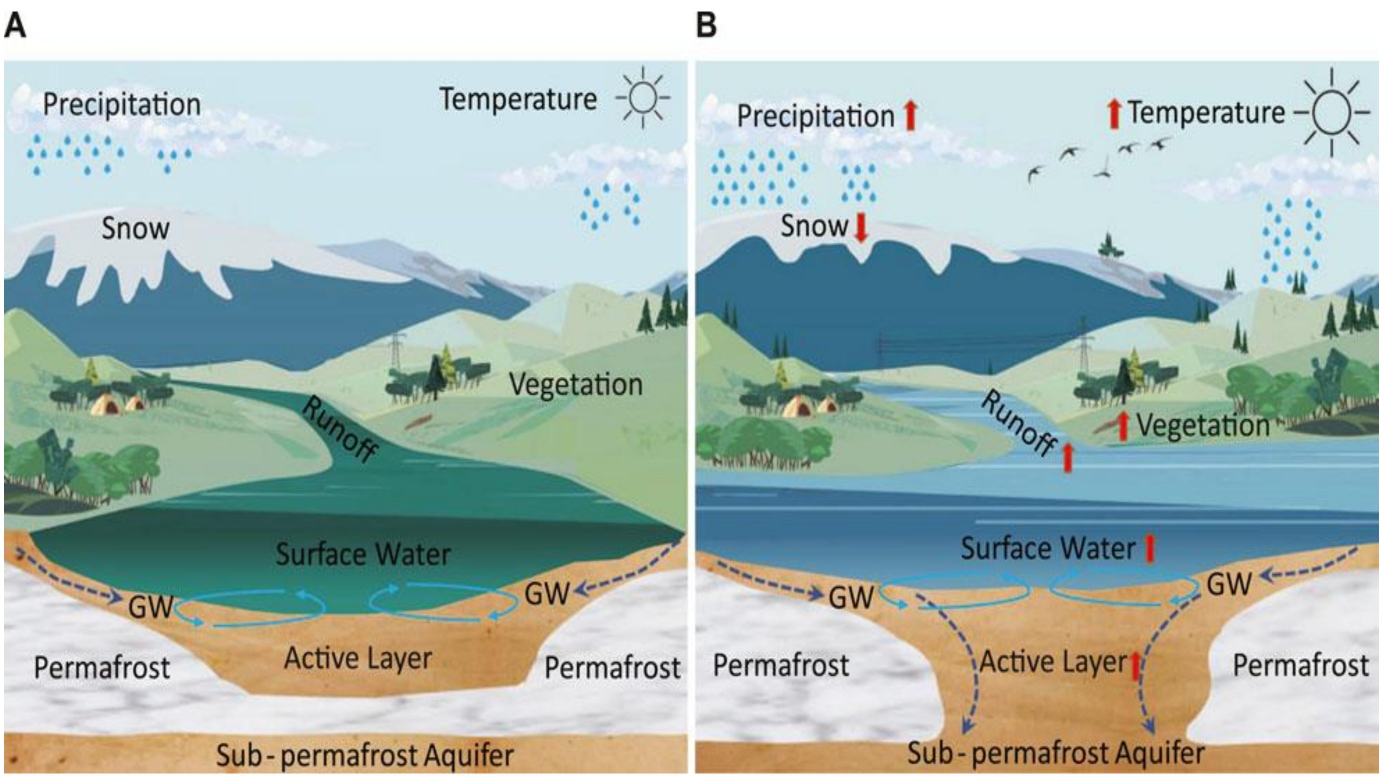
DEPARTMENT OF GEOLOGY

GOVERNMENT COLLEGE (A) ANANTAPUR ANDHRAPRADESH



Watersheds

A watershed is a basic unit of hydrological behavior. On the land surface, it is a geographical unit in which the hydrological cycle and its components can be analyzed. Usually a watershed is defined as the area that appears, on the basis of topography, to contribute all the water that passes through a given point of a stream. A watershed embraces all its natural and artificial (man-made) features, including its surface and subsurface features, climate and weather patterns, geologic and topographic settings, soils and vegetation characteristics, and land use (shown in figure 5.1). A watershed carries water "shed" from the land after rain falls and snow melts. Drop by drop, water is channeled into soils, groundwater, creeks, and streams, making its way to larger rivers and eventually the sea.

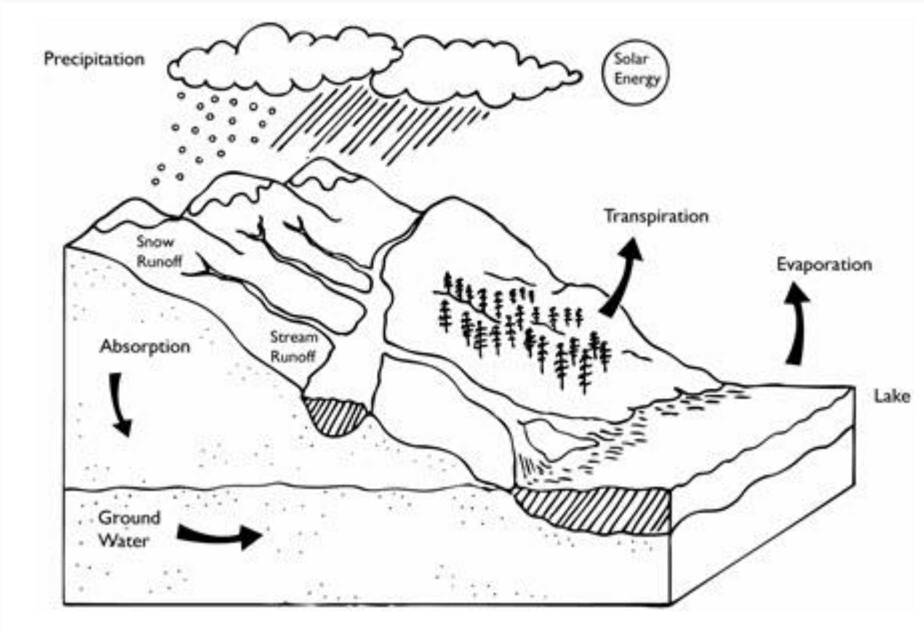
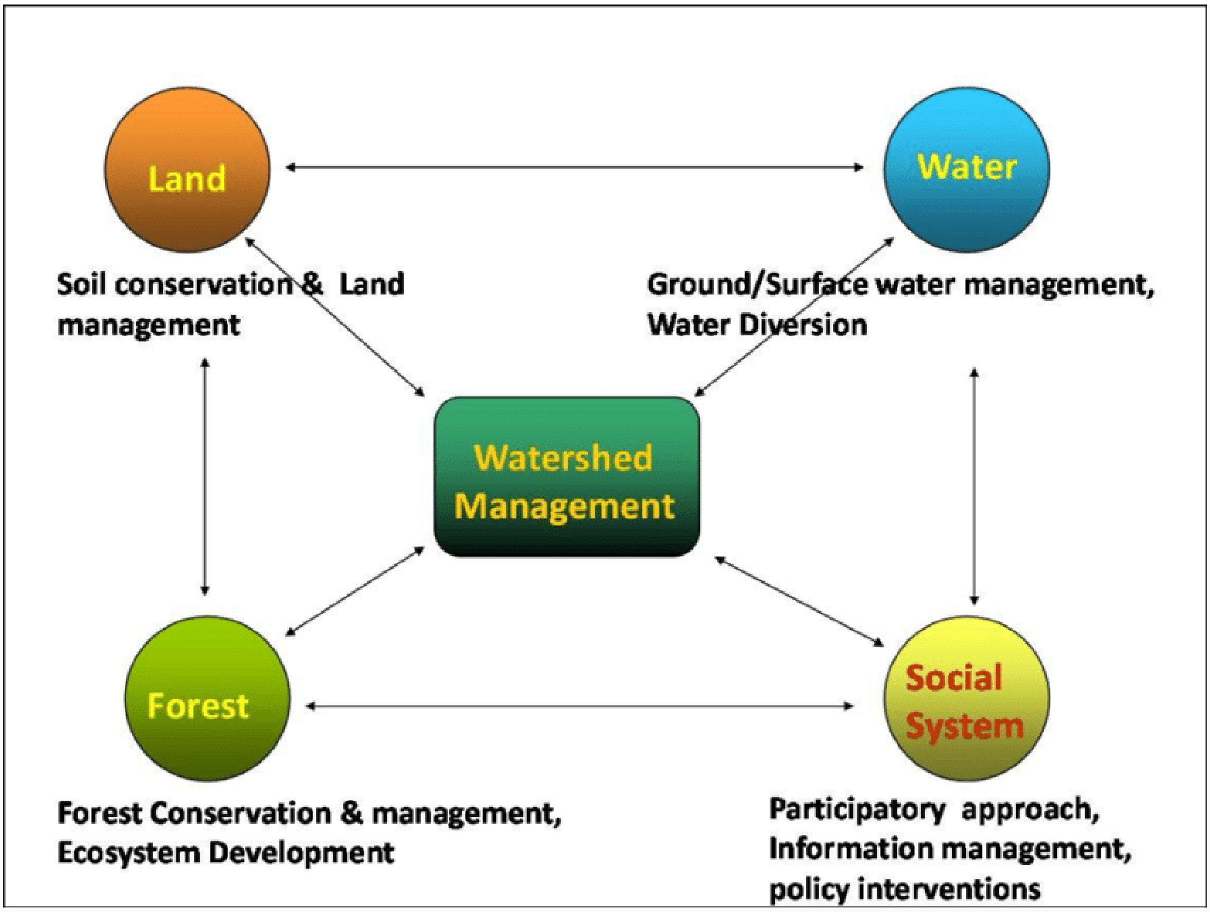


Fig. 5.1. A Watershed Illustration. (Source: Rees, 1986)

Scope of the watershed management



Watersheds represent small basins. By delineating the ridgelines in a medium or a large river basin, the entire basin can be subdivided into a number of watersheds, each with an area within 2,000 km^2. Because of their compact size, it is always easier to manage watersheds rather than a river basin. In a well-managed watershed, all the natural resources such as soil, water, vegetation, etc. are conserved.

