WATERSHED

A watershed is an area that supplies water by surface or sub-surface flow to a given drainage system or body of water. Size is not a factor in the definition. Watersheds vary from a few hectares (or less) to millions of square kilometers (for example, Ganga river basin). If a "watershed" does not discharge directly into the ocean, then it is actually part of a larger watershed that does.

Where a watershed is defined by surface drainage, a groundwater basin or catchment's is not necessarily so defined; that is, surface water and groundwater boundaries do not necessarily coincide. Shallower, surficial aquifers may and often do follow the same boundaries that define surface-water watersheds. Deeper aquifers, however, are less likely to follow surface features. For these, the groundwater divide or boundary between two adjacent groundwater basins is the high point in the water table, and is constituted by a geologic or hydrologic, rather than a topographic, boundary.

While watersheds are one of the most basic units of natural organization in landscapes, they seldom if ever coincide with units of social, economic, or political organization. Thus, organizing efforts and activities around watersheds are best pursued only when strictly necessary and relevant, such as when land or water-related externalities are of sufficient concern to drive development objectives and priorities. India's 1995 Common Guidelines for Watershed Development Projects took a pragmatic approach to resolving any such issues of "institutional" versus "natural" boundaries by defining "operational watersheds" that align largely to village boundaries.

This tactic—based on socially, politically, and/or administratively meaningful units has been successfully applied throughout the world, especially where decentralized approaches are taken and local governments are seen as principal actors and stakeholders.

The Report of the Technical Committee on Watershed Programs in (GOI 2006) India went further and stated:

*Since we believe the watershed program is primarily a social program, and also because VWCs [Village Watershed Committees] within each Gram Panchayat [GP] are to be the ultimate implementing agency, the fi nal selection of implementation area must be according to the GP boundaries, to which [*watershed*] boundaries are to be approximated.*

WHAT IS WATERSHED MANAGEMENT?

Watershed management (WSM) is the integrated use and/or management of land, vegetation, and water in a geographically discrete drainage area for the benefi t of its residents, with the objective of protecting or conserving the hydrologic services that the watershed provides and of reducing or avoiding negative downstream or groundwater impacts. That is, WSM is ultimately about achieving water resources-related objectives.

In practice, one can observe that there are basically two approaches taken to WSM, which we will call here a “targeted approach” and a “mainstreamed approach”. The former has very specific objectives and indicators related to water resources and hydrologic outcomes, and the management interventions and the instruments applied are designed to address these. The latter has broader goals and objectives, such as sustainable land and natural resources management,
poverty reduction, and/or rural development. Here, WSM practices are integrated (mainstreamed) into planning and investment. Most development-oriented WSM programs—certainly those in India— are of this latter type. Irrespective of the approach, a number of factors are (or should be) common to the two approaches:
 Clarity of objectives regarding WSM issues and desired outcomes regarding water resources and the interactions with land use and vegetation;

Watershed management is the study of the relevant characteristics of a watershed aimed at the sustainable distribution of its resources and the process of creating and implementing plans, programs and projects to sustain and enhance watershed functions that affect the plant, animal, and human communities within the watershed boundary.[1] Features of a watershed that agencies seek to manage to include water supply, water quality, drainage, stormwater runoff, water rights and the overall planning and utilization of watersheds. Landowners, land use agencies, stormwater management experts, environmental specialists, water use surveyors and communities all play an integral part in watershed management.

Controlling pollution

In agricultural systems, common practices include the use of buffer strips, grassed waterways, the re-establishment of wetlands, and forms of sustainable agriculture practices such as conservation tillage, crop rotation and inter-cropping. After certain practices are installed, it is important to continuously monitor these systems to ensure that they are working properly in terms of improving environmental quality.

In urban settings, managing areas to prevent soil loss and control stormwater flow are a few of the areas that receive attention. A few practices that are used to manage stormwater before it reaches a channel are retention ponds, filtering systems and wetlands. It is important that storm-water is given an opportunity to infiltrate so that the soil and vegetation can act as a "filter" before the water reaches nearby streams or lakes. In the case of soil erosion prevention, a few common practices include the use of silt fences, landscape fabric with grass seed and hydroseeding. The main objective in all cases is to slow water movement to prevent soil transport.

