DEPARTMENT OF AI&DS, AI&ML, CIVIL, CSE & IT
QUESTION BANK

MODULE

SUBJECT CODE: 23CH6603 **YEAR/SEMESTER: III/VI**

SUBJECT NAME: WATER AND SOIL CONSERVATION

UNIT-I WATER CONSERVATION

SYLLABUS:

Introduction – Soil and water resources –Watershed management – rainwater harvesting - Irrigation principles – Surface irrigation – Sprinkler irrigation – Micro irrigation - Benefits of Water Conservation.

1.1 Soil and water resources

1.1.1 soil resources

1. Soil as a Natural Resource

Soil is an important natural resource that forms the uppermost layer of the Earth's surface. It is made up of minerals, organic matter, air, water, and living organisms. Soil is essential for plant growth as it provides nutrients, water, and support to plants. It also plays an important role in agriculture, forestry, and maintaining ecological balance. Without soil, food production would not be impossible, making it vital for human survival.

- Soil is a mixture of eroded rock, minerals, partly decomposed organic matter, and other materials.
- It is essential for plant growth, so it is the foundation of terrestrial ecosystems.
- Soil is important for other reasons as well. For example, it removes toxins from water and breaks down wastes.
- Although renewable, soil takes a very long time to form—up to hundreds of millions of years.

2. Formation of Soil

Soil is formed by the gradual weathering of rocks over a long period of time. This process occurs due to physical, chemical, and biological factors. Temperature changes, flowing water, and wind break rocks into smaller particles. Plants, animals, and microorganisms further mix organic matter into the soil, making it fertile. Since soil formation is a slow process, soil is considered a limited natural resource.Soil is formed through a slow process called weathering, which includes:

- Physical weathering – breaking of rocks due to temperature changes, wind, and water
- Chemical weathering – decomposition of rocks by chemical reactions
- Biological weathering – action of plants, animals, and microorganisms

3. Types of Soil

Soil can be classified into sandy, clayey, and loamy soils based on texture and composition. Sandy soil has large particles and allows water to drain quickly but has low fertility. Clayey soil has very fine particles and can hold water for a long time, making it fertile. Loamy soil is a balanced mixture of sand, silt, and clay, and is ideal for agriculture because it retains moisture and nutrients while allowing proper drainage.

Importance of Soil

- Supports plant growth and agriculture
- Stores water and nutrients
- Provides habitat for organisms
- Basis for construction and human settlements

4. Soil Erosion

Soil erosion is the removal of the fertile top layer of soil by wind, water, or human activities. Deforestation, overgrazing, and improper farming practices increase soil erosion. This leads to loss of soil fertility, reduced agricultural productivity, and increased flooding. Soil erosion is a serious environmental problem and must be controlled to protect land resources.

5. Soil Conservation

Soil conservation refers to methods used to protect soil from erosion and degradation. Techniques such as afforestation, contour ploughing, terrace farming, and crop rotation help in conserving soil. These methods reduce water runoff, improve soil fertility, and maintain sustainable agricultural practices. Soil conservation is essential for long-term food security and environmental protection.

1.1.2 water resources

1. Water as a Natural Resource

Water is one of the most important natural resources required for life on Earth. It is used for drinking, agriculture, industry, and power generation. Water supports all living organisms and plays a key role in maintaining ecosystems. Although water is renewable, its availability is limited, making proper management and conservation necessary.

2. Sources of Water

Water resources can be divided into surface water, groundwater, and rainwater. Rivers, lakes, and ponds are sources of surface water, while wells and tube wells provide groundwater. Rainwater is the primary source that replenishes both surface and groundwater resources. These sources are essential for meeting the water needs of humans, animals, and plants.

3. Water Scarcity

Water scarcity occurs when the demand for water exceeds its availability. Overuse of water, population growth, pollution, and climate change are major causes of water scarcity. Scarcity of water affects agriculture, industry, and daily life. Conserving water and using it wisely are important to prevent future water shortages.

4. Water Conservation

Water conservation means using water efficiently and avoiding wastage. Methods such as rainwater harvesting, drip irrigation, recycling water, and repairing leaking taps help in saving water. Conserving water ensures its availability for future generations and helps in maintaining ecological balance.

1.2 Water Harvesting:

The term 'water harvesting' is usually taken to mean the immediate collection of rainwater running off surfaces upon which it has fallen directly. This definition excludes run-off from land watersheds into streams, rivers, lakes, etc. Hence it is the catching of rain water when it falls and storing to use during the non rainy season.

Small reservoirs or farm ponds or percolation ponds are constructed for the purpose of storing water essentially from runoff. They are used for storing water during rainy season and using the same for irrigation subsequently. The design and construction of these water harvesting structures require a thorough knowledge of the site conditions and requirements.

