Principles of Watershed Management

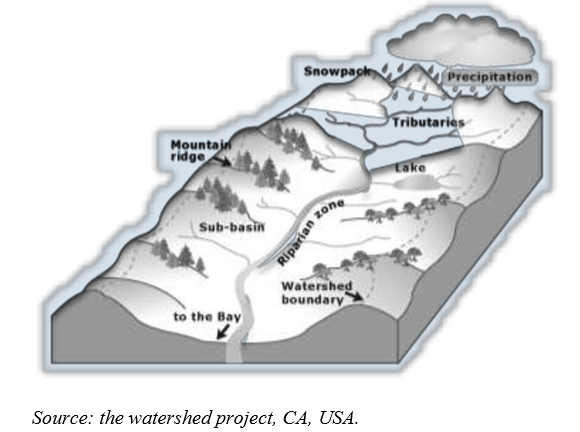
**Concept of Watershed**

Watershed is a part of the land, where rain water or melted ice is captured as a drainage area and let out from a single exit to major rivers or streams. (Fig: 1) Technically, a watershed is the divide separating one drainage area from another (Chow, 1964). Watershed or catchment area or drainage basin are terms used for part of the earth surface, where precipitation and stream or river water are collected and drained out to a bigger river, these terms are used depending on the size of the physiographic unit. For instance, India has 35 drainage basins, 112 catchment areas and 3237 watersheds (Watershed Atlas of India, AISLUS, 1990). (Fig: 2)

Precipitation that falls in a watershed ultimately reaches river system. Basically, the extra water from the catchment area is drained into rivers. Watersheds are found in varied sizes on the surface of the earth from very small to very large. Large watersheds are also known as macro watersheds and the smaller in size watersheds are called micro watersheds. Watershed looks like branches of tree where small branches join the trunk of the tree. Smaller size watersheds combine to form larger watersheds. Earth’s landscape determines the size of the watershed to a large extent; for instance in areas of intensive agriculture or mountainous areas smaller watersheds are preferred whereas in plain areas bigger watersheds are easily maintained. Also, at times smaller or sub watersheds supply water to the tributaries of the main river and nests within the larger watersheds.

 Watersheds act as bowls, which collect excess runoff and rain water at the bottom. Uneven land in any region forms watershed areas, which collect water and drains out the same from single outlet. All valleys, mountainous regions, jungles etc. those enfolds precipitation and channelize it into rivers and streams, forms watersheds. All rivers, their tributaries and smaller streams have related watersheds. A watershed apart from maintaining hydrological unit and storing water supports life on the earth by providing source of food; drinking water and habitat for aquatic organisms.These are also conducive sites for many bio chemical reactions.

***Fig: 1***                        ***Watershed Area***

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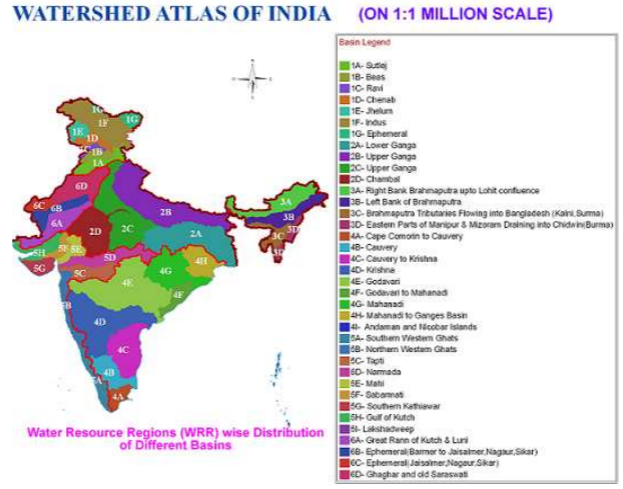
**Demarcation of Watershed Area**

Watershed management can be done accurately only when the area is demarcated. Watershed demarcation is done on toposheet with drainage and contour lines, as watershed boundary runs perpendicular to the elevation contours. Once the watershed is demarcated on a toposheet, the same is overlaid on other maps such as cadastral map, soil map etc. Digitally also the watershed area can be delineated on the basis of satellite images. The Digital Elevation Model can be attained from satellite images. The data about the topography is stored in grid cells of DEM.