Governance

The 2nd World Water Forum held in The Hague in March 2000 raised some controversies that exposed the multilateral nature and imbalance the demand and supply management of freshwater. While donor organizations, private and government institutions backed by the World Bank, believe that freshwater should be governed as an economic good by appropriate pricing, NGOs however, held that freshwater resources should be seen as a social good. The concept of network governance where all stakeholders form partnerships and voluntarily share ideas towards forging a common vision can be used to resolve this clash of opinion in freshwater management. Also, the implementation of any common vision presents a new role for NGOs because of their unique capabilities in local community coordination, thus making them a valuable partner in network governance.

Watersheds replicate this multilateral terrain with private industries and local communities interconnected by a common watershed. Although these groups share a common ecological space that could transcend state borders, their interests, knowledge and use of resources within the watershed are mostly disproportionate and divergent, resulting to the activities of a specific group adversely impacting on other groups. Examples being the Minamata Bay poisoning that occurred from 1932 to 1968, killing over 1,784 individuals and the Wabigoon River incidence of 1962. Furthermore, while some knowledgeable groups are shifting from efficient water resource exploitation to efficient utilization, net gain for the watershed ecology could be lost when other groups seize the opportunity to exploit more resources. This gap in cooperative communication among multilateral stakeholders within an interconnected watershed, even with the likely presence of the usually reactive and political boundary-constraint state regulations, makes it necessary for the institutionalization of an ecological-scale cooperative network of stakeholders. This concept supports an integrated management style for interconnected natural resources; resonating strongly with the Integrated Water Resources Management system proposed by Global Water Partnership.

Moreover, the need to create partnerships between donor organizations, private and government institutions and community representatives like NGOs in watersheds is to enhance an "organizational society" among stakeholders. This posits a type of public-private partnership, commonly referred to as Type II partnership, which essentially brings together stakeholders that share a common watershed under a voluntary, idea sharing and collectively agreed vision aimed at granting mutual benefits to all stakeholders. Also, it explicates the concept of network governance, which is "the only alternative for collective action", requiring government to rescale its role in decision making and collaborate with other stakeholders on a level playing field rather than in an administrative or hierarchical manner.

Several riparian states have adopted this concept in managing the increasingly scarce resources of watersheds. These include the nine Rhine states, with a common vision of pollution control, the Lake Chad and river Nile Basins, whose common vision is to ensure environmental sustainability. As a partner in the commonly shared vision, NGOs has adopted a new role in operationalizing the implementation of regional watershed management policies at the local level. For instance, essential local coordination and education are areas where the services of NGOs have been effective. This makes NGOs the "nuclei" for successful watershed management. Recently, artificial Intelligence techniques such as neural networks have been utilized to address the problem of watershed management.

Watershed Management

What is a watershed?

A ***watershed*** is simply the geographic area through which water flows across the land and drains into a common body of water, whether a stream, river, lake, or ocean. The watershed boundary will more or less follow the highest ridgeline around the stream channels and meet at the bottom or lowest point of the land where water flows out of the watershed, the mouth of the waterway.

Much of the water comes from rainfall and stormwater runoff. The quality and quantity of stormwater is affected by all the alterations to the land--mining, agriculture, roadways, urban development, and the activities of people within a watershed. Watersheds are usually separated from other watersheds by naturally elevated areas.

Why are watershed important?

Watersheds are important because the surface water features and stormwater runoff within a watershed ultimately drain to other bodies of water. It is essential to consider these downstream impacts when developing and implementing water quality protection and restoration actions. Everything upstream ends up downstream. We need to remember that we all live downstream and that our everyday activities can affect downstream waters.

> Management of the environment has been primarily focussed on specific issues such as air, land, and water. Most efforts have resulted in decreasing pollutant emissions to air and water, improved landfills, remediation of waste sites and contaminated groundwater, protection of rare and endangered species, design of best management practices to control water and contaminant runoff and much more.
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> What is still a continuing problem for our waters are nonpoint source pollution and habitat degradation. These are the problems that are responsible for most of the water quality use impairments throughout. These are typically complex problems that are difficult to manage. Both nonpoint pollution and habitat degradation generally cross program purviews. To establish a method to tackle these remaining problems managements must come together to better understand the interactions between the environmental components and the actions that can be taken by all towards the goal of ecosystem integrity.

