

112 Watersheds and Watershed Functions

Module 1: Basics of Watershed Management	General
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Chapter 1.1.2: Watersheds and their Functions

Watershed – Definition of the Term

Watershed management takes place in spatial units called watersheds. A *watershed* is, literally, the area which sheds water into a river. It includes all the land, extending from the watershed divide to the river, from which runoff water flows towards the river. Along with the water, sediments and dissolved materials drain to a common outlet or destination.

As the term watershed is not universally established in terms of scale or size, the following terminology for river systems and their sub-divisions is suggested:

Box 1: River basin: All the land contributing water to a river system, from the headwaters to the river mouth [2].
Watershed: The land contributing water to a tributary of the river system, thus the river basin may consist of several watersheds [2].
Catchment: A small area of land contributing water to a specific stream or to a specific feature, such as a reservoir [2].

Other definitions abound, which for instance attempt to reflect holistic watershed management approaches that integrate the socio-economic and socio-cultural aspects with the purely geophysical and ecological, such as: “A watershed can be defined as a bio-physical and socio-economic unit comprising all natural resources, people and their socio-economic activities within the confines of a drainage divide” [3].




Watersheds are the most natural geomorphologic spatial unit on the terrestrial landscape. They contain and define the geophysical and ecological processes related to surface water and its movement to a common point. Human modification of these units, their soils and vegetation has a direct impact upon the delivery of water, sediments, and nutrients into these river drainage systems (See also: Chapter 1.2.5: Impacts of Vegetation and Land Use on Water Resources). Watersheds therefore integrate the interrelations between key natural resources and human activity within a natural geographical and biophysical unit.

Watersheds – A Hierarchy of Multiple Scales

Watersheds form unique landscape hierarchies, which are interdependent across several scales. They vary in size from the micro level, such as tributary catchments to the macro level namely a river basin, such as the Lower Mekong Basin. These scale categories are visualised in figure 1 and are further illustrated by an example from the region in a technical annex (See also: TA: Hierarchy of Watersheds – An Example from the Lower Mekong Basin [1.1.2]).

Table 1: Hierarchy of Watershed scales:

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	<p><i>River basin:</i></p> <p>All the land contributing to a river system, from the headwaters to the river mouth</p> <p>Macro level: Regional, national</p>
	<p><i>Watershed:</i></p> <p>The land contributing water to a tributary or the river system. A riverbasin may consist of several watersheds. In some countries watersheds may also have different names such as sub-river basin</p> <p>Meso level: sub-national</p>
	<p><i>Catchment:</i></p> <p>A small area contributing water to a specific stream or feature (e.g.a reservoir). (The word 'catchment' is also used as a technical term designing the area contributing water or its limits irrespective of size)</p> <p>Micro level: local, commune</p>

Watershed Functions

Watersheds are understood to have various functions, as seen for example from the point of view of sustainable development:

Box 2: The watershed function is the sustainable provision of goods and services. This comprises biophysical and ecological (such as provision of water of sufficient quantity and quality) as well as economic (such as sustainable provision of natural resource products) or social and cultural (such as protection and improvement of livelihoods) goods and services [7].

This definition reflects the modern understanding of watershed management. Historically, the bio-physical and ecological functions of watersheds dominated the watershed management process, as is reflected in the following definition: *"Watershed functions can be defined as the way landscapes determine quantity, timing and quality of river flow, by the way they transmit, buffer and gradually release the rainfall that is received, modify water quality and maintain the integrity of the soil capital in the catchment area"* [4].

More recently, however, the interdependency and overlap of the ecological functions with social and economic aspects has been recognised and integrated in a more holistic view [1]. The following figure presents an overview of the watershed functions, and table 1 provides further examples.

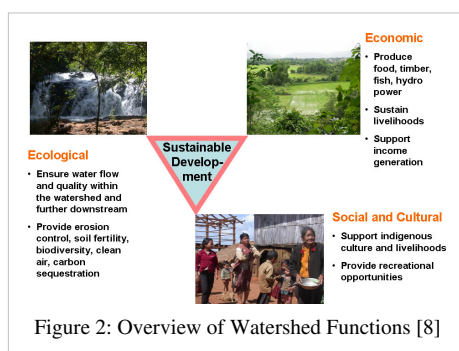


Table 1: Examples of Watershed Functions ([1], [6])