Vegetation or plants play a vital role in conserving the natural resources of a watershed such as soil and water. The underground components of the plants such as roots spread within the soil and thereby stabilize and reinforce the soil. This generally leads to soil conservation. The water infiltrates below the ground through the voids in the soil as well as through the interface between the root surface and the soil. The terrestrial components of plants such as stems, branches and leaves prevent the soil below it from getting directly exposed to sunlight as well as to the impact of raindrops. Thus, a significant part of the momentum and energy in rainwater is absorbed and thereby inducing/ accelerating the downward movement of rainwater through stem flow and infiltration. On one hand this process creates water bodies like the groundwater reservoirs and rivers, which are good sources of water and nutrients required for plant growth. On the other hand, this process also substantially reduces the soil erosion and the surface flow velocity of storm water.

Additionally, there will be release of ample amount of oxygen, generation of colorful and fragrant flowers, fresh leaves as well as fruits through the process of photosynthesis. This makes the entire watershed very pleasant for human beings, migratory birds, flying insects as well as all other animals. The fruits and leaves also serve as food for human beings and animals.

A watershed containing large amounts of vegetation is considered as a healthy watershed. It is also called a well-managed or a 'green watershed'. It has no or very limited soil erosion and also it has large reserves of groundwater as well as surface water. In general, it has most of its natural resources conserved.

Thus, the scope of watershed management involves all the actions and programs aimed at achieving an overall balance between utilization and conservation of natural resources in a watershed. It represents a sustainable approach for resource conservation through watershed management

Classification of Watershed

Watersheds can be classified using any measurable characteristics in the area like- size, shape, location, ground water exploitation, and land use. However, the main classification of watershed is discussed broadly on the basis of size and land use. Two watersheds of the same size may behave very differently if they do not have similar land and channel phases. The descriptions of different watershed classifications are as below.

1 Size – The main implication of watershed size appears in terms of spatial heterogeneity of hydrological processes. The spatial variability of watershed characteristics increases with size, therefore, large watersheds are most heterogeneous. As the watershed size increases, storage increases. Based on size, the watersheds are divided into three classes.

1. Small Watersheds	< 250 km^2
2. Medium Watersheds	between 250 to 2500 km^2

3. Large Watersheds	> 2500 km^2

Small Watersheds: Small watersheds are those, where the overland flow and land phase are dominant. Channel phase is relatively less conspicuous. The watershed is highly sensitive to high-intensity and short-duration rainfalls.

Medium Watersheds: Being medium in size, the workability in these watersheds are easy due to accessible approach. Rather than size, shape of the watershed plays a dominant role. Overland flow and land phase are prominent.

Large Watersheds: These watersheds are less sensitive to high-intensity-rainfalls of short duration. The channel networks and channel phase are well-developed, and, thus, channel storage is dominant.

2 Land Use – Land use defines the exploitation (natural and human interactions) characteristics of watersheds which affect the various hydrological processes within the watershed. The watershed classification based on the land use can be given as below.

1. Agricultural
2. Urban
3. Mountainous
4. Forest
5. Desert
6. Coastal or marsh, or
7. Mixed - a combination of two or more of the previous classifications

1 Agricultural Watershed: Agricultural watershed is the watershed in which agricultural activities (crop cultivation) is dominant. It experiences perhaps the most dynamically significant land-use change. This usually leads to increased infiltration, increased erosion, and/or decreased runoff. Depression storage is also increased by agricultural operations. When the fields are barren, falling raindrops tend to compact the soil and infiltration is reduced. There is lesser development of streams in agricultural watersheds. The small channels formed by erosion and runoff in the area are obliterated by tillage operations. The soil structure is altered by regular application of organic and/or inorganic manure. This, in turn, leads to changed infiltration characteristics.

2 Urban Watershed: These are the watershed areas having maximum manipulation for the convenience of human being. These are dominated by buildings, roads, streets, pavements, and parking lots. These features reduce the infiltrating land area and increase imperviousness. As drainage systems are artificially built, the natural pattern of water flow is substantially altered. For a given rainfall event, interception and depression storage can be significant but infiltration is considerably reduced. As a result, there is pronounced increase in runoff and pronounced decrease in soil erosion. Thus, an urban watershed is more vulnerable to flooding if the drainage system is inadequate. Once a watershed is urbanized, its land use is almost fixed and its hydrologic behavior changes due to changes in precipitation.

3 Mountainous Watershed: Because of higher altitudes, such watersheds receive considerable snowfall. Due to steep gradient and relatively less porous soil, infiltration is less and surface runoff is dominantly high for a given rainfall event. The areas downstream of the mountains are vulnerable to flooding. Due to snow melt, water yield is significant even during spring and summer.

4 Forest Watershed: These are the watersheds where natural forest cover dominates other land uses. In these watersheds, interception is significant, and evapotranspiration is a dominant component of the hydrologic cycle. The ground is usually littered with leaves, stems, branches, wood, etc. Consequently, when it rains, the water is held by the trees and the ground cover provided greater opportunity to infiltrate. The subsurface flow becomes dominant and there are times when there is little to no surface runoff. Because forests resist flow of overland water, the peak discharge is reduced. Complete deforestation could increase annual water yield by 20 to 40 %.

5 Desert Watershed: There is little to virtually no vegetation in desert watersheds. The soil is mostly sandy and little annual rainfall occurs. Stream development is minimal. Whenever there is rainfall, most of it is absorbed by the porous soil, some of it evaporates, and the remaining runs off only to be soaked in during its journey. There is limited groundwater recharge due to occurrence of less rainfall in these watersheds.

6 Coastal Watershed: The watersheds in coastal areas may partly be urban and are in dynamic contact with the sea. Their hydrology is considerably influenced by backwater from wave and tidal action of the sea. Usually, these watersheds receive high rainfall, mostly of cyclonic type, do not have channel control in flow, and are vulnerable to severe local flooding. In these watersheds, the water table is high, and saltwater intrusion threatens the health of coastal aquifers, which usually are a source of the fresh water supply.

7 Marsh or Wetland Watershed: Such lands are almost flat and are comprised of swamps, marshes, water courses, etc. They have rich wildlife and plenty of vegetation. As water is no limiting factor to satisfy evaporative demand, evaporation is dominant. Rainfall is normally high and infiltration is minimal. Most of the rainfall becomes runoff. The flood hydrograph peaks gradually and lasts for a long time.

8 Mixed Watershed: These are the watersheds, where multiple land use/land cover exists either because of natural settings or due to a combination of natural and human interaction activities. In these watersheds, a combination of two or more of the previous classifications occurs and none of the single characteristics dominate the area. In India, most of the watersheds are of mixed nature of characteristics, where agriculture, forest, settlements (urban and rural) etc. land use occurs.

Watershed Characteristics: Physical and Geomorphologic Characteristics associated with Watersheds

Watershed geomorphology refers to the study of the characteristics, configuration and evolution of land forms and properties; developing physical characteristics of the watershed. It comprises of the characteristics of land surface as well as the characteristics of the channels within the watershed/basin boundary. These properties of watersheds significantly affect the characteristics of runoff and other hydrological processes. The principal watershed characteristics are:

1. Basin Area
2. Basin Slope
3. Basin Shape
4. Basin Length

Basin shape is reflected by a number of watershed parameters as are given below.

1. Form Factor
2. Shape Factor

3. Circularity Ratio
4. Elongation Ratio
5. Compactness Coefficient

Along with the surface characteristics of a watershed, the channel characteristics are important in transiting the runoff water from the overland region to channels (streams) and also from the channel of one order (primary) to the other higher order (e.g. river stream). The most common and important channel characteristics of the watersheds are:

1. Channel Order
2. Channel Length
3. Channel Slope
4. Channel Profile
5. Drainage Density

The quantification of these physical and geomorphologic properties of watershed/basin are important for estimating the watershed hydrologic processes.

Quantitative Characteristics of Watersheds

1 Physical Characteristics

Watershed geomorphology refers to the physical characteristics of the watershed. Basin area, basin length, basin slope, and basin shape are the physical characteristics of watersheds, significantly affecting the characteristics of runoff and other hydrologic processes. The quantification of these watershed/basin characteristics can be done as discussed below.

1.1 Basin Area: The area of watershed is also known as the drainage area and it is the most important watershed characteristic for hydrologic analysis. It reflects the volume of water that can be generated from a rainfall. Once the watershed has been delineated, its area can be determined by approximate map methods, planimeter or GIS.

Basin area is defined as the area contained within the vertical projection of the drainage divide on a horizontal plane. Watershed area is comprised of two sub-components; Stream areas and Inter-basin areas. The inter-basin areas are the surface elements contributing flow directly to streams of order higher than 1. Stream areas are those areas that would constitute the area draining to a predetermined point in the stream or outlet. For example, the stream area for first-order streams would be delineated by measuring the drainage area for each first-order channel. Horton (1945) inferred that mean drainage areas of progressively higher orders might form a geometric sequence. This characteristic was formulated as a law of drainage areas.

$$\bar{A}_w = \bar{A}_1 R_a^{w-1}$$

or

$$\log \bar{A}_w = \log \bar{A}_1 + (w-1)\log R_a$$

$$\log \bar{A}_w = \log\left(\frac{\bar{A}_1}{R_a}\right) + w \log R_a = a + bw$$

where A_w = mean area of basins of order w, A_1 = mean area of first-order basins, R_a = **Stream Area Ratio** and normally varies from 3 to 6

$R_a = A_w/A_{w-1}$

1.2 Basin Length: Length can be defined in more than one way (Fig. 5.2) -

1. The greatest straight-line distance between any two points on the perimeter
2. The greatest distance between the outlet and any point on the perimeter
3. The length of the main stream from its source (projected to the perimeter) to the outlet

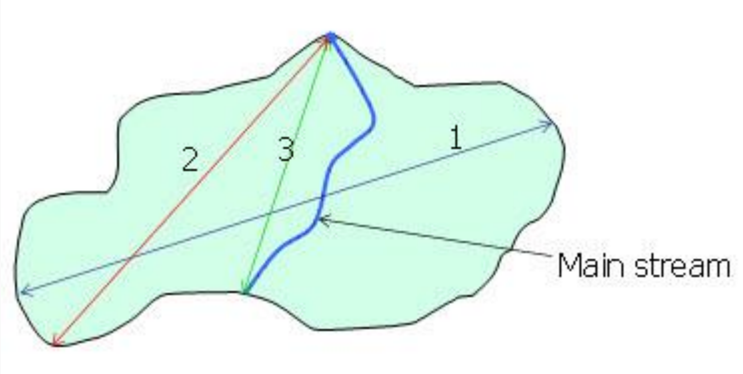


Fig. 5.2. Diagram Defining Basin Length. (Source: Zavoianu, 2011)

Conceptually the basin length is the distance traveled by the surface drainage and sometimes more appropriately labeled as hydrologic length. This length is generally used in computing a time parameter, which is a measure of the travel time of water through a watershed. The watershed length is therefore measured along the principal flow path from the watershed outlet to the basin boundary. Since the channel does not extend up to the basin boundary, it is necessary to extend a line from the end of the channel to the basin boundary. The measurement follows a path where the greatest volume of water would generally travel.