A ridge line, acts as a dividing line between two watersheds. Ridge is the higher elevation point of the watershed from where the slope starts. The entire stretch of the slope of a watershed from the ridge to the plain is called Ridge area. Within watersheds the streams or rivers are categorized in different orders such as small stream at the beginning of its journey is called first order streams or lower order stream, first order streams joins with second order streams and second order stream with third order or higher order stream or river and so on and so forth.

**Fig: 2**   **Map of Watershed**

***Source: Soil and Land Survey of India, Dept. of Agriculture & Cooperation, GOI***



**Watershed Management in India**

Watershed development and management in India has a long history. Watershed management at community level has been practiced in the form of harvesting and storing rainwater and managing runoffs. Storing rainwater in tanks and small underground storages has been an effective traditional method of rainwater harvesting practiced in the country. Many such traditional methods have been adopted by The Government of India (GOI) with focus on micro-watersheds planning, since the late 1980s.

Land, water and human resources are major components of watershed development programs in India. These programs have multiple objectives from rainfall harvesting, building small dams and tanks, groundwater recharging and rehabilitation of the locals to conservation of water resources along with development of irrigation facilities for agriculture. Studies conducted by different government agencies to assess the impact of watershed management programs in India shows some positives in terms of reduction in soil erosion, controlling runoffs and marginal increase in groundwater levels. However, variations have been noted with states like Tamil Nadu and Gujarat faring well in water harvesting in comparison to other states. Also, most of the positive outcomes of watershed management have been noted in micro watershed areas.

**Why Watershed need to be developed?**

To understand the need for watershed development, we need to understand the importance of watershed. Watershed plays an important role in not only collecting rain water but also in supporting life on the earth, balancing hydrological cycle and maintaining the environment. In a country like India and many other countries rainfall is received only for few days or months in a year. In most cases rain water would fall in a river or on the ground and will be wasted or expensive dams would be constructed to utilize the river water for energy.But watershed development reduces water wastage by conserving the rain water wherever it falls through drainage basins. In India, where about 70% of population is dependent on income from agriculture, water scarcity or drought condition can cause havoc in their lives. Watershed development is an important measure even to mitigate drought conditions. Watershed maintenance and development is important as it also controls excess runoff with a chain of interventions and guides the water through a proper vertical channel rather than spreading across horizontally. It reduces the velocity of flow of rain water and thus controls soil erosion, as the force of water is not intense enough to remove the top soil. Watershed help in reduction of siltation as the limited silt carried by water cant flow longer as the size of the streams are shortened by watersheds, thus reduces the amount of silt stacking up in the lower reaches of watershed. It also increases the amount of groundwater as by storing the water in the basin like structure the possibility of water penetration to the ground increases. The moisture content of soil increases near the watershed area and it further results in better prospect of crops and biomass. Watershed is also a healthy source of drinking water. Extremities of climate and pollution are controlled by the stored water in watersheds. A well maintained watershed sustains streams, river and other water bodies also.

In brief, following are the importance of watershed Management

Watershed Management leads to capability based utilization of the territory.

Vegetation cover is increased on the soil to stop soil erosion mainly during rainy season. Gully formation is restricted and at regular intervals checks are put to control top soil removal and refuel ground water storage.

Precipitation is captured in the areas where it falls or places of heavy rainfall.

Through watershed management the excess water is channelized into storage areas such as lakes or ponds, the same water can be utilized for future usage.

Cropping intensity is increased through rotational and integrated cropping.

The land, which is not suitable for agricultural production or marginal land can be utilized for alternate land usages through proper management of watershed.

Maintain sustainable ecosystem suitable for man, animal and resources relationship over the years.

Capitalizing the potential of combined earnings from dynamic interactions between resources.

Increasing yield per unit extent, per unit water and per unit of time.

Watershed development program is required to mitigate extreme effects of changing climatic conditions such as floods, droughts, desertification of crops etc. These programs help in economic development of the region along with betterment of the poor people residing in the watershed areas. Increase in employment generation, poverty alleviation, community empowerment etc. are few of the objectives of watershed development program.

