Watershed Management

Basic knowledge

This module is intended for people involved in the conservation, use and sustainable management of forests, land and water at the watershed scale. It outlines the key principles and main planning steps involved in designing measures to preserve or restore the ecosystem functions of watersheds. The module also provides links to tools and case studies to guide users in the planning and implementation of watershed management initiatives.

A watershed is the geographical area drained by a watercourse. The concept applies at various scales – from, for example, a farm drained by a creek (a “micro-watershed”) to a large river basin (or a lake basin). A river basin usually comprises a complex system of watersheds and micro-watersheds crossed by and draining into a major river and its tributaries, from the beginning of the river (its “source”) to its mouth (and a lake basin may be defined as a geographic land area draining into a lake). Because soils and vegetation are intimately linked to the water cycle, watersheds are the most useful planning unit for integrated water and land resource management.

Watersheds perform the following important functions and services, among others:

- the provision of freshwater (particularly upland watersheds);
- the regulation of water flow;
- the maintenance of water quality;
- the provision and protection of natural resources for local livelihoods;
- protection against natural hazards (e.g. local floods and landslides);
- the provision of energy (e.g. hydropower);
- biodiversity conservation; and
- recreation.

Forests and trees play crucial roles in hydrological processes in watersheds. Forested mountain and upland watersheds supply an estimated 70 percent of the world’s accessible freshwater resources for domestic, agricultural, industrial and ecological needs. The modules on Forests and Water and Mountain Forests provide more discussion on the interactions between forest vegetation and hydrological processes on sloping land.

Watershed services and functions may be threatened by deforestation, uncontrolled timber harvesting, changes in farming systems, overgrazing, roads and road construction, pollution, and the invasion of alien plants. They may also be affected by natural disturbances such as wildfires, windstorms and disease. The deterioration of watershed functions has significant negative impacts, potentially leading to erosion and the depletion of soil productivity; the sedimentation of watercourses, reservoirs and coasts; increased runoff and flash flooding;

reduced infiltration to groundwater; reduced water quality; and the loss of aquatic habitat and biodiversity.

Watershed management, defined as any human action aimed at ensuring the sustainable use of natural resources in a watershed, attempts to provide solutions to these threats. The origin of watershed management is closely linked to forestry; for example, the uncontrolled removal of forests in Europe and North America before the 1950s created significant changes in the hydrological regimes of important watersheds, leading to accelerated erosion and hazards downstream. The recognition of this relationship between upstream land use and water yields and quality led to the development of watershed management concepts. Watershed management considers the management and conservation of all available natural resources in a comprehensive way. It provides a framework for integrating different land-use and livelihood systems (e.g. forestry, pasture and agriculture), using water as the “entry point” in the design of interventions. Watershed management aims to preserve the range of environmental services – especially hydrological services – provided by a watershed and to reduce or avoid negative downstream impacts while, at the same time, enhancing resource productivity and improving local livelihoods.

Watersheds should be understood as dynamic systems characterized by diverse interactions and spatial relations between humans and the environment that manifest as mosaics of different land-use systems. The socioeconomic, cultural and environmental relationships, flows and conflicts between the upper and lower parts of a watershed are called upstream–downstream linkages. The consideration of these linkages is one of the key principles of watershed management. Other key principles are:

- addressing the root causes and drivers of environmental degradation (instead of treating symptoms);
- planning in an iterative process involving cycles of analysis, plan formulation, implementation and evaluation that allows for continuous learning and adjustments;
- working across sectors, with all stakeholder groups and administrative levels, thereby integrating bottom-up and top-down aspects; and
- combining local and scientific knowledge.

The demand for watershed services and the recognition that these services have economic value are growing globally. Increasingly, schemes are being created whereby downstream water users compensate upstream watershed managers for management that ensures the provision of environmental services, such as clean water.

Watershed management contributes to SDGs:

Related modules

- Forest and water
- Mountain forests

In more depth

Watershed management has developed significantly in recent decades. In the mid-twentieth century, the focus was mainly on agricultural land drainage and reclamation schemes and the development of infrastructure for water resources and hydropower schemes in uplands in the name of economic and social development. The environmental movement that arose in some countries in the 1970s brought with it growing recognition of upstream–downstream linkages, the socioeconomic effects of watershed management activities, and the need for integrated land and water resource planning. Today, based on the many field experiences that have now been gained, watershed management emphasizes multistakeholder participation and negotiation in resolving conflicts over scarce resources, balancing competing needs, and generating simultaneous benefits for people and the environment.

Main purposes of watershed management
Natural resource management

By considering, in a comprehensive way, all the natural resources in a watershed, especially water, land and soil, watershed management provides a framework for assessing the ways in which those resources are used, what affects them, and how they can best be used and protected.

Most people agree that natural resources are under increasing pressure. Rising demand for agricultural land to produce at least 70 percent more food by 2050 in order to feed the growing world population competes with an increasing need for land and water for urban expansion, industrial development and tourism. At the same time, recognition is growing that a substantial proportion of cultivated lands is already highly or moderately degraded due to unsustainable agricultural practices leading to soil erosion, nutrient depletion and the loss of productivity. Unsustainable agricultural practices also have off-site impacts, such as changes in runoff patterns, river hydrology and groundwater recharge rates, and the pollution and siltation of downstream water bodies.