Basin length, L_b, is the longest dimension of a basin parallel to its principal drainage channel and Basin width can be measured in a direction approximately perpendicular to the length measurement. The relation between mainstream length and drainage-basin area for small watershed is given below; where L_b is in km and A in km^2.

$L_b = 1.312\ A^{0.568}$

1.3 Basin Slope: Watershed/basin slope affects the momentum of runoff. It reflects the rate of change of elevation with respect to distance along the principal flow path. It is usually calculated as the elevation difference between the endpoints of the main flow path divided by the length. The elevation difference may not necessarily be the maximum elevation difference within the watershed since the point of highest elevation may occur along a side boundary of the watershed rather than at the end of the principal flow path. If there is significant variation in the slope along the main flow path, it may be preferable to consider several sub-watersheds and estimate the slope of each.

Basin slope has a profound effect on the velocity of overland flow, watershed erosion potential, and local wind systems. Basin slope S is defined as

$S = h/L$

where h = fall in meters, and L = horizontal distance (length) over which the fall occurs.

1.4 Basin Shape: Basin shape is not usually used directly in hydrologic design methods; however, parameters that reflect basin shape are used occasionally and have a conceptual basis. Watersheds have an infinite variety of shapes, and the shape supposedly reflects the way that runoff will “bunch up” at the outlet. A circular watershed would result in runoff from various parts of the watershed reaching the outlet at the same time. An elliptical watershed having the outlet at one end of the major axis and having the same area as the circular watershed would cause the runoff to be spread out over time, thus producing a smaller flood peak than that of the circular watershed. A number of watershed parameters have been developed to reflect basin shape. Form factor, shape factor, circularity ratio, elongation ratio, and compactness coefficient are the typical parameters; important in defining the shape of a watershed/basin; and are discussed as below.

1.5 Form Factor: The area of the basin divided by the square of axial length of the basin; where value < 1

A/L^2

1.6 Shape Factor: The drainage area divided by the square of the main channel length; where value > 1

L^2/A

1.7 Circularity Ratio: The ratio of basin area to the area of a circle having the same perimeter as the basin; where value £ 1

$12.57\ A/P_r^2$

1.8 Elongation Ratio: The ratio of the diameter of a circle of the same area as the basin to maximum basin length; where value £ 1

$1.128A^{0.5}/L$

Compaction Coefficient: The perimeter of the basin divided by circumference of equivalent circular area; where value ³ 1

$0.2821P_r/A^{0.5}$

2 Channel Characteristics

The basin geomorphology plays an important role in the transition of water from the overland region to channels (streams) and also from the channel of one order to the other. It is easily determined by contour map and drainage map of the basin. Channel order, channel length, channel slope, channel profile, and drainage density are the most common channel characteristics, important in estimating the watershed hydrological processes and are discussed as below.

2.1 Channel Order: The first-order streams are defined as those channels that have no tributaries. The junction of two first-order channels form a second-order channel. A third-order channel is formed by the junction of two second-order channels. Thus, a stream of any order has two or more tributaries of the previous lower order. This scheme of stream ordering is referred to as the Horton-Strahler ordering scheme (Fig.5.3)

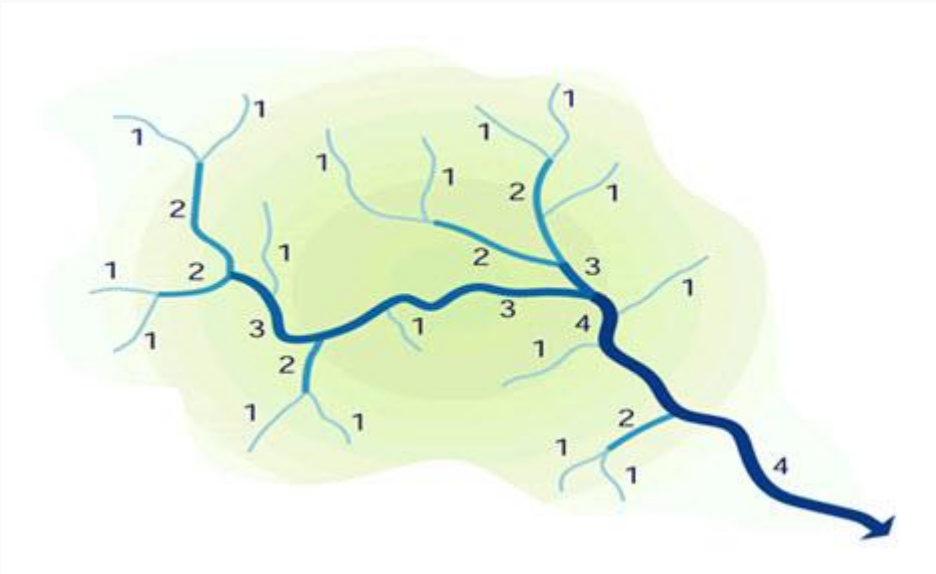


Fig. 5.3. The Horton-Strahler ordering scheme.

(Source: http://www.fgmorph.com/fg_4_8.php)

$N_w = R_b^{W-w}$

Or

$\log N_w = W \log R_b - w \log R_b = a – b$

($a= W \log R_b,$ $b=w \log R_b$)

where N_w = number of streams of order w; W = order of the watershed; and R_b = **Bifurcation Ratio** varies between 3 and 5. This law is an expression of topological phenomenon, and is a measure of drainage efficiency.

Bifurcation ratio is defined as the ratio between the number of streams of a particular order to the number of streams of one higher order.

$R_b = N_w/N_{w+1}$

2.2 Channel Length: This refers to the length of channels of each order. The average length of channels of each higher order increases as a geometric sequence. Thus, the first-order channels are the shortest of all the channels and the length increases geometrically as the order increases. This relation is called Horton's law of channel lengths and can be formulated as:

$$\bar{L}_w = \bar{L}_1 R_L^{w-1}$$

$$\bar{L}_w = \frac{L_w}{N_w}$$

where L_w = total length of all channels of order w; N_w = number of channels of order w; L_w = mean channel length of order w; L_1 = mean length of the first-order streams; R_L = **Stream-Length Ratio** generally varies between 1.5 and 3.5

$R_L = L_w/L_{w-1}$

2.3 Channel Slope: The channel slope is determined as the elevation difference between the endpoints of the main channel divided by the channel length.

2.4 Channel Profile: It includes the point of origin of the stream called the head, the point of termination called the mouth, and a decreasing gradient of the stream channel towards the mouth.

2.5 Drainage Density: Drainage density (D_d) is the measure of closeness of drainage spacing. It is the indication of drainage efficiency of overland flow and the length of overland flow as well as the index of relative proportions. It is defined as the length of drainage per unit area. This term was first introduced by Horton (1932) and is expressed as

$D_d = L/A$

or

$$D_d = \frac{\sum_{w=1}^{w} \sum_{i=1}^{N_w} L_{wi}}{A}$$

where L = Total length of all channels of all orders, A = Area; W = Basin order; N_w = No. of basin of different order.

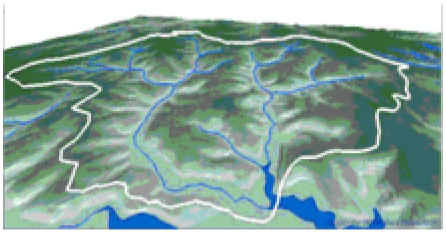
Horton (1945) recommended using one-half the reciprocal of the drainage density to determine the average length of overland flow (L_0) for the entire drainage basin

$L_0 = 1/(2\ D_d)$

Where D_d basically describes the average distance between streams and L_0 approximates the average length of overland flow from the divides of the stream channels.

WATERSHEDS-TOPOGRAPHY

Topography is the key element affecting how land drains to a particular point. The boundary of a watershed is defined by the highest elevations surrounding a lake or river segment. A drop of water falling outside of the boundary will drain to another watershed.



Topography determines watershed boundaries

Topography controls the movement of water and solutes within watersheds and their export to streams via groundwater drainage.
Watersheds are topographically defined areas – something like bowls.

All watershed delineation means drawing lines on a map to identify a watershed's boundaries. These are typically drawn on topographic maps using information from contour lines. Contour lines are lines of equal elevation, so any point along a given contour line is the same elevation.

To delineate a watershed's boundaries on a topographic map the following steps have to be followed.

1) The primary lines on a topographic map are called contour lines, and as stated before, they represent points of equal elevations. Some of these lines are numbered, and those numbers are the elevations of those contour lines.

2) Streams and rivers are shown by blue lines. Solid blue lines show perennial streams, and the dashed blue lines show what are estimated to be intermittent streams.

3) Contour lines point upstream (they form kind of what looks like a V) as they cross over a stream or river.

4) The closer the contour lines are together the steeper the terrain; the further apart they are the flatter the terrain.

Channel Networks and Watersheds

Streams naturally assemble themselves into surprisingly well-organized (quasi-fractal) networks. Figure 2 shows a typical channel network where many small streams converge to make progressively larger streams.