**Watershed Management Approaches**

Watershed management approaches are evolving throughout the world and are being used to address watersheds that have multiple problems.

**Integrated Approach:**The term “integrated” here means integration of all the basic resources such as land, vegetation, and water with technology within natural drainage area for better development of the resources to sustainably meet the basic demand of the population. To achieve the goals of integrated management, water and land resource maintenance, restoring of groundwater, use of higher variety of seeds, focus on crop intensification etc. are required.

**Conglomerate Approach**This approach highlights on cooperative action and public participation involving government officials, locals, policy makers and other patron organizations, which have the knowledge and capacity to take decision related to natural resource management. Even NGOs, Local authorities, municipalities as well as private companies facilitate cooperation between watershed management programs and public. For the success of watershed management program timely suggestion and assistance to the farmers, locals as well as policy makers is required.

**Principles of watershed management**

Watershed is a comprehensive system with several components. Interaction between the components defines the watershed system. The constituents and resources of watershed are both spatially and functionally related, thus the value of the integrated usages is enormous.

Watershed management should have participation and partnership of the locals, the communities and the concerned authorities in planning and implementation of various duties and responsibilities. Identification and Involvement of prime decision and policy makers in the planning process is important.

Watershed planning involves a combination of social values with scientific and technological know-how. Planning thus requires comprehensive statistics about the specific watershed constituents, procedures and other basic info. Planning involves identifying step toward solutions to specific problems and reaches the goal. Generally to deal with economic, social and environmental concerns or issues formal plans are developed.

The acceptability of the plans more than the technical element depends on the human aspects, hence planning needs to begin with focus on the human population living in the area. Approach to watershed planning should not be rigid; steps of planning must involve the social concept accepted by public living in the watershed areas.

Watershed planning is a dynamic process with integrated multi -disciplinary approach including inputs from representative from various fields such as geology, social science, hydrology, engineering, economy and forestry.

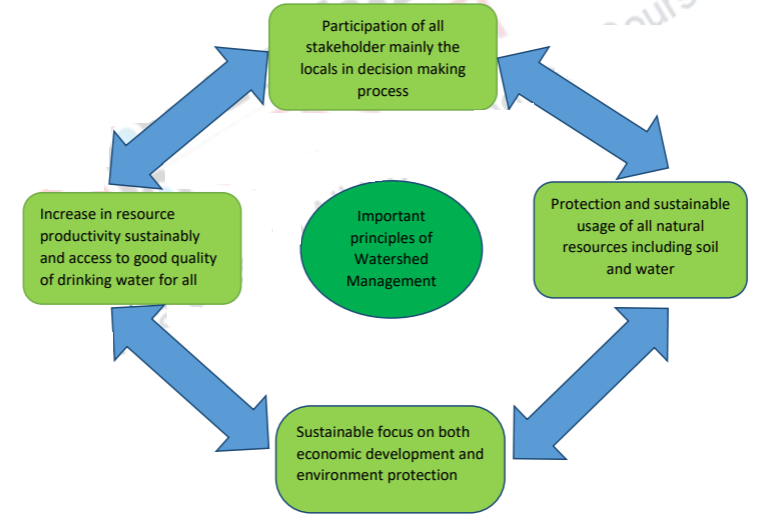
Another important aspect of watershed management is being gender sensitive by involving women in the planning, implementation and management of resources. Women are most impacted by environmental difficulties. Women in developing countries particularly in rural part like in India still walk long distances to fetch water and other important resources. Their participation is necessary to ensure they equally gain from different measures of the watershed management.

Inclusion of knowledge and wisdom of local people in watershed management is important to identify many local problems and their solutions. Recognizing and broadly defining the actual problem is necessary to develop a proper innovative solution. If the actual reasons and dynamics behind a problem is identified then solving the same become easier. It is necessary that watershed planning advocate sustainable management of watershed.

  Watershed management should involve not only identification of the solution but also examining the requirement of resources, implementation of plans, procedures of receiving feedback etc.

Evaluation of the possible solution on the basis of its feasibility, costing, political and acceptance, technicality etc. Finally, evaluation of success of the plan is very important for future references.