Farm ponds are small tanks constructed to collect the surface runoff. The water stored can be used for irrigation water supply for the cattle, fish production etc. Some ponds get water from surface runoff and some from groundwater seeping into the pit. Ponds may either be of impounding type for which the existing depressing is chosen for the pond construction or of dugout type which are excavated at the site and the soil obtained by excavation is formed as an embankment around the pond.

1.2.1 Importance of Water Harvesting:

Rainwater harvesting, is a technology used for collecting and storing rainwater for human use from rooftops, land surfaces or rock catchments using simple techniques such as jars and pots as well as engineered techniques. Rainwater harvesting has been practiced for more than 4,000 years, owing to the temporal and spatial variability of rainfall. It is an important water source in many areas with significant rainfall but lacking any kind of conventional, centralised supply system. It is also a good option in areas where good quality fresh surface water or ground water is lacking. Water harvesting enables efficient collection and storage of rainwater, makes it accessible and substitute for poor quality water. There are a number of ways by which water harvesting can benefit a community.

- Improvement in the quality of ground water,
- Rise in the water levels in wells and bore wells that are drying up,
- Mitigation of the effects of drought and attainment of drought proofing,
- An ideal solution in areas having inadequate water resources,
- Reduction in the soil erosion as the surface runoff is reduced,
- Decrease in the choking of storm water drains and flooding of roads and
- Saving of energy to lift ground water.

1.2.2 Principles of Water Harvesting:

The basic principle of water harvesting is to capture precipitation falling in one area and transfer it to another, thereby increasing the amount of water available in the latter. The main water harvesting principles are,

- Studying of Rainfall and suitable Locations.
- Construct small structures which can be constructed by locally available materials.
- Start constructing from high point and gradually come down.
- Stream should be made of water rather than runoff and erode lot of soils.
- Create a storage so that the harvested water be allowed for percolation to take place.
- Always plan for an overflow route and manage that overflow as a resource.
- Using this harvested water multiple purposes can be served.
- Continually reassess the system such that any shortage can be met with in the next face in 2nd principle.

1.2.3 Rain Water Harvesting and its Techniques:

Rain Water Harvesting:

Rainwater harvesting is a sustainable process that helps in preserving rain water for different purposes and for the future needs as well. Rainwater Harvesting is a method of collecting and storing rain water to be used for various purposes while it can be used in future as well.

Main Objectives are:

1. To store rainwater and to ensure water supply even during dry months or droughts.
2. To recharge the underground water table.

Techniques of Rain water Harvesting:

The techniques of rain water harvesting can be divided according to the purpose and the source of collecting water.

Methods:

1. Roof top harvesting
2. Run off harvesting

These methods can be selected considering the purpose, the type and quantity of storage, Catchment state.

1. **Roof top harvesting:** This method include the catchment area as the roof top in rural and urban area. This include Roof top of houses, flats, factories, offices, complexes.
2. **Runoff harvesting:** Here the runoff water is collected- Gardens, driveways, landscapes, open fields, parks, roads and pavements and other open areas of the environment can be used to harvest the rain water runoff. Using this method, it is possible to collect water from a larger area. This is particularly advantageous in areas of low rainfall.

1. Roof Top Harvesting:

It is a technique of capturing and storing of rain water for future utilization.

Need or objectives:

- To meet the increasing demands.
- Raise the water table by recharging the ground water.
- Reduce ground water contamination.
- Reduce the surface run off loss & soil erosion.
- Increase in hydro static pressure.
- Minimize water crisis & water conflicts.

1.3 Rainwater Harvesting: Rainwater harvesting is defined as the method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions. Three types of water harvesting are covered by rainwater harvesting.

- Water collected from roof tops, courtyards and similar compacted or treated surfaces is used for domestic purpose or garden crops.
- Micro-catchment water harvesting is a method of collecting surface runoff from a small catchment area and storing it in the root zone of an adjacent infiltration basin. The basin is planted with a tree, a bush or with annual crops.
- Macro-catchment water harvesting, also called harvesting from external catchments is the case where runoff from hill-slope catchments is conveyed to the cropping area located at foothill on flat terrain.

Advantages of rain water harvesting:

- Reduces the use of current
- Prevent drought
- Increase the water level in well
- Rise in ground water level
- Minimize soil erosion & flood hazards

- Upgrading the social & environmental status
- Future generation is assured of water.

Figure 1.1: Roof Top Harvesting

Flood Water Harvesting: Flood water harvesting can be defined as the collection and storage of creek flow for irrigation use. Flood water harvesting, also known as 'large catchment water harvesting' or 'Spate Irrigation', may be classified into following two forms:

- In case of 'flood water harvesting within stream bed', the water flow is dammed and as a result, inundates the valley bottom of the flood plain. The water is forced to infiltrate and the wetted area can be used for agriculture or pasture improvement.
- In case of 'flood water diversion', the wadi water is forced to leave its natural course and conveyed to nearby cropping fields.

