.K. & Coates, K.D. (eds). 2013. Managing forests as complex adaptive systems: building resilience to the challenge of global change. Routledge.

Moore, B. & Allard, G. 2008. *Climate change impacts on forest health.* FAO, Rome.

Russell, A J.M., Locatelli, B., Pramova, E., Alumai, G.J. & Behr, D.C. 2012. *Using forests to enhance resilience to climate change: what do we know about how forests can contribute to adaptation?* Working Paper. Washington DC. PROFOR.

Secretariat of the Convention on Biological Diversity. 2009. *Connecting biodiversity and climate change mitigation and adaptation: report of the second ad hoc technical expert group on biodiversity and climate change.* CBD, Montreal.

Sedjo, R.A. 2010. *Adaptation of forests to climate change: some estimates.* Resources for the Future.

Seppälä, R., Buck, A. & Katila, P. (eds). 2009. *Adaptation of forests and people to climate change: a global assessment report.* IUFRO World Series Volume 22. Helsinki.

Seppälä, R., Buck, A. & Katila, P. (eds). 2009. *Making forests fit for climate change: a global view of climate-change impacts on forests and people and options for adaptation.* IUFRO Policy Brief. Helsinki.

Stocks, B.J. & Ward, P.C. 2011. *Climate change, carbon sequestration, and forest fire protection in the Canadian boreal zone.* Ontario Ministry of Natural Resources.

Thompson, I., Mackey, B., McNulty, S. & Mosseler, A. 2009. *Forest resilience, biodiversity, and climate change: a synthesis of the biodiversity/resilience/stability relationship in forest ecosystems.* Secretariat of the Convention on Biological Diversity, Montreal.

Vellinga, P. & van Verseveld, W. J. 2000. *Climate change and extreme weather events.* WWF.

Web references

Climate funds update (last accessed 11 june 2014)

EcoAdapt (last accessed 11 june 2014)

Credits

This module was developed with the kind collaboration of the following people and/or institutions:

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This module was revised in 2018 to strengthen gender considerations.

Initiator(s): Gender Team in Forestry

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