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A watershed is made up of its physical and hydrological natural resources as well as human resources. Watershed management is the process of guiding and organizing land use and use of other resources in the watershed to provide desired goods and services without adversely affecting soil and water resources.

Watershed is a geo-hydrological unit, which drains at a common point. Rain falling on the mountain starts flowing down into small rivulets. Many of them, as they come down, join
to form small streams. The small streams form bigger streams; and finally the bigger streams join to form a *nullah* to drain out excess water from a village. The entire area that supplies water to a stream or river, that is, the drainage basin or catchment area, is called the watershed of that particular stream or river.

Identification of Watershed

All the watershed programme executing agencies work hard to identify a watershed which may be taken up on priority for development. In the absence of any clear-cut parameters, the identification of the watersheds for development is done on parameters like approach, cooperation of the villagers, etc. It is a matter of concern that in certain watersheds more than 10 agencies are working and in some none. There is no doubt that every watershed has to be taken up for development and a watershed developed today may be needing further management/development after a lapse of 10-15 years. However, there is a need of selecting a watershed for development on priority.

Focus and Principles Of Water Shed Management

Watershed degradation in the third world countries threatens the livelihood of millions of people and constrains the ability of countries to develop a healthy agricultural and natural resource base. Increasing populations of people and livestock are rapidly depleting the existing natural resource
base because the soil and vegetation system cannot support the present level of use. In a sense, the carrying capacity of these lands is being exceeded. As the population continues to rise, the pressure on forests, community lands and marginal agricultural lands leads to inappropriate cultivation practices, forest removal and grazing intensities that leave a barren environment yielding unwanted sediment and damaging streamflow to down stream communities

The focus of watershed development

Village common lands as well as private lands
• Institutionalized community participation
• Sustainable rural livelihood support system
• Capacity building

• Decentralized planning and decision-making
• Ridge to valley treatment approach
• Integrated and holistic development of the unit
• Protecting natural resources through stakeholders' participation
• Provides best unit for planning a development programme
• Principles of Watershed Management

The main principles of watershed management are:

• Utilizing land according to its capacity.
• Putting adequate vegetal cover on the soil.
• Conserving as much rainwater as possible at the place where it falls both at farmlands and common property resources: In-situ conservation.
• Draining out excess water with a safe velocity and diverting it to storage ponds and storing it for future use.
• Avoiding gully formation and putting checks at suitable intervals to control soil erosion and recharge ground water.
Maximizing productivity per unit of area, per unit of time, and per unit of water.
• Increasing cropping intensity and land equivalent ratio through intercropping and sequence cropping.
• Safe productive utilization of marginal lands through alternate land use system.
• Ensuring sustainability of the eco-systems benefiting the man-animal-plant-land-water-complex in the watershed.
• Maximizing the combined income from the interrelated and dynamic crop-livestock-tree-labour complex over the years.

Limitations Of Water Shed Management

• Limited success of watershed programme indicates that itwas mainly due to:
• Inadequate analysis of physical and socio-economic environment;
• Indifference to farmers' circumstances;
• Strong bias towards crop production;
• Lack of farmers' involvement; and no flexibility in the technological options to suit farmers' needs and their resources.
• Lack of continuation of the soil and water conservation measures up to the point of financial support;
• Poor acceptance of contour-based water conservation measures due to their disregard to ownership boundaries;
• Antipathy of farmers to maintain structures like diversion drains, which cost money and resources to some farmers but benefited others;
• Inadequate arrangement on social fencing to protect forestry and pasture lands;
• Lack of focus to address the problems of livelihoods of landless laborers;

• Disregard to indigenously known and practiced methods of soil and water conservation; and

• Lack of clear arrangements and understanding on sharing of the harvested water.