Groundwater Harvesting: Groundwater harvesting is a rather new term and employed to cover traditional as well as unconventional ways of ground water extraction. Qanat systems, underground dams and special types of wells are a few examples of the groundwater harvesting techniques. Groundwater dams like 'Subsurface Dams' and 'Sand Storage Dams' are other fine examples of groundwater harvesting. They obstruct the flow of ephemeral streams in a river bed; the water is stored in the sediment below ground surface and can be used for aquifer recharge.

2. Runoff Harvesting

Runoff harvesting for short and long term is done by constructing structures as given below.

Short Term Runoff Harvesting Techniques

Contour Bunds: This method involves the construction of bunds on the contour of the catchment area. These bunds hold the flowing surface runoff in the area located between two adjacent bunds. The height of contour bund generally ranges from 0.30 to 1.0 m and length from 10 to a few 100 meters. The side slope of the bund should be as per the requirement. The height of the bund determines the storage capacity of its upstream area.

Figure: 1.2 Contour Bunds

Semicircular Hoop: This type of structure consists of an earthen impartment constructed in the shape of a semicircle. The tips of the semicircular hoop are furnished on the contour. The water contributed from the area is collected within the hoop to a maximum depth equal to the height of the embankment. Excess water is discharged from the point around the tips to the next lower hoop. The rows of semicircular hoops are arranged in a staggered form so that the over flowing water from the upper row can be easily interrupted by the lower row. The height of hoop is kept from 0.1 to 0.5 m and radius varies from 5 to 30 m. Such type of structure is mostly used for irrigation of grasses, fodder, shrubs, trees etc.

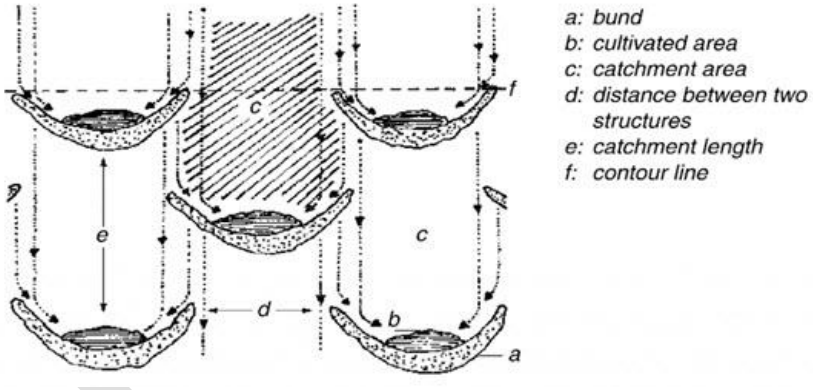

Figure: 1.3 Semicircular Hoop

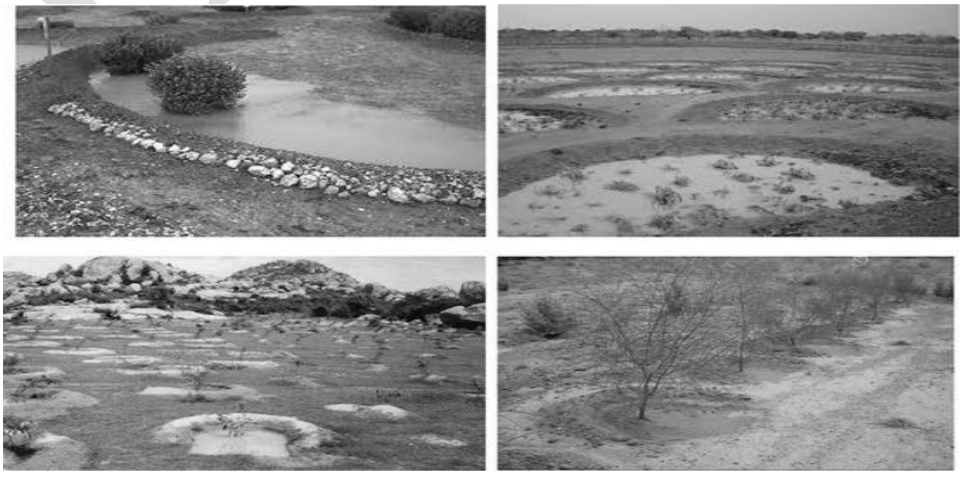

Figure: 1.4 Semicircular Hoop

Trapezoidal Bunds: Such bunds also consist of an earthen embankment, constructed in the shape of trapezoids. The tips of the bund wings are placed on the contour. The runoff water yielded from the watershed is collected into the covered area. The excess water overflows around the tips. In this system of water harvesting the rows of bunds are also arranged in staggered form to intercept the overflow of water from the adjacent upstream areas. The layout of the trapezoidal bunds is the same as the semicircular hoops, but they unusually cover a larger area. Trapezoidal bund technique is suitable for the areas where the rainfall intensity is too high and causes large surface flow to damage the contour bunds. This technique of water harvesting is widely used for irrigating crops, grasses, shrubs, trees etc.