The smallest streams in the network, which have no other streams flowing into them, are referred to as first order streams.

When two first order streams meet, a second order stream is formed.

When two second order streams meet, they form a third order stream, and so on.

According to this conventional stream ordering system, first developed by Horton (1945) and refined by Strahler (1957), when a smaller order stream (e.g., first order) meets a larger order stream (e.g., second order), the resulting stream retains the order of the larger stream (in this case, second order).

Each stream has a watershed, also known as a 'river basin' or 'catchment' because it is the land that 'catches' precipitation and funnels it towards the stream.

The watersheds of two first order streams are outlined with grey dashed lines in Figure 2.

The watershed of a second order stream is outlined in black dashed lines and encompasses the two first order watersheds.

The solid black outline in Figure 2 shows the watershed boundary for the fourth order watershed, which encompasses all other watersheds nested within it.

The right side of Figure 2 shows the Mississippi River watershed highlighted in green, with the Missouri River watershed nested within it, highlighted in orange

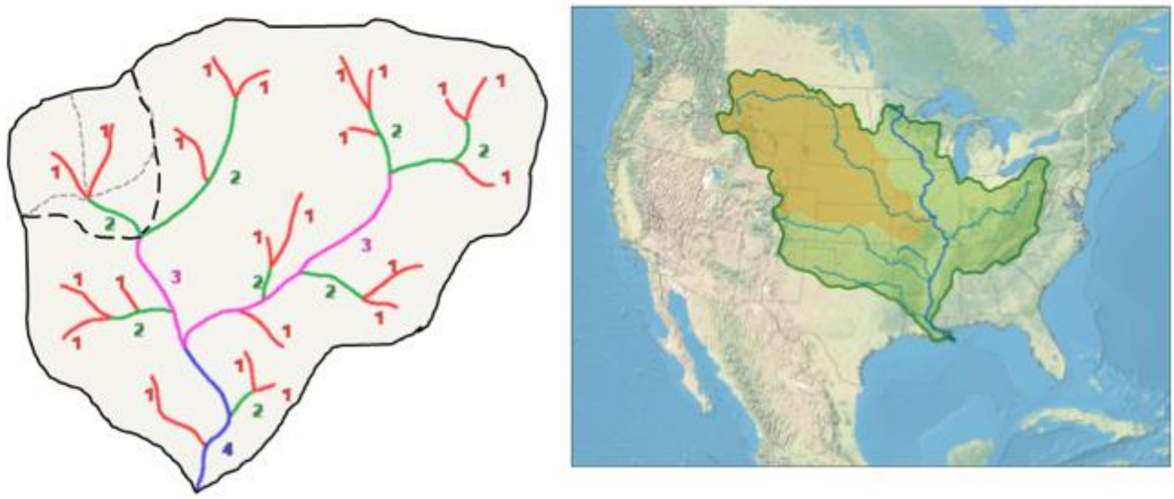


Figure 2. Left panel shows a stream network colored and labeled according to stream order. Dashed grey, dashed black and solid black lines indicate watershed boundaries. Right panel shows entire Mississippi River watershed (green) with the Missouri River watershed (orange) nested within it.

Geomorphology of Watershed:

Watershed geomorphology refers to the study of the characteristics, configuration and evolution of land forms and properties. It comprises of the characteristics of land surface as well as the characteristics of the channels within the watershed/basin boundary. These properties of watersheds significantly affect the characteristics of runoff and other hydrological processes. The geomorphological attributes of watersheds often provide valuable insight into their hydrological behaviour and can be used to develop design hydrologic models. The quantification of these geomorphologic properties of watershed are important for estimating the watershed hydrologic processes.

The morphological Characteristics of watershed may Broadly be classified as

A. Linear aspects (one dimensional)

B. Aerial aspects (two dimensional)

C. Relief aspects (three dimensional)

Linear aspects: Linear aspects of watershed is concerned with the streams and its network. In general, these are one dimensional property. The important characteristics are watershed length& width, stream order, stream number, bifurcation ratio &stream length ratio.

Areal aspects: Areal aspects of watershed include the description of areal elements such as watershed area, Watershed slope. watershed shape, watershed perimeter, drainage density, stream frequency, is reflected by some parameters such as shape factor,form factor, elongation ratio, circulatory ratio and compactness coefficient. In general, these are two dimensional properties.

Relief aspects: Relief aspect is related to elevation difference between reference points in watershed. In general, these are three dimensional properties. Few important characteristics are watershed relief, relative relief, channel slope, law of stream slope & ruggedness number.

Land Use/Land Cover

Overview

Land Use Land Cover (LULC) maps of an area provide information to help users to understand the current landscape. Annual LULC information on national spatial databases will enable the monitoring of temporal dynamics of agricultural ecosystems, forest conversions, surface water bodies, etc. on annual basis .

Annual Land use / Land cover mapping is carried out at 1 : 250000 scale and net sown area is estimated apart from generation of the Landuse / Land cover information. Land use / land cover information is generated once in 5 years at 1: 50000 scale. Land use / Land cover is generated at 1: 10000 scale which is useful for water land resources planning at village / taluk level.

Wasteland mapping and monitoring has been carried out 1t 1: 50000 and 1: 25000 scales. Land use / land cover information generated at 1: 10000 scale can be used for planning Gram sadak Yojna project.

Aquifer

aquifer is an underground layer of porous rocks or permeable rocks that store and retain groundwater levels in the soil. The underground aquifer is built with all types of porous or permeable rock materials, such as sand, gravel, or silt, making it a suitable water absorber. The rainwater enters the aquifer through the soil and becomes a part of the groundwater. The groundwater from the aquifers then resurfaces from springs and wells. We can also extract the aquifer water with the help of a water well. The study of groundwater, aquifer, and their property is known as hydrogeology.

Now that we know what an aquifer is, let's discuss the types of aquifers and their uses in detail.

Properties and Terms Related to an AquiferAn

aquifer forms near the surface and can also range deeper than 9,000 metres or 30,000 feet. The groundwater aquifers closer to the surface are used for irrigation and drinking purposes. However, there are many other properties of aquifers that we should know. Below we have discussed some of the crucial properties of an aquifer.

Aquitard: An aquitard refers to the different layers of an aquifer that prevent one aquifer's water from flowing to another. Examples of an aquitard include the clay layer or solid rock layer.

Hydraulic Head: Hydraulic head is referred to the height to which water rises inside the aquifer. It may be measured as the depth below the natural surface. We can also measure the hydraulic head against the sea level.

Hydraulic Gradient: A hydraulic gradient can be defined as the difference between two hydraulic heads in an aquifer divided by the distance between them.

Transmissivity of Aquifer: Transmissivity of an aquifer refers to its capability to transmit groundwater throughout its total saturated thickness. It can also be defined as the rate at which the groundwater flows through an aquifer section under a unit hydraulic gradient.

Hydraulic Conductivity: Hydraulic conductivity refers to the speed or ease with which water moves through the aquifer. It can be calculated by dividing the transmissivity of the aquifer by its thickness.Above, we discussed the properties and some terms related to an aquifer. Next, let's discuss the types of aquifers.

Types of Aquifers

Aquifers can be classified into various types depending upon their formation, size, and materials. Let's discuss each type of aquifer in detail.

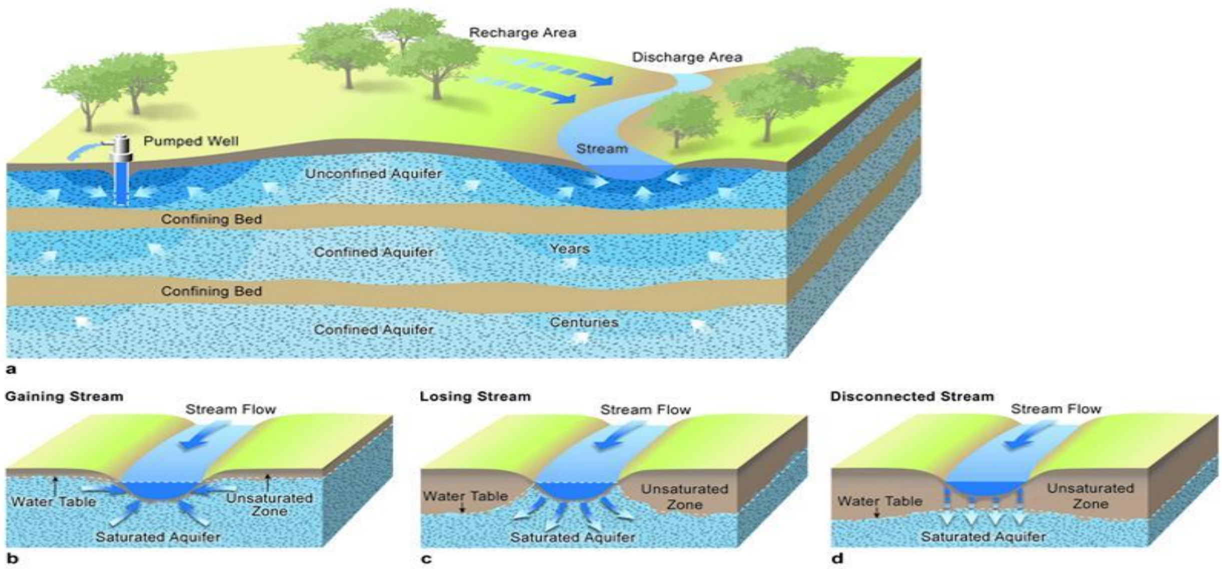
Confined Aquifer: A confined aquifer is a part of a rock bed or sand covered by a clay confining layer and prevents the groundwater from moving from one aquifer to another. The water in confined aquifers can have high pressure due to the overlying confining layer. If a bore is created on a confined aquifer, the water level will rise above the aquifer for the high pressure. There are two types of confined aquifers: artesian aquifer and leaky aquifer.