Category	Examples
Ecological Functions	<ul style="list-style-type: none"> • Provision of sufficient water with a minimum required quality, • Provision of minimum water flow over time, • Provision of other goods and services from natural resources e.g. erosion control, soil fertility biodiversity, clean air, carbon sequestration.
Economic Functions	<ul style="list-style-type: none"> • Provision of sufficient natural resource products (food, fuel wood, timber, water, fish, (hydraulic) energy required for basic needs of the local population, • Provision of income generating opportunities. • Sustain livelihoods
Social and Cultural Functions	<ul style="list-style-type: none"> • Maintenance of social structures, • Protection and development of knowledge and lifestyle arrangements, • Maintenance and revitalization of cultural identity and values, • Recreational facilities

This view of watershed functions as being of utmost importance as well as interdependent is firmly rooted in *scientific evidence about ecosystem functions and services*, which confirms that [1]:

- Ecosystem services are essential to the whole of civilisation.
- Ecosystem services operate on such a grand scale and in such intricate and only partially explored ways that most could not be replaced by technology.
- Human activities are already impairing the flow of ecosystem services on a large scale.
- If current trends continue, humanity will dramatically alter virtually all of the earth's remaining natural ecosystems within a few decades.
- Many of the human activities that modify or destroy natural ecosystems may cause deterioration of ecological services whose value, in the long term, dwarfs the short-term economic benefits society gains from those activities.
- Considered globally, very large numbers of species and populations are required to sustain ecosystem services.
- The functioning of many ecosystems could be restored if appropriate actions were taken in time.

The beneficial use of natural resources refers to their utilisation for human benefit, welfare, safety, health or enjoyment. Seen from this perspective of the beneficial use of resources, we can also define watershed functions as follows:

- *Primary function* – as drainage unit: Sustain beneficial economic, ecological and social uses of water resources both on-site (within the watershed) and off-site (outside the watershed).
- *Secondary function* – as land area: Sustain beneficial uses of other resources on-site.

Upstream and Downstream

Watersheds can be divided further into upstream and downstream areas. These *upstream and downstream areas* of watersheds are spatially separated, but they are inseparably integrated through a number of bio-physical and socio-economic linkages. Changes of resource conditions or interventions upstream may have a positive or a negative impact on the downstream areas and their populations. As downstream areas, we also understand areas outside the watershed itself, to which the watershed contributes water. In this context, and especially when considering the primary function of watersheds (as a drainage unit), the following key concerns are immediately obvious [9]:

- *Quality of water*: Changes in the water quality upstream, as a result of e.g. pollution, may affect the quality of surface and / or groundwater downstream.

- *Quantity of water:* The way water flows through watersheds is affected by land and water use in upstream areas. The key concerns are not usually changes in the average flow conditions but rather in the frequency and severity of extremes during the dry and wet seasons. Low flows are a key concern as they can be reduced by upstream activities to a degree that threatens water availability downstream. On the other hand increased upstream flood runoff due to land use change raises the flood risk downstream.
- *Movement of material:* The transportation and accumulation of soil and sedimentary materials may be accelerated by upstream land use practices and may generate negative impacts downstream, but in some cases may also create positive opportunities downstream.

These key concerns clearly illustrate the upstream cause and downstream effect of the dynamics of watershed processes, even though there often is a significant geographical separation between the two, perhaps even across an international border. The watershed therefore provides an ideal planning unit [3] that integrates all land use effects, highlights the linkages between land use and water and facilitates the monitoring and measurement of complex cumulative effects and their downstream impacts.

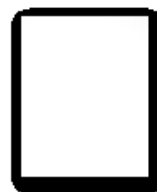
Consequently, watershed management aims to achieve the balance between increasing the potential for exploiting upstream water related ecological processes in a positive way, while reducing the risks of negative impacts downstream. Often, this implies that the areas for which goals and targets are set differ from those areas where the corresponding implementation measures are required to achieve these goals and targets. This spatial separation very logically explains the need for integrated watershed management [9].

These upstream downstream relationships and dependencies, as well as related impacts are illustrated in a technical annex and case studies (See for example: TA: The Water Flow through the River Basin [1.2.3] | CS: Hydrological Impacts of Forest Conversion into Tea Plantations – A Case from the Nilwala River Basin, Sri Lanka [1.2.5]).

References and Sources for Further Reading

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Additional Visualisation Materials

1. VM: Hierarchy of Scales of Watersheds [1.1.2]
2. VM: Watershed Functions [1.1.2]

References

- [1] <http://www.epa.gov/watertrain/pdf/issue2.pdf>
- [2] <http://www.worldagroforestrycentre.org/water/downloads/Watershed%20Publications/Thomas-et-al-2004-ASB-Thailand%5B1%5D.pdf>

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