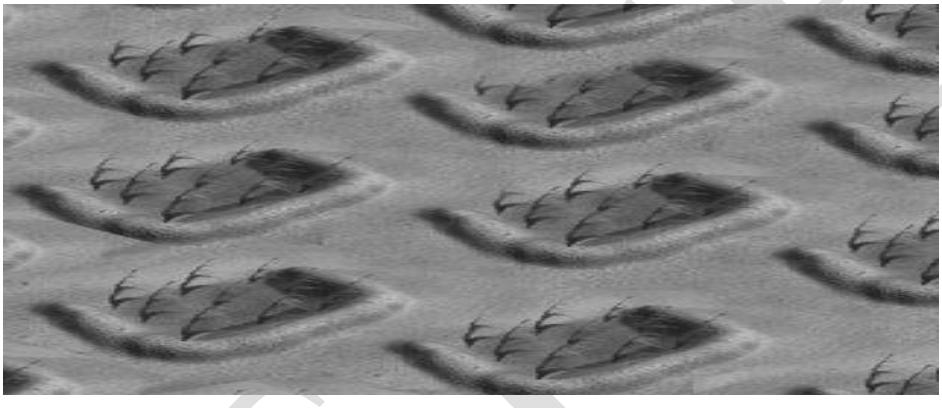

Figure: 1.5 Trapezoidal Bunds

Graded Bunds: Graded bunds also referred as off contour bunds. They consist of earthen or stone embankments and are constructed on a land with a slope range of 0.5 to 2%. The design and construction of graded bunds are different from the contour bunds. They are used as an option where rainfall intensity and soils are such that the runoff water discharged from the field can be easily intercepted. The excess intercepted or harvested water is diverted to the next field though a channel ranges. The height of the graded bund ranges from 0.3 to 0.6 m. The downstream bunds consist of wings to intercept the overflowing water from the upstream bunds. Due to this, the configuration of the graded bund looks like an open ended trapezoidal bund. That is why sometimes it is also known as modified trapezoidal bund. This type of bunds for water harvesting is generally used for irrigating the crops.

Figure: 1.6 Graded Bunds

Rock Catchment: The rock catchments are the exposed rock surfaces, used for collecting the runoff water in a part as depressed area. The water harvesting under this method can be explained as: when rainfall occurs on the exposed rock surface, runoff takes place very rapidly because there is very little loss. The runoff so formed is drained towards the lowest point called storage tank and the harvested water is stored there. The area of rock catchment may vary from a 100 m^2 to few 1000 m^2; accordingly the dimensions of the storage tank should also be designed. The water collected in the tank can be used for domestic use or irrigation purposes.

Ground Catchment: In this method, a large area of ground is used as catchment for runoff yield. The runoff is diverted into a storage tank where it is stored. The ground is cleared from vegetation and compacted very well. The channels are as well compacted to reduce the seepage or percolation loss and sometimes they are also covered with gravel. Ground catchments are also called roaded catchments. This process is also called runoff inducement. Ground catchments have also been traditionally used since last 4000 years in the Negev (a desert in southern Israel) where annul crops and some drought tolerant species like pistachio dependent on such harvested water are grown.

Long Term Runoff Harvesting Techniques

The long term runoff harvesting is done for building a large water storage for the purpose of irrigation, fish farming, electricity generation etc. It is done by constructing reservoirs and big ponds in the area. The design criteria of these constructions are given below.

- Watershed should contribute a sufficient amount of runoff.
- There should be suitable collection site, where water can be safely stored.
- Appropriate techniques should be used for minimizing various types of water losses such as seepage and evaporation during storage and its subsequent use in the watershed.
- There should also be some suitable methods for efficient utilization of the harvested water for maximizing crop yield per unit volume of available water.

The most common long term runoff harvesting structures are:

- Dugout Ponds

- Embankment Type Reservoirs

Dugout Ponds: The dugout ponds are constructed by excavating the soil from the ground surface. These ponds may be fed by ground water or surface runoff or by both. Construction of these ponds is limited to those areas which have land slope less than 4% and where water table lies within 1.5-2 meters depth from the ground surface. Dugout ponds involve more construction cost, therefore these are generally recommended when embankment type ponds are not economically feasible. The dugout ponds can also be recommended where maximum utilization of the harvested runoff water is possible for increasing the production of some important crops. This type of ponds require brick lining with cement plastering to ensure maximum storage by reducing the seepage loss.