Unconfined Aquifer: An unconfined aquifer is a section of rock bed or sand not covered by a confining layer. An unconfined aquifer is always shallow in-depth, and its top consists of the water table. It acts like a sponge where the water level fluctuates depending on the outflow and inflow of water.The difference between a confined and unconfined aquifer is that a confined aquifer has a confining layer to prevent water flow. In contrast, an unconfined aquifer does not have a confining layer to prevent water flow.

Saturated Aquifer: Saturated aquifers are those aquifers that are filled with water and have no space to store more water. These aquifers store water with high-pressure heads.

Unsaturated Aquifer: Unsaturated aquifers are those aquifers that contain water but still have some space filled with air and can store more water. These aquifers generally occur above the water table, and their pressure head is negative or less than a saturated aquifer.

Perched Aquifer: Perched aquifer is a type of aquifer that occurs over unsaturated rock formations. These aquifers develop as a result of discontinuous impermeable layers of rock or sand

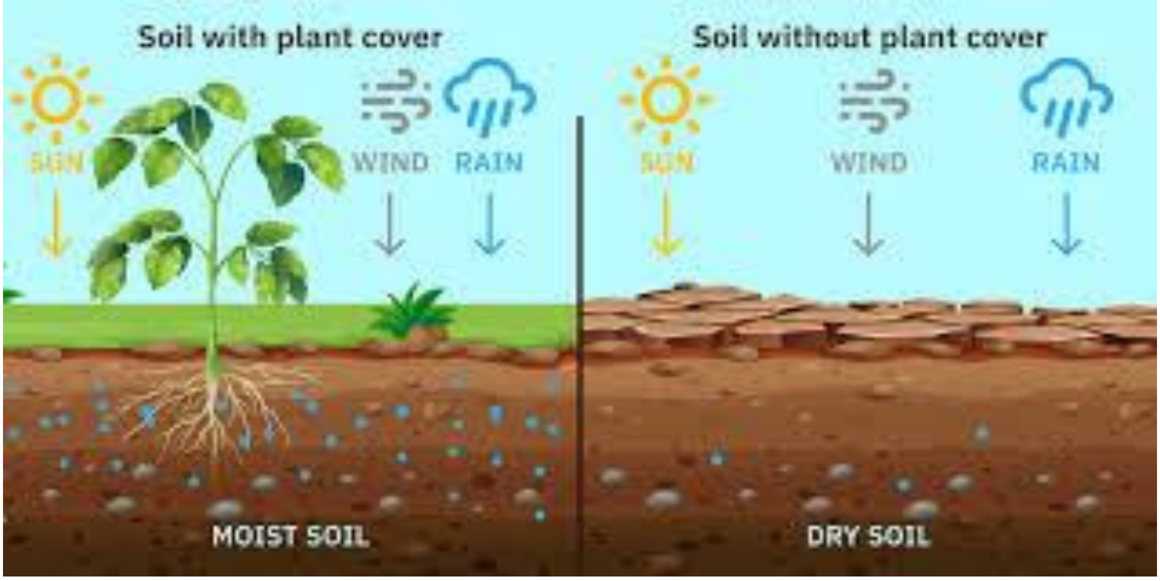


soil and water conservation

Soil and water conservation are those activities at the local level which maintain or enhance the productive capacity of the land including soil, water and vegetation in areas prone to degradation through. prevention or reduction of soil erosion, compaction, salinity; conservation or drainage of water and.

method to conserve soil and water

Chemical-free methods of soil conservation and nutrient management include the plowing of residues, crop rotation, growing green manure, applying a lot of compost and manure, and using microbiological fertilizers.



5 ways to conserve soil

1. Contour ploughing. Contour ploughing orients furrows following the contour lines of the farmed area. ...
2. Terrace farming. Terracing is the practice of creating nearly level areas in a hillside area. ...

3. Keyline design. ...
4. Windbreaks. ...
5. Cover crops/crop rotation. ...
6. Soil-conservation farming. ...
7. Mineralization.

How to conserve water

save water

1. Check your toilet for leaks. ...
2. Stop using your toilet as an ashtray or wastebasket. ...
3. Put a plastic bottle in your toilet tank. ...
4. Take shorter showers. ...
5. Install water-saving shower heads or flow restrictors. ...
6. Take baths. ...
7. Turn off the water while brushing your teeth. ...
8. Turn off the water while shaving.

Soil Erosion

Soil Erosion

In this process, the soil particles are loosened or washed away in the valleys, oceans, rivers, streams or far away lands. This has been worsening due to human activities such as agriculture and deforestation.

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Soil erosion is a continuous process that occurs either slowly or at an alarming rate. It results in a continuous loss of topsoil, ecological degradation, soil collapse, etc.

Let us have a detailed look at the causes, effects and prevention of soil erosion.

Cause of Soil Erosion

Following are the important causes of soil erosion:

Rainfall and Flooding

Higher intensity of rainstorms is the main cause of soil erosion. Four types of soil erosion are caused by rainfall:

- Rill erosion
- Gully erosion
- Sheet erosion
- Splash erosion

The raindrops disperse the soil, which is then washed away into the nearby streams and rivers. Regions with very heavy and frequent rainfall face a large amount of soil loss. The flowing water during floods also erodes a lot of soil by creating potholes, rock-cut basins, etc.

Agriculture

The farming practices are the major cause of soil erosion. The agricultural activities disturb the ground. The trees are cleared and the land is ploughed to sow new seeds. Since most of the crops are grown during the spring season, the land lies fallow during winters. Most of the soil is eroded during winters.

Also, the tyres of tractors make grooves on the land, making a natural pathway for water. Fine soil particles are eroded by wind.

Grazing

The grazing animals feed on the grasses and remove the vegetation from the land. Their hooves churn up the soil. They also pull out plants by their roots. This loosens the soil and makes it more prone to erosion.

Logging and Mining

A large number of trees are cut down to carry out the logging process. Trees hold the soil firmly. The canopy of the trees protects the soil from heavy rainfall. The leaf litter that protects the soil from erosion, is also lost during logging.

Mining activities also disturb the land and leave the soil more prone to erosion.

Construction

The construction of roads and buildings exposes the soil to erosion. The forests and grasslands are cleared for construction purposes, which exposes the soil making it vulnerable to erosion.

Rivers and Streams

The flowing rivers and streams carry away the soil particles leading to a V-shaped erosion activity.

Heavy Winds

During dry weather or in the semi-arid regions, the minute soil particles are carried away by the wind to faraway lands. This degrades the soil and results in desertification.

Effects of Soil Erosion

The major effects of soil erosion include:

Loss of Arable Land

Soil erosion removes the top fertile layer of the soil. This layer is rich in the essential nutrients required by the plants and the soil. The degraded soil does not support crop production and leads to low crop productivity.

Clogging of Waterways

The agricultural soil contains pesticides, insecticides, fertilizers, and several other chemicals. This pollutes the water bodies where the soil flows.

The sediments accumulate in the water and raise the water levels resulting in flooding.

Air Pollution

The dust particles merge in the air, resulting in air pollution. Some of the toxic substances such as pesticides and petroleum can be extremely hazardous when inhaled. The dust plumes from the arid and semi-arid regions cause widespread pollution when the winds move.

Desertification

Soil erosion is a major factor for desertification. It transforms the habitable regions into deserts. Deforestation and destructive use of land worsens the situation. This also leads to loss of biodiversity, degradation of the soil, and alteration in the ecosystem.

Destruction of Infrastructure

The accumulation of soil sediments in dams and along the banks can reduce their efficiency. Thus, it affects infrastructural projects such as dams, embankments, and drainage.

Soil Erosion Prevention

Soil erosion is a serious environmental issue. Steps should be taken to curb this problem. Following are some of the methods of soil erosion prevention:

1. Plant trees on barren lands to limit erosion of soil.
2. Add mulch and rocks to prevent the plants and grass underneath to prevent soil erosion.
3. Mulch matting can be used to reduce erosion on slopes.
4. Put a series of fibre logs to prevent any water or soil from washing away.
5. A wall at the base of the slope can help in preventing the soil from eroding.
6. Every household should have a proper drainage system so that water flows down into proper water collecting systems.

waste land in agriculture

Waste Land : Land is considered "degraded" when its productivity is diminished. This type of land is that land which is presently lying unused or which is not being used to its optimum potential due to some constraints. Land degradation caused by agriculture takes many forms and has many causes.

wasteland in forestry

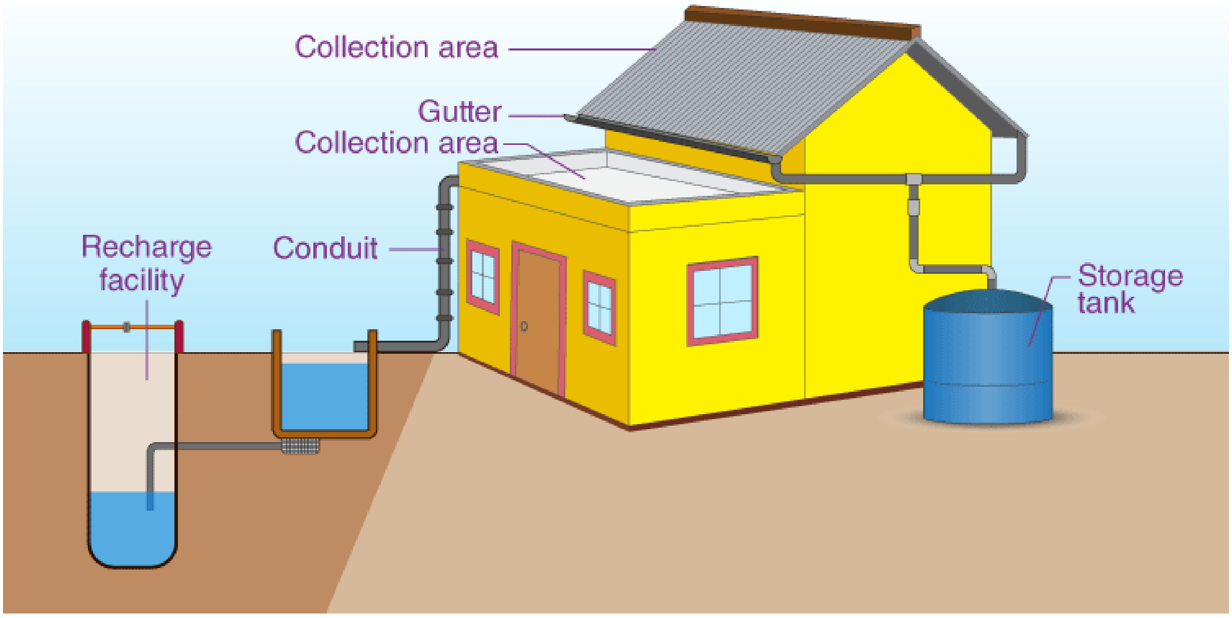
Wasteland - All lands affected by water erosion, wind erosion, floods, water-logging, soil salinisation, and soil alkalisation, thereby rendered unfit for cultivation of most plants. In India, the calculation of the total area under wasteland generally includes degraded forest lands

types of waste land

- Degraded Pasture/ Grazing Land.
- Degraded Land of Plantation Crops.
- Desertic sands or Coastal sands.
- Mining or industrial waste lands.
- Barren land with rock/ stony wastes.
- Steep sloping lands.
- Snow covered lands.