Water Shed Management Process

The collection, inventorization and documentation of the resources required for water shed management is known as benchmark survey. The benchmark survey on one hand provides requisite information for suitable watershed planning and on the other hand helps in estimating the effect of watershed management works through evaluation and monitoring. The various resources can be collected, inventoried and documented through the following surveys.

1. Demographic Survey

The demographic survey consists of documentation of human and cattle population, wild animals, etc. for better planning. Our basic aim for the development of the watershed is to develop the socio-economic condition of the habitant of the area, hence the related information on these aspects is very
necessary.

2. Vegetation

The information on type of vegetation, its status, present yield, agronomical practices, etc. helps in identifying the gaps with respect to expected optimum, that is, sustained production.

The gap in present and optimum yield of all the vegetation is very important to identify proper control measures.

3. Soil-cum-Land Capability Survey

The information on soil (both chemical and physical properties) including geology, drainage, etc. coupled with topographical and hydrological survey helps in preparation of land capability classification map of the watershed which is the of top sheet, revenue map and other suitable instruments/equipments.

4. Engineering-cum-Topographical Survey

The topographical survey basically consists of demarcation of hillocks, ridges, valleys, depressions, streams, land slope (both degree and length), etc. in order to know the extent of degree of risk and ease of planning. The engineering survey consists of mapping the existing structural measures of erosion control in the watershed viz. dams, culvert, retaining walls, terracing, bonding, trenching, water harvesting structure, etc. It also provides the opportunity for identification of problem area.

5. Hydrological and Water Resources

This basically helps in estimating the water balance of the watershed for crop production. The information on precipitation and other agro climate logical parameter is generally collected from the meteorological observatory already existing in the watershed or from the nearby area. The information on existing water resources, that is, water bodies, viz. reservoirs, ponds, lakes, wells (both shallow and deep), stream flow, etc. is collected by surveying the watershed. Now as on today, the thrust has shifted from Watershed Management to Integrated Watershed Management. The emerging issues or new paradigms of Integrated Watershed Management are:

1. Participation
2. Equality (gender issue, legal issues and policies, landless economically weaker section)
3. Equitability
4. Common property resources
5. Societies, associations
6. Employment generation
7. After care and maintenance
8. Responsibilities
9. Monitoring and evaluation

• Crop yield
• Cropping intensity
• Cropping sequence and rotation
• Ground water level
• Water resources
• Flora and fauna
• Land development index
• Low flow index
• Fertilizer intake index
• Micro-climate
• Runoff and soil loss