**Principles of Watershed Management**



**Watershed Inventories**

Successful watershed planning requires access to information along with support and suggestion of specialists. Building a watershed Inventory is important step of planning with information on all features of water and underlying rocks including their chemical properties influenced by weathering process; physical properties including the surface geology and type of bedrock. The type of bedrock defines the characteristics of overlying soils and influences the movement of water. The biological content includes the study of the presence of microorganism, plants, bacteria, etc. in the water that impacts the quality and movement of water. The idea behind the inventory is to bring all information at a common place, which makes it easier to manage. Information on general climate, temperature, wind speed, quantity and direction of precipitation etc. and the influence on water resource in a watershed, if available then management of watershed become easier. Precipitation intensity, frequency and duration impact the water resource quantity, even wind speed and direction impacts the land and water resources.

Watershed Inventory should include information on number and types of plants and animal species available in the watershed. Information on the relationship between different species and their surroundings and number of threatened, vulnerable, endangered and extinct species should also be part of the inventory.

Statistics about land use by human at present and future capabilities of infrastructure development should be part of inventory. Changes in land use due to resource mining bring in changes in the watershed features. Inventory on land use should have information from government authorities, zoning department, transport department, maps on topography and roads. Detailed information on land use and other resources can help the locals and the society to analyze the value it would safeguard through watershed planning.

Information on society, built and natural environment and the economic set up of the watershed helps determine their impact on people’s approach and their support towards watershed management.

All of the above mentioned information’s should help in apt watershed planning.

**Pillars of watershed management**

   The success of watershed management depends on four pillar, which are finance, effective management team, involvement of all stakeholders and observation.

Effective management team is required to plan the watershed management program. The team is responsible for setting targets, forecasting, observing and implementation. Authorities responsible for implementation are generally part of the management team. The team is familiarized with the local conditions as a result can implement the measures easily.

Finance for steering the entire watershed programis the most important requirement. Programs are generally financed by government and other competent authorities.

Participation and involvement of all stakeholders is also important for successful implementation of the program. Coordination and interactions between the authorities and public promotes awareness about the system and thus increases consensus towards the procedures. More participation stimulates the political decision making.

Continuous observation of the program implementation and proper utilization of the funds is crucial. Regular observation and procurement of information about the water resources aids the watershed management awareness among people.

**Constituents of Watershed Management**

**Conservation of water and land:**

Conservation and preservation of the valuable resources water and land are the prime aim of watershed management. Watershed management is done at two level in –site(or in situ) and out-site or (ex-situ). In situ management is done on the site or on the fields by construction of terraces, graded bunds, furrows etc. to protect the soil moisture. This management procedures help maintain the soil quality along with increase in ground water storage. In ex-situ management procedures pits or basins or dams are constructed along the stream or river to control excess runoff and increase the potential of irrigation and refuel the groundwater storage.

**Capacity Development or Building**

Watershed management requires participation and involvement of all stakeholders to improve the resource base. For participation of stakeholders, their capacity building needs to be developed. Capacity building is done by strengthening the abilities of the stakeholders to use the resource judiciously to meet their own aims and goal sustainably. Capacity building emphasizes onlow cost conservation method of soil and water, production of organic pesticides and fertilizers, waste land improvement etc. Main stakeholders like government officials, policy makers and local people should have clarity on management techniques, planning and evaluation mechanisms, thus training at different level of watershed management is important.

**Crop Intensification and diversification**

Crop intensification involves increasein intensity of cropping and its production in a given area to meet the ever growing demand of food. Crop diversificationon the other hand involves bringingsystematic or technological changes in the cropping pattern to reduce crop loss. Watershed management program focuses on better technologies, higher quality of seed and fertilizer and proper irrigation facilities for improvement in cropping.

**Utilization of Various Resources**

Depending only on agricultural production and activities hold very high risk and uncertainty for farmers, as failure of crops due to extreme weather conditions, attack of pests and changes in market demand are very common now. Hence, to have sustainable source of income farmer need to utilize more than one resource. For instance, agriculture and dairy farming can we worked together upon, after crop harvesting the biomass or crop straw can be utilized as food for cow, buffalo etc. and milk production of these animals can be increased for commercial utilization. On the other hand, the cow dung can be utilized as manure for improving soil quality.