Rainwater harvesting

Rainwater harvesting is the simple process or technology used to conserve rainwater by collecting, storing, conveying and purifying of rainwater that runs off from rooftops, parks, roads, open grounds, etc. for later use. Here, let us have a look at the diagram of rainwater harvesting system.



Rainwater harvesting

All living things including plants, animals and human beings need water to live and to carry out different cellular activities.

Have you ever imagined a day without water?

No, we have not and it is hard to imagine. We all use water for different kinds of day to day activities, such as cleaning, washing, bathing, cooking, drinking and other domestic and industrial uses.

Water is a precious, essential and an abiotic component of the ecosystem. Today we all are heading toward the scarcity of water, and this is mainly because of the lack of water conservation and pollution of water bodies. So, let us not waste a drop of water and start conserving water for further use.

Water

There are different methods used for conserving water; this article explains the rainwater harvesting system with a simple diagram.

How to Harvest the Rainwater?

Rainwater harvesting systems consists of the following components:

- Catchment- Used to collect and store the captured rainwater.

- Conveyance system – It is used to transport the harvested water from the catchment to the recharge zone.
- Flush- It is used to flush out the first spell of rain.
- Filter – Used for filtering the collected rainwater and removing pollutants.
- Tanks and the recharge structures: Used to store the filtered water which is ready to use.

The process of rainwater harvesting involves the collection and the storage of rainwater with the help of artificially designed systems that run off naturally or man-made catchment areas like- the rooftop, compounds, rock surface, hill slopes, artificially repaired impervious or semi-pervious land surface.

Several factors play a vital role in the amount of water harvested. Some of these factors are:

- The quantum of runoff
- Features of the catchments
- Impact on the environment
- Availability of the technology
- The capacity of the storage tanks
- Types of the roof, its slope and its materials
- The frequency, quantity and the quality of the rainfall
- The speed and ease with which the rainwater penetrates through the subsoil to recharge the groundwater.

Why do we Harvest Rainwater?

The rainwater harvesting system is one of the best methods practised and followed to support the conservation of water. Today, scarcity of good quality water has become a significant cause of concern. However, rainwater, which is pure and of good quality, can be used for irrigation, washing, cleaning, bathing, cooking and also for other livestock requirements.

Advantages of Rainwater Harvesting

The benefits of the rainwater harvesting system are listed below.

- Less cost.
- Helps in reducing the water bill.
- Decreases the demand for water.
- Reduces the need for imported water.
- Promotes both water and energy conservation.
- Improves the quality and quantity of groundwater.
- Does not require a filtration system for landscape irrigation.
- This technology is relatively simple, easy to install and operate.

- It reduces soil erosion, stormwater runoff, flooding, and pollution of surface water with fertilizers, pesticides, metals and other sediments.
- It is an excellent source of water for landscape irrigation with no chemicals, dissolved salts and free from all minerals.

Disappearing Act of Water

Disadvantages of Rainwater Harvesting

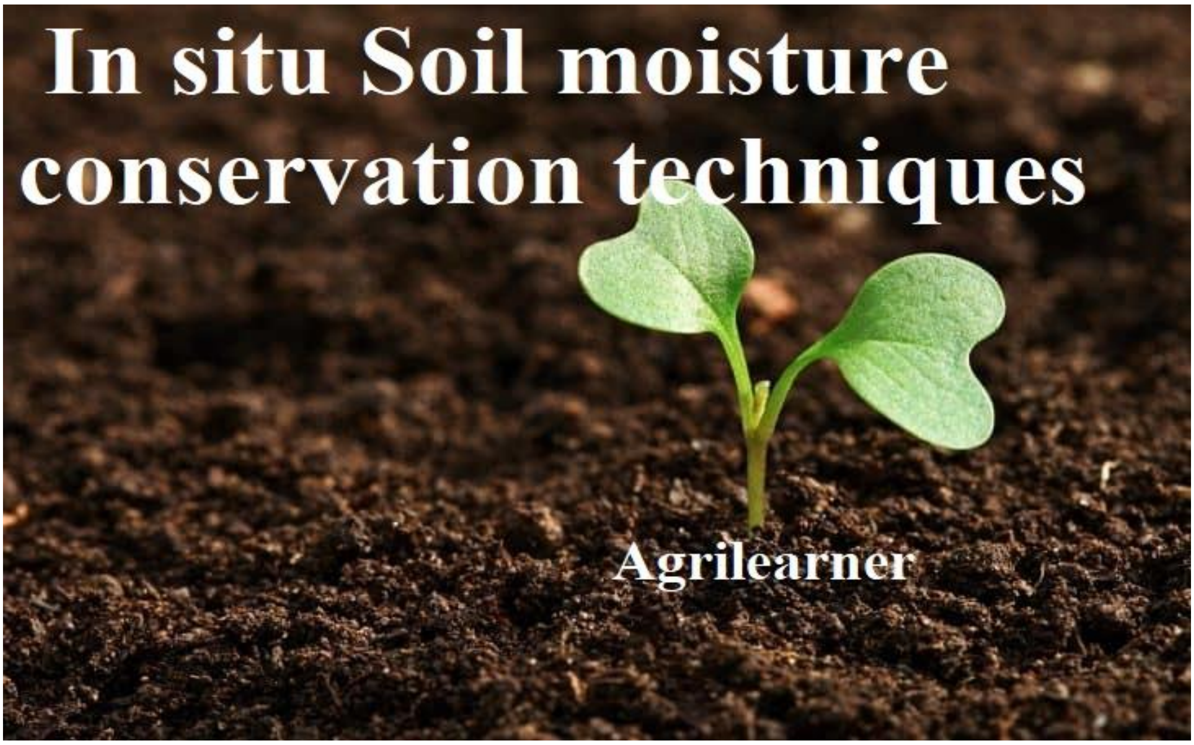
In addition to the great advantages, the rainwater harvesting system has a few disadvantages like unpredictable rainfall, unavailability of the proper storage system, etc.

Listed below are a few more disadvantages of the rainwater harvesting process.

- Regular maintenance is required.
- Requires some technical skills for installation.
- Limited and no rainfall can limit the supply of rainwater.
- If not installed correctly, it may attract mosquitoes and other waterborne diseases.
- One of the significant drawbacks of the rainwater harvesting system is storage limits.

Know more about Rainwater Harvesting and other Biology related diagram concepts at

In situ Soil moisture conservation techniques



Storage of rainfall in soil at the place where it falls is termed as “in situ” soil moisture conservation. It aims at increasing infiltration of rainfall into the soil and reducing runoff loss of rainwater. In situ soil moisture conservation can be accomplished through.

- Cultural/agronomic methods

- Mechanical methods

- Agrostological/biological methods

Extent of soil moisture storage from rainfall is influenced quantity and intensity of rainfall, slope, soil properties such as texture, structure, depth, surface characters, presence of subsoil hard pans, rate of infiltration and permeability, water holding capacity, vegetative cover, etc.

1. Cultural /Agronomical methods

(i) Addition of organic matter: By improving soil physical properties and water holding capacity.

(ii) Off season/summer tillage: Plough furrows can hold water in the depressions and thereby increase the infiltration. When done across the slope, the plough furrows check runoff, reduce the velocity of runoff water and improve storage. Summer tillage is a traditional practice helps in the storage of pre-sowing rainfall. When ploughing is done along contour, it is termed as contour ploughing and is more helpful for in situ moisture conservation. Summer ploughing also helps in control of perennial weeds, pest control and enables early sowing with onset of rains.

(iii) Contour farming: Ploughing along the contour and sowing reduce soil erosion and reduce runoff. For e.g., Jowar sown in the black soils on contour line restricts the run off to 13.7% of the total rainfall and soil loss to 2.4 t/ha/year.

(iv) Cover crops: Erosion will be reduced if the land surface is fully covered with foliage. e.g., black gram, green gram, groundnut and fodder grasses like Cenchrus ciliaris, Cenchrus glaucus, dinanath grass, marvel grass. Both contour cropping and cover cropping can be practiced when the slope is less than 2 per cent.

(v) Mixed cropping

(vi) Inter cropping

(vii) Mulching

(viii) Strip cropping: Strip intercropping involves erosion resistant crops and erosion permitting crops in alternate strips of 2-3 m width across slope and along the contour. Erosion resistant crops include grasses and legumes with rapid canopy development. For example, Cenchrus glaucus + Stylosanthes hamata.

2. Mechanical methods The basic principle are:

(i) shaping the land surface manually or with implements in such a way as to reduce the velocity of runoff,

(ii) to allow more time for rainfall to stand on soil surface, and

(iii) to facilitate more infiltration of rainfall into soil layers.

Choice of any particular method under a given situation is influenced by rainfall characters, soil type, crops, sowing methods and slope of land.

(i) Basin listing: Formation of small depressions (basins) of 10–15 cm depth and 10–15 cm width at regular intervals using an implement called basin lister. The small basins collect rainfall and improve its storage. It is usually done before sowing. It is suitable for all soil types and crops.