10. Partial area concepts

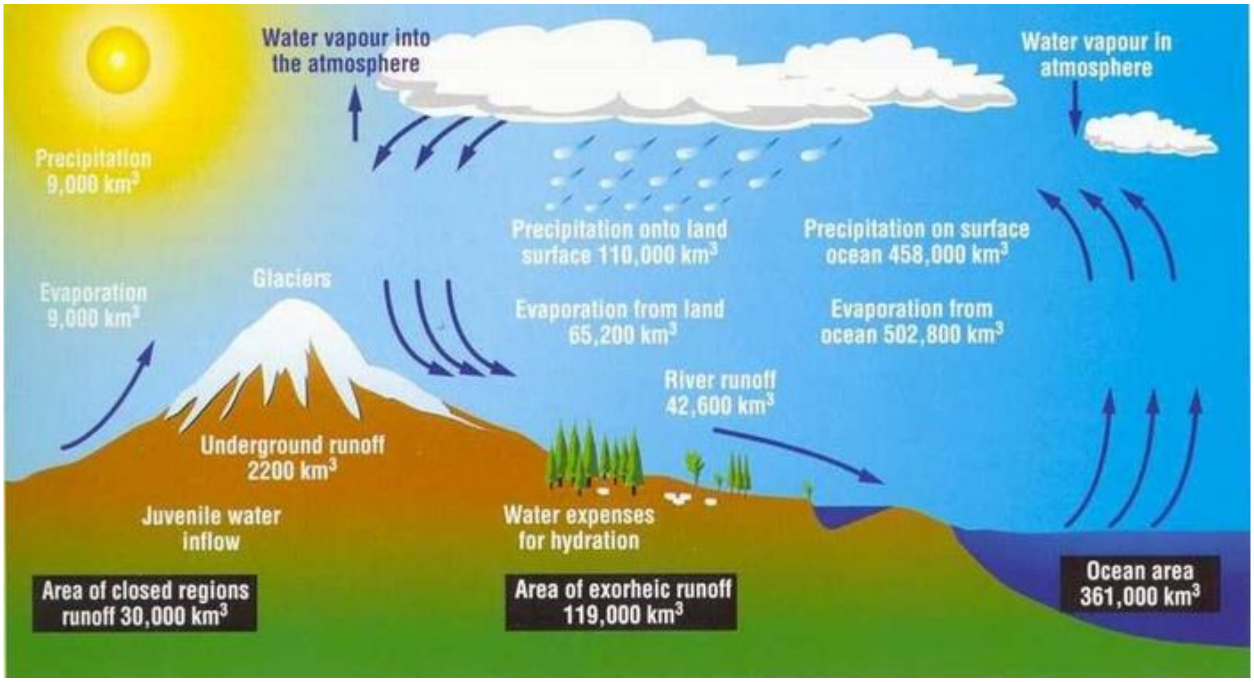
Conclusion

Watershed is a geo-hydrological unit, which drains at a common point. Rain falling on the mountain starts flowing down into small rivulets. Many of them, as they come down, join to form small streams. The small streams form bigger streams; and finally the bigger streams join to form a *nullah* to drain out excess water from a village. The entire area that supplies water to a stream or river, that is, the drainage basin or catchment area, is called the watershed of that particular stream or river. The Silt Yield Index (SYI) is recommended as the parameter to decide the prioritization of the watershed. The watershed which is observed to yield maximum yield is taken first for development followed by the one which is next to yield the silt and so on. A proper watershed management plan can be termed as one, which provides sustained production from the watershed without further deteriorating the environment and is limited to the resources of the watershed.

The Hydrological Cycle

Water is the most widespread substance to be found in the natural environment. It exists in three states: liquid, solid and invisible vapour. It forms the oceans, seas, lakes, rivers and the underground waters found in the top layers of the Earth's crust and soil cover. In a solid state, it exists as ice and snow cover in polar and alpine regions. A certain amount of water is contained in the air as water vapour, water droplets and ice crystals, as well as in the biosphere. Huge amounts of water in bound up in the composition of the different minerals of the Earth's crust and core.

Water is essential to life. Without it, the biosphere that exists on the surface of the earth wouldn't be possible. The hydrologic cycle begins with the evaporation of water from the surface of the ocean. There are five processes at work in the hydrologic cycle: condensation, precipitation, infiltration, runoff and evapotranspiration. These occur simultaneously and, except for precipitation, continuously. Together, these five processes make up the Hydrologic Cycle. Water vapor condenses to form clouds, which result in precipitation when the conditions are suitable. Precipitation falls to the surface and infiltrates the soil or flows to the ocean as runoff. Surface water (e.g., lakes, streams, oceans, etc.), evaporates, returning moisture to the atmosphere, while plants return water to the atmosphere by transpiration.



The Hydrological Cycle

Condensation is the process of water changing from a vapour to a liquid. Water vapour in the air rises mostly by convection. This means that warm, humid air will rise, while cooler air will flow downward. As the warmer air rises, the water vapour loses energy, causing its temperature to drop. The water vapour then has a change of state into liquid or ice.

Precipitation is water being released from clouds as rain, sleet, snow or hail. Precipitation begins after water vapour, which has condensed in the atmosphere, becomes too heavy to remain in the atmospheric air currents and falls.

A portion of the precipitation that reaches the Earth's surface seeps into the ground through the process called infiltration.

The amount of water that infiltrates the soil varies with the degree of land slope, the amount and type of vegetation, soil type and rock type, and whether the soil is already saturated with water. The more openings in the surface (cracks, pores, joints), the more infiltration occurs. Water that doesn't infiltrate the soil, flows on the surface as runoff.

Precipitation that reaches the surface of the Earth but does not infiltrate the soil is called runoff. Runoff can also come from melted snow and ice.