**Watershed Forest Management: General**

Forests in the watershed areas need to be efficiently managed to protect quality of water for a longer time by restricting negative impacts during management operations.

Negative impact on water quality of tributaries such as changes in temperature of stream water, nutrients, and cloudiness in water due to forest management procedures can be reduced with appropriate road layout, maintenance and planning of silvicultural actions.

Trees grown in their suitable climatic range and on their natural sites grow faster and live longer, hence such watershed forest require less nurturing; e.g. in a wet site location red maple tree remains firm on wind throw and tolerates soil wetness however white pine might grow fast on such site but is more prone root viruses.

Uneven aged method developed in forest stands generally include younger and shorter trees between mature and strong stem trees in these stands. The strong and older trees withstand strong wind and the younger trees in un-even aged stands with their regeneration ability enable them to swiftly recuperate from disturbances, thus improving their long term protection of water quality.

**Watershed threats and its Protection**

Unrestrained human action on supply of water in the watersheds poses a threat of water contamination. Even deforested lands such as urban and agricultural lands pollutes more water as compared to wooded watersheds and yield lower quality of water.Water quality can be protected if human activities are effectively restricted.

Heavily forested Watershed covered from all corners strongly regulate most nutrients; though to maintain nutrients such as nitrogen and prosperous different watershed conditions are regulated.

Protection from fire, sampling of water quality, forest protection, water quality maintenance and other activities of watershed management can be successfully done with properly built road network.

The protection and maintenance of wetland and riparian areas is a most important factor of watershed protection.

Degradation of watersheds has emerged in many parts of the world as one of the serious threat to natural resource with negative impact on environment mainly in developing countries. Watershed degradation does not always refer to water resource but also the soil, due to their inter relation in a watershed. Countries like Lesotho and Morocco in Africa have in the past experienced watershed degradation due to soil erosion and sedimentation of water. The reason behind these were over grazing and excessive agricultural production resulting in decline in the soil productivity.

In many Asian countries deforestation for expansion of roads and burning of forest for cultivation purposes have increased the rate of soil erosion. In addition, increase in pollution level due to dumping of waste in the river water leads to decline in water quality.

Thus, an effective watershed management is where both the land and water resource is maintained sustainably by controlling degradation of the resources for the benefit of both population and environment.

**Dynamics of Watershed Management**

Watershed Management forms the base for water and land resource planning, thus degradation of watershed, in recent times has impacted both the quality and quantity of water as noticed in countries like Lesotho and Morocco. The reason behind watershed degradation varies from man-made to natural factors such as removal of top soil, excess extraction of water, felling of trees, over grazing, pollution and changes in agricultural pattern.

As discussed, watershed management is the combined usage of land, plants and water resources in a distinct catchment area for the benefit of the locals, with the purpose of conserving the natural resources and reducing the negative effect on groundwater and downstream water.

In the 70’s and 80’s the watershed management approach focused on water and soil planning particularly in developing countries with emphasis on engineering works on specific sites and at the downstream, less importance were given to the population of the upstream area; the management cost was also high and not justifiable. As a result by the end of 80’s the engineering work approach was replaced by integrated and participatory approach accepted by international and national communities.

The engineering approach was not completely written off but more emphasis was given on community participation and demand driven solution at the local level. Poverty reduction in rural areas was made part of the development programs. Focus was slowly shifted from planned investment to farming patterns. However, the challenge with the new approach of watershed management was to increase income of the local along with conservation and intensification of the natural resources with community participation.

In many countries of the world, including India, China, Brazil and Turkey, success in integrated participatory based approaches led to formulation of national policies based on participatory watershed management approach. However countries, like Indonesia and Morocco, due to uncertainties about the cost of community based approach and income; led to the interruption in its formulation of national policies. In the participatory approach all stakeholders are not only involved in implementation of the measures but are also associated in research process in every step starting from designing the plans, implementation, technological application and evaluation. This approach needs organizations or institutes to coordinate with the research agencies at all levels. However, many countries of the world are now relying on integrated watershed management approach for conservation and restoration of nature.

To conclude, it can be said that watershed management is an effective and sustainable method of utilizing land and water resources.

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| **you can view video on Principles of Watershed Management** |  |

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