Forest and Water

Basic knowledge

The Forest and Water Module underlines the importance of the relationship between forests and water and the role of water in various forest functions. The module presents general guidance on water management priorities in forests, as well as more detailed guidance on specific water-management issues, such as those relating to swamp forests, forests on saline-susceptible soils, riparian buffer zones and vernal pools.

The module also provides links to key tools and case studies of effective water management in forests.

Water is an essential factor in SFM, and forests are crucial for regulating the water cycle. One of the challenges for forest managers is to maximize forest benefits while conserving water resources.

Forests need water

Forests are important water users. Trees use water at their highest rate when they have reached their final height (that is, the maximum height they will grow in their lifetimes) and during the season of their most intensive growth. The amount of water used by forests is also influenced by climate, topography, soil, forest age, species composition and management practices. Either too little water (as a result of insufficient precipitation or a reduction in groundwater availability), or too much (i.e. waterlogging), can have a negative effect on forest health.

Forests provide and regulate water

A large part of the world's drinking water comes from forested areas, and millions of people depend on high-quality freshwater flowing from forests. For example, the forests of the Uluguru Mountains supply drinking water to the 2.5 million residents of the Tanzanian capital, Dar es Salaam. Similarly, 1.3 million people in Quito and 20 million people in Mexico City get their drinking water from mountain forests. Forests help maintain high water quality, influence the volume of available water, and regulate surface and groundwater flows. Forests also help reduce water-related risks such as landslides, floods and droughts and prevent desertification and salinization.

Forest buffer extreme weather

Forests perform important buffering functions, such as cooling effects, the interception of precipitation, and water infiltration and retention.

Forests can therefore mitigate extreme weather and reduce the impacts of climate change on water resources. Conversely, forests themselves are vulnerable to the effects of climate change, such as reduced or changed precipitation patterns. Forest managers should aim to reduce the vulnerability of forests to water stress and increase their role in ensuring a continuous water supply (see climate change adaptation and mitigation).

Forest water management

Water management priorities in forests depend largely on the physical geography of the forest, and they are likely to differ in lowlands (where precipitation is lower and water infiltration is higher because of gentler slope gradients) and uplands (where there are more frequent and extreme precipitation events, shallower soils and steeper slope gradients with more surface runoff). Management guidelines exist for the following specific, water-sensitive forest contexts:

- mountain cloud forests;
- swamp forests;
- forests on saline-susceptible soils;
- riparian buffer zones;
- vernal pools (a distinctive form of wetland); and
- avalanche protection forests.

Forest and water contributes to SDGs:

Related modules

- Forest restoration
- Mountain forests
- Watershed management

In more depth

General goals of forest water management

SFM requires consideration of the importance of water in various forest functions. Important water management goals in forests include:

- maintaining the ideal height of groundwater (i.e. water in saturated soil, the top of which is known as the water table) to create stable (growth) conditions for trees;
- ensuring that water quantity and quality are maintained or improved;
- protecting natural resources and human-made infrastructure against water damage; and
- maintaining or improving conditions for rest and recreation in forests.

Determining forest water resources and needs

Activities aimed at improving or maintaining water resources in a given forest should be based on previously identified water resource needs for specific forest management goals (keeping in mind the water needs of all forest functions). Water-related indicators should give information about the general status of forest water resources for a specific site. Such indicators may include:

- measurements of water bodies (e.g. the extent of shoreline and depth of standing water, flow rates and water levels of watercourses);
- the height of the water table; and
- the volume of precipitation.

These indicators may fluctuate seasonally and from year to year. A reliable period over which to observe longer-term trends is 8–10 years.

Stream-flow regulation

In general, forests return less water to soils compared with grasslands or cultivated land because of their higher contribution to atmospheric moisture content via evapotranspiration. Water infiltration and retention are encouraged in forest soils by dense, deep root systems and a thick and porous organic top layer. Surface runoff is therefore minimal in forests and groundwater recharge efficient, resulting in more consistent stream flows over time compared with any other land cover. To support this regulating function of forests, forest managers should aim to maintain permanent vegetation cover, limit the compaction of soils, maintain a high amount of organic matter in the soil, and increase the “surface roughness” (that is, the unevenness of the soil surface, which helps increase water infiltration).

Water quality

To improve or maintain good water quality in a forest area it is important to minimize soil erosion and to reduce sedimentation in water bodies by filtering water pollutants in the forest litter and undergrowth. Good tree cover, with healthy undergrowth, is the most effective land cover for minimizing water sediments. Because most forestry activities do not involve fertilizers or pesticides, forests are vital for the supply of safe drinking and irrigation water. Where forest extraction is carried out, sediment production (from roads, log landings, skid trails and soil compaction) and chemical pollution should be minimized by good forest practices.

Flood protection

Forest soils act as sponges and retain water longer than soils under other land uses. Tree and forest removal therefore increases water discharge and the risk of flooding in rainy seasons and the risk of drought in dry seasons. Reforestation and afforestation have the opposite effect on water quantity. At larger scales and for longer, heavier rainfall events the effects of local forest cover change are not as important for flood protection. These effects are most prominent at the micro level and for short-duration and low-impact rainfall events and need to be considered in the planning of forest management activities. If the management goal is to increase water yield in a forest area through tree removal, the potential negative effects on water quality, landslip risk, avalanche protection and biodiversity need to be taken into account.