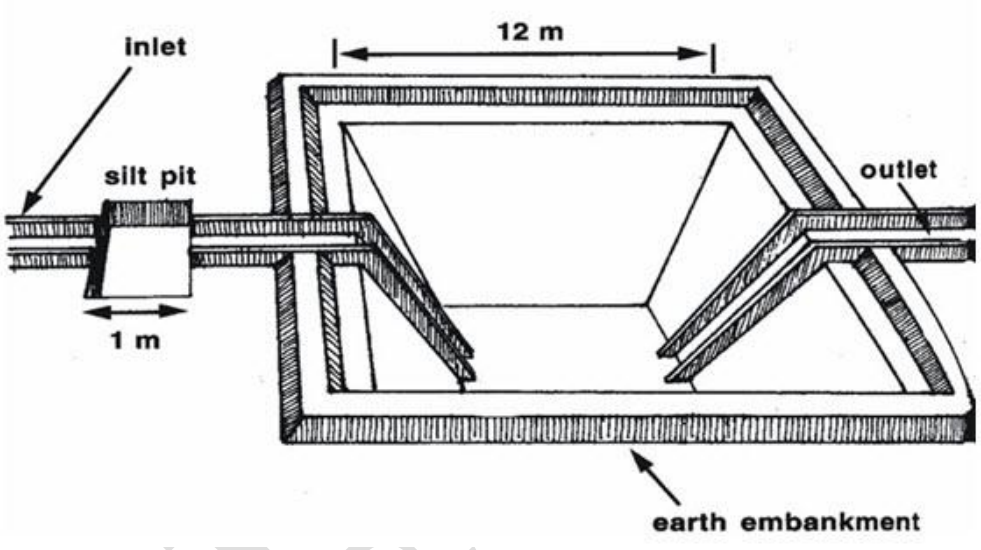

Figure: 1.7 Illustration of Dugout Pond

Embankment Type Reservoir: These types of reservoirs are constructed by forming a dam or embankment on the valley or depression of the catchment area. The runoff water is collected into this reservoir and is used as per requirement. The storage capacity of the reservoir is determined on the basis of water requirement for various demands and available surface runoff from the catchment. In a situation when heavy uses of water are expected, then the storage capacity of the reservoir must be kept sufficient so that it can fulfill the demand for more than one year.

Embankment type reservoirs are again classified as given below according to the purpose for which they are meant.

Irrigation Dam: The irrigation dams are mainly meant to store the surface water for irrigating the crops. The capacity is decided based on the amount of input water available and output water desired. These dams have the provisions of gated pipe spillway for taking out the water from the reservoir. Spillway is located at the bottom of the dam leaving some minimum dead storage below it.

Silt Detention Dam: The basic purpose of silt detention dam is to detain the silt load coming along with the runoff water from the catchment area and simultaneously to harvest water. The silt laden

water is stored in the depressed part of the catchment where the silt deposition takes place and comparatively silt free water is diverted for use. Such dams are located at the lower reaches of the catchment where water enters the valley and finally released into the streams. In this type of dam, provision of outlet is made for taking out the water for irrigation purposes. For better result a series of such dams can be constructed along the slope of the catchment.

High Level Pond: Such dams are located at the head of the valley to form the shape of a water tank or pond. The stored water in the pond is used to irrigate the area lying downstream. Usually, for better result a series of ponds can be constructed in such a way that the command area of the tank located upstream forms the catchment area for the downstream tank. Thus all but the uppermost tanks are facilitated with the collection of runoff and excess irrigation water from the adjacent higher catchment area.

Farm Pond: Farm ponds are constructed for multi-purpose objectives, such as for irrigation, live-stock, water supply to the cattle feed, fish production etc. The pond should have adequate capacity to meet all the requirements. The location of farm pond should be such that all requirements are easily and conveniently met.

Water Harvesting Pond: The farm ponds can be considered as water harvesting ponds. They may be dugout or embankment type. Their capacity depends upon the size of catchment area. Runoff yield from the catchment is diverted into these ponds, where it is properly stored. Measures against seepage and evaporation losses from these ponds should also be.

Percolation Dam: These dams are generally constructed at the valley head, without the provision of checking the percolation loss. Thus, a large portion of the runoff is stored in the soil. The growing crops on downstream side of the dam, receive the percolated water for their growth.

Advantages of Runoff Harvesting

- Water harvesting techniques which harvest runoff from roofs or ground surfaces fall under the term rainwater harvesting while all systems which collect discharges from watercourses are grouped under the term flood water harvesting.
- Runoff harvesting increases water availability for on-site vegetation and play an important role in replenishing floodplains, rivers, wetlands and groundwater.
- Runoff harvesting reduces water flow velocity, as well as erosion rate and controls siltation problem.
- Runoff harvesting carrying not only rich silt but also fish which can swim through the canals into the lakes and tanks to feed on the larva of mosquitoes.