(ii) Bunding: Formation of narrow based or broad based bunds across slope at suitable intervals depending on slope of field. The bunds check the free flow of runoff water, impound the rainwater in the inter-bund space, increase its infiltration and improve soil moisture storage. Leveling of inter-bund space is essential to ensure uniform spread of water and avoid water stagnation in patches.

It can be classified into three types:

(a) Contour bunding: Bunds of 1 m basal width, 0.5 m top width and 0.5 m height are formed along the contour. The distance between two contour bunds depends on slope. The interbund surface is leveled and used for cropping. It is suitable for deep red soils with slope less than 1%. It is not suitable for heavy black soils with low infiltration where bunds tend to develop cracks on drying. Contour bunds are permanent structures and require technical assistance and heavy investment.

(b) Graded/field bunding: Bunds of 30-45 cm basal width, and 15-20 cm height are formed across slope at suitable intervals of 20-30 m depending on slope. The inter-bund area is leveled and cropped. It is suitable for medium deep-to-deep red soils with slopes up to 1%. It is not suitable for black soils due to susceptibility to cracking and breaching. Bunds can be maintained for 2-3 seasons with reshaping as and when required.

(c) Compartmental bunding: Small bunds of 15 cm width and 15 cm height are formed in both directions (along and across slope) to divide the field into small basins or compartments of 40 sq. m. size (8 × 5 m). It is suitable for red soils and black soils with a slope of 0.5-1%. The bunds can be formed before sowing or immediately after sowing with local wooden plough. It is highly suitable for broadcast sown crops. CRIDA has recommended this method as the best in situ soil moisture conservation measure for Kovilpatti region of Tamil Nadu. Maize, sunflower, sorghum performs well in this type of bunding.

(iii) Ridges and furrows: Furrows of 30-45 cm width and 15-20 cm height are formed across slope. The furrows guide runoff water safely when rainfall intensity is high and avoid water stagnation. They collect and store water when rainfall intensity is less. It is suitable for medium deep-todeep black soils and deep red soils. It can be practiced in wide row spaced crops like cotton, maize, chillies, tomato etc. It is not suitable for shallow red soils, shallow black soils and sandy/ gravelly soils. It is not suitable for broadcast sown crops and for crops sown at closer row spacing less than 30 cm. Since furrows are formed usually before sowing, sowing by dibbling or planting alone is possible. Tie ridging is a modification of the above system of ridges and furrows where in the ridges are connected or tied by a small bund at 2–3 m interval along the furrows. Random tie ridging is another modification where discontinuous furrows of 20–25 cm width, 45–60 cm length and 15 cm depth are formed between clumps or hills of crops at the time of weeding. Yet another modification of ridges and furrows method is the practice of sowing in lines on flat beds and formation of furrows between crop rows at 25–30 DAS. This enables sowing behind plough or through seed drill.

(iv) Broad Bed Furrow (BBF): Here beds of 1.5 m width, 15 cm height and convenient length are formed, separated by furrows of 30 cm width and 15 cm depth. Crops are sown on the beds at required intervals. It is suitable for heavy black soils and deep red soils. The furrows have a gradient of 0.6%. Broad bed furrow has many advantages over other methods.

• It can accommodate a wide range of crop geometry i.e., close as well as wide row spacing.

• It is suitable for both sole cropping and intercropping systems.

• Furrows serve to safely guide runoff water in the early part of rainy season and store rainwater in the later stages.

• Sowing can be done with seed drills.

• It can be formed by bullock drawn or tractor drawn implements. Bed former cum seed drill enables BBF formation and sowing simultaneously, thus reducing the delay between rainfall receipts and sowing.

(v) Dead furrow– At the time of sowing or immediately after sowing, deep furrows of 20 cm depth are formed at intervals of 6–8 rows of crops. No crop is raised in the furrow. Sowing and furrowing are done across slope. It can be done with wooden plough in both black and red soils.

3. Agrostological methods

The use of grasses to control soil erosion, reduce run off and improve soil moisture storage constitutes the agrostological method. Grasses with their close canopy cover over soil surface and profuse root system, which binds soil particles, provide excellent protection against runoff and erosion. The following are the various agrostological methods of in situ moisture conservation.

(i) Pastures/grass lands: Raising perennial grasses to establish pastures or grass lands is recommended for shallow gravelly, eroded, degraded soils. Grass canopy intercepts rainfall, reduces splash erosion, checks runoff and improves soil moisture storage from rainfall.

(ii) Strip cropping with grasses: Alternate strips of grasses and annual field crops arranged across slope check runoff and erosion and help in increasing moisture storage in soil.

(iii) Ley farming: It is the practice of growing fodder grasses and legumes and annual crops in rotation. Grasses and legumes like Cenchrus, stylo are grown for 3–5 years and followed by annual crops like sorghum for 2 year. When the field is under grasses or legumes, soil moisture conservation is improved.

(iv) Vegetative barriers: Vegetative barrier consists of one or two rows of perennial grasses established at suitable interval across the slope and along the contour. It serves as a block to free runoff and soil transport. Vetiver, Cenchrus etc., are suitable grasses. Vetiver can be planted in rows at intervals of 40 m in 0.5% slope. Plough furrows are opened with disc plough first before commencement of monsoon. 5–8 cm deep holes are formed at 20 cm interval and two slips per hole are planted in the beginning of rainy season. The soil around the roots is compacted. Vetiver barriers check runoff and prevent soil erosion. While they retain the soil, they allow excess runoff to flow through their canopy without soil loss. It is adapted to drought and requires less care for maintenance. It does not exhibit any border effect on crops in adjacent rows. It allows uniform spread of water to lower area in the field resulting in uniform plant stand thus increasing yield of a crop by 10–15%. It facilitates better storage of soil moisture. If fodder grasses like Cenchrus glaucus or marvel grass are used, fodder can also be harvested and given to the animal. Vegetative barriers are best suited for black soil. Unlike contour bunding, which gives way due to development of crack in summer in black soils, vegetative barriers do not allow such phenomenon in black soil. Hence, the vegetative barriers can be effectively maintained in black soil for 4–5 years. After 4–5 years, replanting material can also be had from the old barrier by 'quartering'.

Artificial recharge

Stated simply, artificial recharge is a process by which excess surface-water is directed into the ground – either by spreading on the surface, by using recharge wells, or by altering natural conditions to increase infiltration – to replenish an aquifer.

Artificial recharge is the process of spreading or impounding water on the land to increase the infiltration through the soil and percolation to the aquifer or of injecting water by wells directly into the aquifer. Surface infiltration systems can be used to recharge unconfined aquifers only.

It is an indirect method of artificial recharge involving pumping from aquifer hydraulically connected with surface water such as perennial streams, unlined canal or lakes. o The heavy pumping lowers the ground water level and cone of depression of depression is created.

1 Ditch and Furrow Method: In areas with irregular topography, shallow, flat bottomed and closely spaced ditches or furrows provide maximum water contact area for recharge water from source stream or canal.

The groundwater is recharged artificially via below 2 means.

- Surface Infiltration Systems. The surface infiltration system works by spreading the excess water available on the surface to make it seep into the ground. ...
- In-channel systems. ...
- Off-channel systems. ...
- Well Injection Systems.

Bhungroo

Drought is a serious issue in the western Indian state of Gujarat, particularly for underprivileged female farmers whose livelihood depends on the monsoon. Limited rainfall in the state leads to water logging in peak cropping season. For the rest of the year, farmers experience severe water scarcity. But thanks to a life-changing technology, poor farmers are now converting crises into opportunities.

Bhungroo is a water management system that injects and stores excess rainfall underground and lifts it out for use in dry spells. Adoption of this technology has decreased salt deposits on soil and increased fresh water supply, saving farmers from drought.

Fast facts:

Bhungroo has freed women from debt, given them land ownership and helped them participate in local governance as a result of their expertise and influence in agriculture and water;

It provides food security and sustainable livelihoods to more than 18,000 marginal farmers (with over 96,000 dependent family members) in India. From the first year, a typical family's annual income increases from USD 210 to USD 700. The breakeven point is reached within three years.

It is now a fully women-driven process, from selecting the farmers, erecting the technology and operating and maintaining the system.

The problem

Flash floods in the region result in water logging, which reduces soil fertility, increases salinity and affects agricultural produce and farmers' income. Older irrigation systems divert water from rivers to cities, which leads to a decrease in farming and an increase in urban migration. Women farmers are most adversely affected by the water crisis.

The solution

Bhungroo is a water management system that injects and stores excess rainfall underground and lifts it out for use in dry spells. The massive underground reservoir can hold as much as 40 million litres of rain water. It harvests water for about 10 days per year and can supply water for as long as seven months.

Artificially recharging aquifers by adding rainwater to underground water reservoirs enables the communities to continue farming for more than half of the year. The non-saline rainwater when mixed with the underground saline water brings down the salinity of the groundwater, making it fit for agricultural use.

Helping the planet

By curtailing desertification, the technology helps to build resilience to climate change and to rejuvenate local biodiversity. This in turn benefits the local community as it allows the growing of local, more nutritious food.

Helping people

Naireeta Services, a social enterprise, trains and empowers women to run and monitor Bhungroo. Groups of five ultra-poor women farmers jointly own the Bhungroo technology, which provides them with an income from their crops. By curtailing desertification, the initiative helps women build resilience to climate change.

Each Bhungroo unit improves land fertility for five families and guarantees cropping for two seasons over the next 30 years. The program has helped free women from debt, attain land ownership, and participate in local governance as a result of their expertise and influence in agriculture and water.

Spillover effect

In India, waterlogging affects 12 states, encompassing 7% of the total national land mass. At least 1.9 million marginal and small landholding farming families are deprived of food security and a sustainable livelihood.

The technology is open source so that it is scalable in other places. Bhungaroo does have a non-negotiable principle, however—that the technology should be used by poor people only.

Opinion leaders and policymakers have expressed interest in helping to scale-up and replicate the initiative across India. The Gujarat Ecology Commission has replicated Bhungroo in other parts of the state while the state education board has incorporated the idea into the school curriculum. Change Agent, a Boston-based organization, has helped spread Bhungaroo to parts of Africa.