Soil protection

Forests are effective in minimizing surface erosion for a range of reasons; for example, their canopies, undergrowth, leaf litter and other forest debris reduce the impact of rain drops on bare soils, their porous soils help infiltration thus reducing surface water flows and their root systems help hold soil particles together. Forests can also help stabilize slopes and protect them from shallow landslips. Slip-prone areas should be kept forested (or maintained as woodland or agroforestry/sylvopastoral systems with high tree densities) to reduce the occurrence and severity of shallow landslips, and tree-harvesting activities in such areas should be light and non-mechanized. Note that although forests can play an important role in soil stabilization, there are cases and sites where they will not prevent or mitigate landslides caused by tectonic movements.

Mountain cloud forests
Mountain forests have a close association with freshwater: they gather water not only through normal vertical precipitation (i.e. rain and snow) but also by "water-stripping" the fogs and clouds that move horizontally through them. Cloud forests (sometimes also called fog forests) are therefore important for water production. Trees can be planted in strategic cloud and fog locations to maximize water-stripping. Cloud forests show a complex relationship between flora, fauna and soils and their loss is irreversible. Given their importance in water production and biodiversity conservation, and their general unsuitability for other uses (for example because of soil limitations and climates that are often unfavourable for agriculture), cloud forests should be maintained as forests and identified in national inventories.

Swamp forests
Swamp forests are environmentally sensitive areas in which the maintenance of hydrological integrity should be a management priority. Swamp forests are important sources of aquatic foods, timber and woodfuel, and they play a fundamental role in maintaining water quality and quantity. Inland swamp forests perform valuable watershed protection services, and coastal swamp forests help protect against tidal surges, rising sea levels and natural hazards such as tsunamis.

Forests on saline-susceptible soils
Deforestation should be avoided in forested areas with saline subsoils or groundwater. Through their use of rainwater and groundwater, forests and trees help prevent water tables from rising by balancing recharge (the movement of water down through a soil profile to a water table) and discharge (the loss of water from a water table). The removal of trees and forests can alter this balance, such that the water table rises, dissolving salts stored in the soil at it does and bringing them to the surface, where they can have severe impacts on plant growth.

In areas that are already salinized, reforestation with fast-growing trees – particularly in groundwater recharge areas (such as upper and middle slopes) – can help reduce recharge and increase discharge and therefore reduce soil salinization (see restoration and rehabilitation).

Riparian buffer zones
Trees on the shores of lakes and along streambeds have important water-protection functions. The deep root systems of these trees stabilize the banks of rivers and lakes, protecting against erosion and the inflow of sediments and pollutants while also providing habitat for aquatic and terrestrial wildlife. To be effective, riparian buffer zones should be at least 30 m wide – and even wider where the slopes are steep or where water bodies are adjacent to agricultural lands. Riparian buffer zones are usually not harvested for wood, and management should aim to minimize disturbances in them. Degraded riparian buffers should be restored to ensure good water quality (see tools and cases).

Vernal pools
Forest vernal pools are small ephemeral wetlands that undergo annual filling and drying cycles. They play a crucial role in the conservation of amphibian biodiversity, and their disturbance and degradation should be avoided. A two-tiered buffer zone – in which disturbance is minimized – is recommended to protect vernal pools. The inner tier should consist of the flooded area plus a buffer of 15 m, in which wood-harvesting is not permitted. The outer buffer (of another 15 m) should be harvested or modified only lightly because the presence of forest vegetation in this zone slows the drying of pools and extends the foraging habitat of amphibian wildlife. Vernal pools can be difficult to spot when empty (e.g. in dry seasons), but their cup-like shape, the lack of vegetation, and a thicker than normal organic layer can be good indicators.

Avalanche protection forests
Forest can significantly influence the formation of avalanches. Trees that are at least twice as tall as the snow depth can prevent avalanches, but shorter trees that are completely covered with snow can promote them (through the elastic movement of their branches). Forests on slopes greater than 58 percent and in areas where there is enough snowfall to trigger avalanches are potential avalanche protection forests. The management of these forests is complex and should be guided by expert advice.

Payments for water services
Forest owners may be able to obtain payments from downstream inhabitants and industries for the service they provide in protecting water catchments. This is a potential "payment for environmental services" (PES), a concept gaining increasing traction internationally and in some countries and cities. See watershed management for more information on water-related PES schemes.

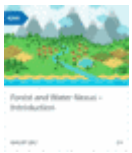
More guidance and support on the topic of forests and water can be found in tools and cases.

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.

Forest and Water Nexus – Introduction



This course is intended to provide on overview of forest and water relationships, and an understanding of the impacts of changing landscapes on water resources. It can be used as a stand-alone course for those interested in learning about the forest-water nexus, or as an introduction for those who will engage in workshops using the FAO capacity development facilitation guide on Advancing the Forest and Water Nexus.

Further learning

FAO. 2013. *Forests and water – International momentum and action.* FAO, Rome.

IUFRO. 2007. *International workshop on water management through forest management.* Beijing, 2007. Conference proceedings.

Credits

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