1.4 Irrigation- Definition

Irrigation is an artificial application of water to the soil. It is usually used to assist the growing of crops in dry areas and during periods of inadequate rainfall.

Need of the Irrigation

• India is basically an agricultural country, and all its resources depend on the agricultural.

• Water is evidently the most vital element in the plant life.

• Water is normally supplied to the plants by nature through rains.

• However, the total rainfall in a particular area may be either in sufficient, or ill-timed.

• Systematic irrigation system – Collecting water during the period of excess rainfall & releasing it to the crop when it is needed.

Less rainfall:

• Artificial supply is necessary

• Irrigation work may be constructed at a place where more water is available & than convey the water where there is less rainfall.

Non uniform rainfall:

• Rainfall may not be uniform over the crop period in the particular area.

• Rains may be available during the starting period of crop but no water may be available at end, with the result yield may be less or crop may be die.

• Collection of water during the excess rainfall & supplied to the crop during the period when there may be no rainfall.

Commercial crops with additional water:

• Rainfall may be sufficient to raise the usual crop but more water may be necessary for Raising commercial & cash crop. (Sugar cane, Tea, Tobacco, cotton, cardamom, & indigo)

Controlled water supply:

• Yield of the crop may be increased by the construction of proper distribution system

1.4.1 Benefits of Irrigation:

- ❖ Increase in food production
- ❖ Protection from famine
- ❖ Cultivation of cash crop (Sugarcane, Tobacco & cotton)
- ❖ Addition to the wealth of the country
- ❖ Increase the prosperity of people
- ❖ Generation of hydro-electric power
- ❖ Domestic & industrial water supply
- ❖ In land navigation

- ❖ Improvement of communication
- ❖ Canal plantations
- ❖ Improvement in the ground water storage
- ❖ General development of the country.

What is Irrigation and Why is it Important?

- ❖ Irrigation is supplying water artificially to the soil for the purpose of agricultural production. It is done to either replace or supplement rainwater with an additional source of water. It is used in dry areas and during periods of inadequate rainfall.
- ❖ Effective irrigation systems are needed to help in the growth of agricultural crops by maintaining the optimum amount of water required, suppress weed growth in grain fields, prevent soil consolidation, to suppress dust, disposal of sewage, mining, etc.

1.4.3 Developmental Aspects of Irrigation:

Irrigation is practiced to maintain the different developmental parameters.

Those are:

1. To make up for the soil moisture deficit.
2. To ensure a proper & sustained growth of crops.
3. To make harvest safe.
4. To colonize the cultivable waste land for horizontal expansion of cultivation.
5. To shift from seasonal cultivation.
6. To promote more intensive cultivation by multiple cropping.
7. To improve the level of agricultural productivity by acting as an agent for adoption of Modern technology.
8. To lessen the regional & size-class in equalities in agricultural productivity that will Reduce inturn socio-economic imbalances.

Advantages of irrigation

Advantages of irrigation can be direct as well as indirect.

I. Direct Benefits

- ❖ The grower has many choices of crops and varieties and can go for multiple cropping for cultivation.
- ❖ Crop plants respond to fertilizer and other inputs and there by productivity is high.
- ❖ Quality of the crop is improved.
- ❖ Higher economic return and employment opportunities. It makes economy drought proof.
- ❖ Development of pisciculture and afforestation. Plantation is raised along the banks of canals and field boundaries.

- ❖ Domestic water supply, hydel power generation at dam site and means of transport where navigation is possible.
- ❖ Prevention of damage through flood.

II. Indirect Benefits

- ❖ Increase in gross domestic product of the country, revenue, employment, land value, higher wages to farm labour, agro-based industries and ground water storage.
- ❖ General development of other sectors and development of the country
- ❖ Increase of food production.
- ❖ Modify soil or climate environment – leaching.
- ❖ Lessen risk of catastrophic damage caused by drought.
- ❖ Increase income & national cash flow.
- ❖ Increase labor employment.
- ❖ Increase standard of living.
- ❖ Increase value of land.
- ❖ National security thus self sufficiency.
- ❖ Improve communication and navigation facilities.
- ❖ Domestic and industrial water supply.
- ❖ Improve ground water storage.
- ❖ Generation of hydro-electric power.

Disadvantages of Irrigation

The following are the disadvantages of irrigation.