When there is a lot of precipitation, soils become saturated with water. Additional rainfall can no longer enter it. Runoff will eventually drain into creeks, streams, and rivers, adding a large amount of water to the flow. Surface water always travels towards the lowest point possible, usually the oceans. Along the way some water evaporates, percolates into the ground, or is used for agricultural, residential or industrial purposes.

Evapotranspiration is water evaporating from the ground and transpiration by plants. Evapotranspiration is also the way water vapour re-enters the atmosphere. Evaporation occurs when radiant energy from the sun heats water, causing the water molecules to become so active that some of them rise into the atmosphere as vapour.

Transpiration occurs when plants take in water through the roots and release it through the leaves, a process that can clean water by removing contaminants and pollution.

What are the basic components of Hydrological Cycle?

The basic components of a hydrological cycle constitute:

1. Precipitation
2. Runoff
3. Evaporation
4. Condensation
5. Transpiration
6. Evapotranspiration
7. Infiltration
8. Depression Storage
9. Interception

1. Precipitation

It is the fall of moisture from the atmosphere to the earth's surface in any form. Example: rain, hail, snow, sleet, glaze, drizzle, snowflakes.

2. Runoff

It is the water flowing over the land making its way towards rivers, lakes, oceans, etc. as surface or subsurface flow.

1. Surface runoff: it is the running water over the land and which ultimately discharge water to the sea.
2. Subsurface runoff: The water getting infiltrated into pervious soil mass, making its way towards rivers and lakes can be termed as subsurface runoff.

3. Evaporation

It is the conversion of natural liquids like water into gaseous form like air. Evaporation happens in the water bodies

4. Condensation

It is the conversion of a vapor or gas to a liquid. The water vapour evaporates from the water bodies like ocean, sea and river. These vapors after reaching a height around 20km in the sky undergo condensation and forms clouds. These later precipitate as rain, fog etc.

Transpiration

It is the evaporation taking place from any plant or greenery. For example, a water droplet on a leaf getting evaporated into the atmosphere.

6. Evapotranspiration

It is the combination of evaporation and transpiration.

7. Infiltration

It is the process of filtration of water to the inner layers of soil based on its structure and nature. Pervious soils go through more infiltration than impervious. Infiltration in soils like sand, gravel and coarser material is more and for finer soil particles like clay and silt, infiltration is less.

Infiltration is inversely proportional to runoff. In soil, if infiltration is less, then the runoff is more. Similarly, more infiltration gives less runoff. Example: bitumen roads have more runoff than metallic red mud roads

8. Depression Storage

It is the part of precipitation required to fill depression zones of land.

Process of Hydrological Cycle

The Process of the hydrological cycle starts with oceans. Water in oceans, gets evaporated due to heat energy provided by solar radiation and forms water vapor. This water vapor moves upwards to higher altitudes forming clouds.

Most of the clouds condense and precipitate in any form like rain, hail, snow, sleet. And a part of clouds is driven to land by winds. Even during the process of precipitation, some parts of water molecules may evaporate back to atmosphere.

The Portion of water that reaches the ground, enters the earth's surface infiltrating various strata of soil. This process enhances the moisture content as well as the water table.

Vegetation sends a portion of water from the earth's surface back to the atmosphere through the process of transpiration. Once water percolates and infiltrates the earth's surface, runoff is formed over the land, flowing through the contours of land heading towards river and lakes and finally joins into oceans after many years. Some amount of water is retained as depression storage.

Further again the process of this hydrological cycle continues by blowing of cool air over the ocean, carrying water molecules, forming into water vapor then clouds getting condensed and precipitates as rainfall. Similarly, the water percolates into the soil, thus increasing the water table and also the formation of runoff waters heading towards water bodies. Thus the cyclic process continues.

Water balance Equation

As per the water balance equation, the sum of inflow waters = sum of outflow waters. Out of the three processes precipitation, runoff, and evaporation, inflow is precipitation. Runoff and evaporation comes under outflow, then the water balance equation can be written as,

Precipitation – runoff = Evaporation

That gives,

Precipitation (P) = Evaporation (E) + Runoff (R)