INTEGRATED APPROACH TO SUSTAINABLE DEVELOPMENT

An integrated approach to sustainable development is a holistic strategy that aims to balance economic, social, and environmental needs in a way that ensures long-term sustainability.

An integrated approach simplifies and describes the interlinkages and potential cohesive actions and thus help policymakers better understand how targets could reinforce the achievement of each other and better manage the often-unpredictable interactions among stakeholders.Sustainable development is based on three fundamental pillars:

1. social,
2. economic
3. environmental.

Integrated Sustainability (IS) is a holistic view that responds to the sustainability challenge by integrating self and contextual awareness and analytical approaches with thought and action. IS includes the fundamental logic of systems thinking.

What is integrated development? It's the deliberate approach to connect the design, delivery and evaluation of programs across disciplines and sectors to produce an amplified, lasting impact on people's lives.

These include the principles of: (1) traditional extensive economy, (2) intensive traditional economy, (3) alternative economies, (4) eco-development, (5) Sustainable Development and (6) entropy sustainable development.

A business that doesn't factor in sustainability risks is less successful in several measures, including profitability, growth, and employee retention. By integrating sustainability into your business strategy, you can find success because, rather than in spite, of sustainability.

Geospatial Techniques for Groundwater

Geospatial technologies is a term used to describe the range of modern tools contributing to the geographic mapping and analysis of the Earth and human societies. These technologies have been evolving in some form since the first maps were drawn in prehistoric times.

In this study, Remote Sensing, GIS, and MCDM techniques have been successfully used and demonstrated to evaluate potential groundwater zone. A three-step methodology was employed to develop thematic layers, deriving the weights using ANP/AHP and overlay analysis to find the potential groundwater zone.

GIS offers many tools to extract the information about the ground water prospect of an area by integrating information regarding geologic structures, geomorphology, soil, lithology, drainage, land use, vegetation etc. Exploring the ground water by geophysical method is termed Ground water geophysics. methods which are useful in solving some of the problems of hydrogeology, are the Electrical, Seismic, Gravity, and Magnetic methods.Groundwater can be explored using different methods. The four major groundwater exploration methods are the areal method, surface method, subsurface method and esoteric methods. Among these methods, esoteric method is not based on science, mostly based on traditional indicators.and output data in two or three dimensions. Geospatial technology is a broad classification that encompasses five fields: thematic mapping, GPS, RS, telemetry, and GIS.

Examples of geospatial data include:

Vectors and attributes: Descriptive information about a location such as points, lines and polygons.

Point clouds: A collection of co-located charted points that can be recontextured as 3D models.

Raster and satellite imagery: High-resolution images of our world, taken from above.

GIS gives hydrologists and land managers the ability to predict the movement of contaminated water, monitor available groundwater, predict groundwater supply, estimate sustainable abstraction potential and conduct future groundwater development planning. Geophysics groundwater exploration surveys focus on identifying zones of permeability that feed the water flow and thus can produce better GPM rates. Survey methods may be combined to provide a more detailed picture.A geographic information system (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships.

Landform Analysis

Scope of Landform Analysis includes all geomorphological aspects of processes, landforms and deposits: tectonic, structural, volcanic, denudational, mass movement (slope), fluvial, glacial, proglacial, periglacial, paraglacial, karstic, aeolian, littoral, coastal, marine and so on, and also geohazards, geodiversity and Landforms are features on the Earth's surface that make up the terrain, such as mountains, valleys, plains or plateaux. They also include coastal features, such as peninsulas or bays, and underwater features, such as ocean basins and mid-ocean ridges.What is the study of landforms? Geomorphology is the field of study dedicated to understanding land formation processes. Acting like a detective, geomorphologists use remote sensing, geographic information system (GIS), and light detection and ranging (LiDAR) techniques to create special maps.Mountains, hills, plateaus, and plains are the four major types of landforms. Minor landforms include buttes, canyons, valleys, and basins. Tectonic plate movement under Earth can create landforms by pushing up mountains and hills.Mountains, Plateaus and Plains are some major landforms of the Earth. Natural processes such as weathering, water, elevation, sinking, and erosion of the soil are constantly shaping the Earth's surface.

Landforms are formed by both endogenic and exogenic forces. Endogenic forces: Sudden forces like earthquakes, volcanoes, and landslides. Exogenic forces: Erosional and depositional landforms formed because of agents like water, wind, sea waves and glaciers.

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- **Endogenic forces:** Sudden forces like earthquakes, volcanoes, and landslides.
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Further Reading:

- Erosional landforms
- Depositional Landforms

Participatory rural appraisal

PRA ranking exercise being carried out by members of a Farmer Field School in Bangladesh, 2004

Participatory rural appraisal (**PRA**) is an approach used by non-governmental organizations (NGOs) and other agencies involved in international development. The approach aims to incorporate the knowledge and opinions of rural people in the planning and management of development projects and programmes.

Origins

The philosophical roots of participatory rural appraisal techniques can be traced to activist adult education methods such as those of Paulo Freire and the study clubs of the Antigonish Movement. In this view, an actively involved and empowered local population is essential to successful rural community development. Robert Chambers, a key exponent of PRA, argued that the approach owes much to "the Freirian theme, that poor and exploited people can and should be enabled to analyze their own reality."

By the early 1980s, there was growing dissatisfaction among development experts with both the reductionism of formal surveys, and the biases of typical field visits. In 1983, Robert Chambers, a Fellow at the Institute of Development Studies (UK), used the term *rapid rural appraisal* (RRA) to describe techniques that could bring about a "reversal of learning", to learn from rural people directly. Two years later, the first international conference to share experiences relating to RRA was held in Thailand. This was followed by a rapid acceptance of usage of methods that involved rural people in examining their own problems, setting their own goals, and monitoring their own achievements. By the mid-1990s, the term RRA had been replaced by a number of other terms including *participatory rural appraisal* (PRA) and *participatory learning and action* (PLA).

Robert Chambers acknowledged that the significant breakthroughs and innovations that informed the methodology came from community development practitioners in Africa, India and elsewhere. Chambers helped PRA gain acceptance among practitioners. Chambers explained the function of participatory research in PRA as follows:

> The central thrusts of the [new] paradigm ... are decentralization and empowerment. Decentralization means that resources and discretion are devolved, turning back the inward and upward flows of resources and people. Empowerment means that people, especially poorer people, are enabled to take more control over their lives, and secure a better livelihood with ownership and control of productive assets as one key element. Decentralization and empowerment enable local people to exploit the diverse complexities of their own conditions, and to adapt to rapid change.

Land and its Uses

Land is a valuable natural resource that plays a significant role in the survival and prosperity of human society. The earth's surface offers numerous advantages such as food security, shelter facilities, and a comprehensive workspace for business activities. Nonetheless, it becomes crucial to utilize land appropriately to ensure sustainability and preserve its distinct ecological systems. In this article, we will discuss different land uses in-depth so that you will understand how much important it is to preserve land.

Land may well be characterized because of the highest layer of the world's covering on that farming and non-rural exercises square measure completed. At the top of the day, the land will likewise be characterized because of the robust side of the world's surface that has as its elements water, air, soil, rock, minerals, traditional vegetation, and creature life, and it's affordable for farming creation.

What are the Uses of Land?

The usage of not entirely set in stone by actual components like earth science, soil, atmosphere, minerals, and accessibility of water. Human factors like world and innovation square measure likewise important determinants of land use design. Let's go over some common and important uses of land:

- Land use demands aware progress to guarantee extended agricultural production. The land is employed for various functions like commercial enterprise, office administration, mining, building homes, roads, and fixing endeavor.
- Land used for commercial enterprise primarily creates nourishment for people to eat. this might be developing organic products or vegetables or raising animals that manufacture meat, eggs, and poultry.
- The land wherever you reside is used for personal functions. this suggests the land is used to allow lodging for people to measure in.
- The land is used for numerous functions like commercial enterprise, ranger service, mining, building homes, streets, and fixing enterprises.

- Land use requests cautious preparation to ensure enlarged husbandry creation.
- The land will equally be organized into non-public land and neighborhood seeable of possession, they are: Private land – warranted by people and Is possessed by a personal or relative and is used for individual reasons.

Let us further divide land uses into two broad categories to better understand the uses of land.

Ralegan Siddhi

Ralegan Siddhi is a village in Parner taluka of Ahmednagar District, Maharashtra state in western India. It is located at a distance of 87 km from Pune. The village has an area of 982.31 ha (1991). It is considered a model of environmental conservation. The village has carried out programs like tree planting, terracing to reduce soil erosion and digging canals to retain rainwater. For energy, the village uses solar power, biogas (some generated from the community toilet) and a windmill. The project is heralded as a sustainable model of a village republic.

The village's biggest accomplishment is in its use of renewable sources for energy. For example, all the village street lights each have separate solar panels.The village is headed by a Sarpanch who is the chief of the Gram panchayat (village panchayat).

Demographics

In 2001, the village had 394 households with a total population of 2306 (1265 males and 1041 females

Watershed development

In 1975 the village was afflicted by drought, poverty prevailed, and trade in illicit liquor was widespread. The village tank could not hold water as the embankment dam wall leaked. Work began with the percolation tank construction. Anna Hazare encouraged the villagers to donate their labour to repair the embankment. Once this was fixed, the seven wells below filled with water in the summer for the first time in memory.

Now the village has water year round, as well as a grain bank, a milk bank, and a school. There is no longer any poverty.

Model village

The World Bank Group has concluded that the village of Ralegan Siddhi was transformed from a highly degraded village ecosystem in a semi-arid region of extreme poverty to one of the richest in the country. The Ralegan Siddhi example, now 25 years old, by demonstrating that it is possible to rebuild natural capital in partnership with the local economy, is a model for the rest of the country.

Anna Hazare

Indian social activist Anna Hazare, leader of the village, is accredited in helping in the development of the village. He was awarded the Padma Bhushan—the third-highest civilian award—by the Government of India in 1992 for his efforts in establishing this village as a model for others.