Watershed management promotes the adoption of sustainable land and water management practices and encourages investment in better land husbandry that supports, not harms, the ecosystems on which productivity depends. Efforts to improve efficiency in the use of natural resources, especially water, are required to reduce pressures on the natural resource base and to restore the health and quality of freshwater ecosystems.

The key purpose of watershed management is to negotiate a balance among the interests and often competing needs of stakeholders and to jointly identify options for resource use that balance economic, social and environmental objectives and for which the highest consensus can be achieved among stakeholders. Effective watershed management identifies degraded areas in need of restoration, as well as areas with high ecological value that must be protected from degradation or conversion to other uses. Watersheds have long been recognized as an appropriate spatial unit for management, and they are also increasingly recognized as the key scale for resource governance.

Rehabilitation and protection

By considering land and water resources in a holistic and integrated way, watershed management can provide a framework for the planning and implementation of measures that protect sloping land against water-induced natural hazards and risks such as landslides, gully formation, torrents (i.e. swift, violent streams of water) and local flooding. Many watershed protection and rehabilitation measures are available, some of which are described below. More information on watershed rehabilitation and protection can be found in the FAO conservation guidelines (see Tools).

Protection of denuded slopes through vegetative and soil treatment measures
Vegetative and soil treatment measures are particular important in the protection and stabilization of denuded slopes when there is an abundance of vegetative material, natural vegetation is easily propagated and established, structural works are unsuitable or unnecessary, and aesthetic values are important. Measures include the (re)vegetation of exposed slopes to protect against erosion, and the stabilization of slopes with living or dead plant material.

Stabilizing slopes through vegetative and soil treatment measures is often more sustainable and requires less maintenance than the use of engineering structures. Vegetative measures may not always be sufficient, however, for example in dealing with torrents and landslides, in which case check dams, retaining walls and other engineered structures may be necessary.

Gully control. Minimizing surface runoff is essential for gully control. Poor land management practices, intense rain, prolonged rain of moderate intensity, and rapid snow melts can result in high levels of runoff, flooding and the formation of gullies. For watershed managers, gully control means:

- improving gully catchment to reduce and regulate peak flows;
- the diversion or retention of surface water above gully areas; and
- stabilizing gullies by structural measures and accompanying revegetation.

Structural measures should be considered only after appropriate land-use management measures have been explored and adopted in the watershed.

Landslide prevention. Landslides are natural phenomena that may occur in areas characterized by fragile geology, steep topography and high precipitation. It is difficult to predict when landslides will occur, and the volume of soil movement they will involve, but human activities may promote them. The conversion of forest to grasslands, road and dam construction, logging, and other activities can cause changes in slope stability and therefore increase the risk of landslides. Watershed managers can play important roles in preventing landslides by making appropriate land management decisions. Note, however, that landslides caused by tectonic processes cannot be prevented or ameliorated through watershed management.

Other purposes of watershed management

The watershed management framework has a wide range of applications; for example, it can be used in the planning and implementation of climate-change adaption and mitigation measures. Changes in the hydrological cycle and water availability due to climate change may lead to a greater incidence of flooding and water shortages, increases in the risk of erosion and landslides, and, ultimately, to reductions in crop, pasture and forest productivity. Rising temperatures are likely to lead to the melting of glaciers and the movement of permafrost and therefore to the more frequent occurrence of rock falls, ice and snow avalanches, mud flows, landslides and glacial lake outburst floods in upland watersheds.

By assessing the vulnerability of watersheds to climate change and identifying and prioritizing adaptation options, watershed management can play a crucial role in strengthening the resilience and adaptive capacity of watershed communities. In many watersheds, a key approach in ensuring resilience is likely to be sustainable forest management, because sustainably managed forests and trees have significant capacity to act as buffers as hydrological regimes change. It will also be important to adapt agricultural practices and diversify economic opportunities within watersheds as conditions change.

Watershed management can be applied to mitigate climate change, especially in larger watersheds that have high forest cover or high potential for afforestation and reforestation. Watershed management can be used to identify areas for carbon storage and sequestration by forests and trees and to reduce deforestation and forest degradation by limiting agricultural expansion and the conversion of forests to pasture lands. There is a high degree of overlap between the key principles of watershed management and the REDD+ safeguards.

When biodiversity conservation is the focus of an intervention, watershed management can be used to identify and delineate areas with high conservation value and in the establishment, planning and management of parks and forest protected areas.