- Water logging.
- Salinity and alkalinity of land.
- Ill aeration of soil.
- Pollution of underground water.
- Results in colder and damper climate causing outbreak of diseases like malaria.
- Deposition occurs when the agents (wind or water) of erosion lay down sediment.
- Deposition changes the shape of the land.
- Sediment is solid material that is or has been transported from its site of origin by air, water, gravity, or ice to a field or low landscape position. Deposition occurs when the amount of sediment becomes greater than the carrying capacity of the force that is moving it.
- Deposition is the geological process in which sediments, soil and rocks are added to a landform or landmass. Examples include beaches, deltas, glacial moraines, sand dunes and

salt domes. In order to obtain thin films with good quality, there are two common deposition techniques: physical and chemical depositions.

Ill effects of irrigation system:

- Irrigation not only contributes to increased crop production but may also reduce variability in production through improved control of the crop environment.
- Breeding Area for Mosquitoes. We know that the most suitable place to grow mosquitoes is the water in which there is no current.
- Excess application of water for irrigation leads to water logging and formation of stagnant water fools, which become breeding places for mosquitoes, thus helping spreading of malaria.
- Damp Climate.
- Groundwater Polluted.
- Fertility of land reduced and also reduction of crop yield.
- Any imbalance in the water distribution process results in a scarcity of water in some areas

1.5 Different Types of Irrigation

Now that we are aware of the concept of irrigation, let us study the types of irrigation techniques used in our country. In India, the irrigated area consists of about 36% of the net sown area. The main sources of irrigation are wells, tube-wells, rivers, ponds, lakes, dams, and canals.

The main different types of irrigation are:

1. Surface Irrigation
2. Sprinkler Irrigation
3. Micro irrigation

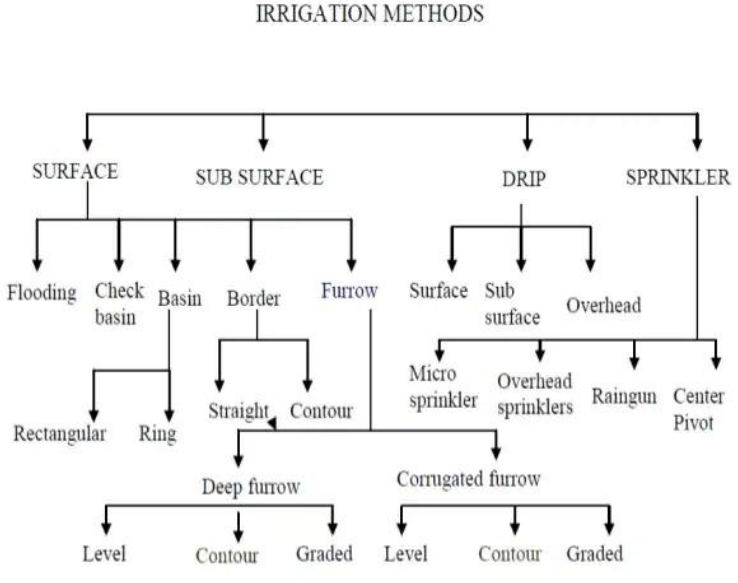

Figure: 1.8 Types of Irrigation

1.5.1 Surface Irrigation

Surface irrigation is the oldest form of irrigation techniques. In this technique, water is applied and distributed over the surface of soil by gravity, i.e., from an area of higher elevation to that of lower region in order to dampen and thereby infiltrate the soil. It is the most common form of irrigation throughout the world.

This technique can be adopted after considering the following factors are which include the hydraulics of surface irrigation:

- Surface slope of the field
- Roughness of the field surface
- Depth of water to be applied
- Length of run and time required
- Size and shape of water course
- Discharge of water course
- Filed resistance erosion

1.5.2 Advantages of Surface Irrigation

- Low initial cost
- Easy maintenance of the system
- Compatibility with all soil types
- Since it is widely used, most farmers have at least minimal understanding of how to operate and maintain the system.

1.5.3 Disadvantages of Surface Irrigation:

- Not applicable on soil with a high filtration rate.
- Plants are always covered with water even when they do not need it.
- Sometimes limited space gets more water than required.
- Water logging
- No drainage outlet

1.5.4 Factors affecting the usage of water in surface irrigation:

- They factors are percolation, soil depth and texture, evaporation and evapo-transpiration, design of irrigation structures and their operation and maintenance and management skills.

1.5.5 Classification of Surface Irrigation

Surface irrigation is classified as under:

1. Wild flood irrigation
2. Basin irrigation
3. Border irrigation
4. Furrow irrigation

Individually, each surface system has varied uses along with certain disadvantages depending upon factors such as initial cost, size and shape of fields, soil characteristics, nature and availability of the water supply, climate, cropping patterns, and influences external to the irrigation system.