Implementation of watershed management initiatives

Watershed management uses community-based approaches in planning, implementing and monitoring field activities. Communities in targeted watersheds are involved at all stages and receive technical assistance from decentralized government line agencies. Since there is a high level of community participation in watershed management, women are also very much involved. Gender relations need to be considered in all aspects of watershed management and women should be able to actively bring their contribution as key stakeholders. In collaboration with all stakeholders, diagnostic studies and mapping exercises are conducted using participatory appraisal, mapping and planning tools to assess the situation, analyse upstream–downstream linkages, establish watershed management committees, prepare watershed management plans, and implement improved practices and technologies. The planning process normally includes the following steps:

- delineation of the watershed;
- assessment of biophysical features, such as climate, geology, topography, soils, water quality and quantity in terms of infiltration rates and runoff, natural vegetation, fauna, and land suitability for different land uses;
- assessment of socioeconomic conditions, and livelihoods analysis, addressing, for example, demographics, major resource user groups, farming systems, access to land, actual land uses, major economic activities and sources of income, markets, social infrastructure, local institutions and service providers, and relevant policies and laws;
- watershed mapping and zoning to visualize current land uses, the degree of degradation, etc., and to develop future scenarios;
- action research for joint problem analysis, the identification of solutions, and immediate field-testing and validation of improved practices in each area;
- establishment of watershed management committees;

- preparation of watershed management plans;
- implementation of prioritized activities;
- monitoring and documentation of processes, results and impacts; and
- capacity building for all stakeholders.

Watershed management committees

Watershed management requires the active participation of all stakeholders, ideally working together in watershed management committees and applying collaborative approaches in which technical experts, policymakers, government agencies, local administrators and watershed communities share responsibility for identifying, prioritizing, implementing and monitoring watershed management. Watershed management committees provide a platform for dialogue, negotiation and decision-making among actors with diverse and sometimes conflicting interests and concerns. A balance must be achieved between the aspirations and interests of stakeholders, the technical recommendations of experts, and local governance policies. Social inclusion is crucial in watershed management, and watershed management committees can be excellent vehicles for ensuring gender balance in decision-making processes. Women are keepers of traditional knowledge and often the primary managers of watershed resources; they are the main providers of water for the household, used for drinking, cooking, washing and irrigating house gardens. Their voices must be heard when decisions are being made that affect the management and use of local resources.

Watershed management plans

A watershed management plan builds on a situational analysis of a watershed that includes information on demographics, land uses, natural resources, and natural resource users; socioeconomic data and livelihood mapping; problem analysis; and the prioritization of activities. The situation analysis must be gender-sensitive and include the collection of gender disaggregated data, so as to address women's and men's particular needs. The plan should specify the activities to be implemented, as well as the required inputs, costs, timeframes, roles and responsibilities, sources of community contributions, and partnerships. Participatory approaches are also used in monitoring and evaluating the implementation of the plan, focusing on the documentation of processes and measuring changes over time in upstream–downstream interactions.

Good practices, innovation and capacity development

Watershed management initiatives usually have a strong capacity-development component that aims to ensure technical quality in, for example:

- slope stabilization and erosion control through cost-effective bioengineering and vegetative techniques;
- low-cost water conservation and storage techniques, such as water-harvesting ponds, roof-water harvesting systems, and irrigation channels;
- good forestry and agroforestry practices to protect springs and watercourses, improve wood-energy supply, and increase the production of wood and non-wood forest products;
- good agricultural practices to improve soil fertility, increase land productivity, and reverse land degradation; and
- livelihood diversification activities, which may include the establishment of forest and fruit tree nurseries, food-processing facilities, fruit orchards, home-based poultry farms, and kitchen gardens that provide households with fresh vegetables while diversifying local diets and improving nutrition.

The combination of activities is highly context-specific, but all selected interventions should follow the principles of best practices: increasing productivity, improving local livelihoods and restoring or conserving ecosystems. The diversification of livelihood options provides multiple benefits and helps increase community resilience to climate change and strengthen adaptive capacity.

Innovative funding for watershed management

Some recent initiatives have set up revolving funds to be managed by watershed management committees with the aim of ensuring economic sustainability and increasing the resilience of communities to sudden shocks. Innovative uses of such funds include:

- the development of incentive-based compensation mechanisms for water-related environmental services based on upstream–downstream linkages and public–private partnerships; and
- the development of social-protection and financial risk-transfer measures through watershed management funds combined with livelihood diversification programmes.

Sustainability and ownership

Watershed management initiatives support institutional development by enhancing the technical and functional capacities of watershed management committees and governmental agencies at the municipality and district levels. The involvement of government officials at the district level is crucial for ensuring that watershed management plans are incorporated in district development plans, which in turn helps foster government ownership, facilitate the scaling up of successful approaches, and strengthen local governance processes. The involvement of communities ensures that local people are committed to sharing the benefits and costs of watershed management and have a stake in maximizing the benefits derived from interventions.

Further guidance and support for watershed management may be found in the tools and case studies provided for this module.

E-learning

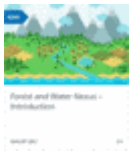
Resilient rivers: watershed-based management of forests, freshwater, and inland fisheries

Focusing on freshwater systems, this course inspires managers, scientists, and community members to work across disciplines and watersheds. The course coaches learners to understand, monitor, and manage watersheds as integrated systems.

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

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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 2017 to strengthen gender considerations.

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