1. Wild flood irrigation

In wild flood irrigation, the water is administered to the field by ditch or pipe and flows over the soil surface through the crops. Though the process seems quite simple, wild flood irrigation tends to have a negative impact on the crop and soil, as both water and labor are often used inefficiently. This is because, with flooding, only half of the applied water is actually used by the crop, the other half is lost to evaporation, runoff, infiltration of uncultivated areas, and transpiration through leaves of weeds. Therefore, wild flood irrigation is mainly used on uneven terrains to irrigate pasture, hay, and small grains, which are not affected by sufficient water. In Spite of the shortcomings, it is to be noted that this technique is a great solution to irrigate lands that cannot be managed by other irrigation methods.

2. Basin irrigation

Basin irrigation is the oldest, most common and the simplest form of surface irrigation. This technique of irrigation requires a leveled soil surface and a narrow ridge about 15 - 50 cm high on all sides of the field which serves as a basin. The irrigated land is generally divided into smaller areas surrounded by small levees (an embankment built to prevent the overflow of a river). Water is transported into each basin by pipes and siphons, or through the levee. Excess water is drained from the land with surface drains on the low contour levee. Basin irrigation is suitable for crops such as maize, grains, cotton, or orchards where irrigation is used on moderate to slow intake soils and deep-rooted, closely spaced crops.

3. Border irrigation

Another type of surface irrigation under surface is border irrigation. Border irrigation works on the principle of basin irrigation. Here, water is transported to the land through wide borders. The area between borders is called a border strip, on which the crops grow, which may range from 3-30 m (10-100 feet) in width. For efficient border irrigation, the border surface should be leveled across its width so the water can spread uniformly across it. Crops that are reactive to excessive water and soil that is too wet are not suitable to irrigate using this method.

4. Furrow irrigation

Under furrow irrigation, water is transported from open ditches or pipes through small channels, or furrows, along with the land. The water flowing through the channel, penetrates the soil, thus irrigating crops. According to furrow direction and level, they can be classified into:

- Level furrow (lengthwise leveled furrows)
- Contour furrow (furrows curved to fit field topography)
- Graded furrow (straight channels down the field slope)

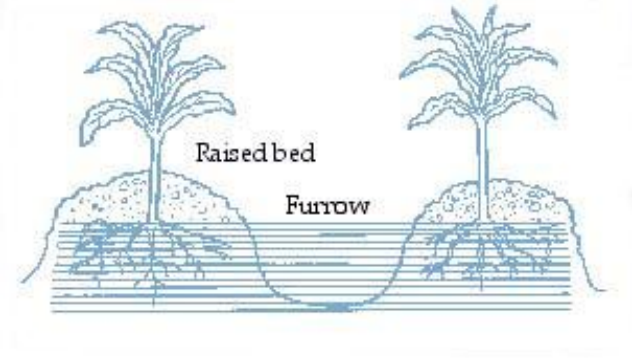

Figure:1.9 Raised Bed Furrow

Furrow irrigation is suitable for crops that are reactive to very wet soil and excessive water over the stem.

Figure:1.10 Furrow Irrigation

Though furrow irrigation does not require special farm equipment and can minimize irrigation costs, furrow irrigation does have certain disadvantages. Such as:

- Labor intensive technique
- High probability of accumulation of salts in the furrows
- Furrow surface needs to be leveled
- It requires experience on the part of the farmer to divide water into each furrow and to maintain the correct flow.

1.6 Sprinkler Irrigation

In the sprinkler irrigation system, water is supplied by overhead high-pressure sprinklers or guns from one or more central locations within the field or from sprinklers on a moving platform. In other words, this system allows the application of water under high pressure with the help of a pump. It releases water similar to rainfall through small sprinklers placed in the pipes. Sprinkler irrigation is suited for most row, field and tree crops and water can be sprayed over or under the crop canopy.

The sprinkler (overhead or pressure) irrigation system conveys water to the field through pipes (aluminium or PVC) under pressure with a system of nozzles. This system is designed to distribute the required depth of water uniformly, which is not possible in surface irrigation. Water is applied at a rate less than the infiltration rate of the soil hence the runoff from irrigation is avoided.

A sprinkler system usually consists of the following parts.

1. A pumping unit
2. Debris removal equipment
3. Pressure gauge / water-meter
4. Pipelines (mains – sub-mains and laterals)
5. Couplers
6. Raiser pipes
7. Sprinklers
8. Other accessories such as valves, bends, plugs, etc.

Figure: 1.11 Sprinkler Irrigation System

1.6.1 Advantages of Sprinkler Irrigation

- Eliminates water conveyance channels, thereby reducing conveyance loss.
- Suitable in all types of soil except heavy clay.
- Saves water up to 30% - 50 %.
- Suitable for irrigation where the plant population per unit area is very high.

- Helps to increase yield.
- Suitable for undulating land.
- Saves land as no bunds required.
- Soluble fertilizers and chemical use are possible.
- Provides frost protection & helps in alteration of micro climate.
- Reduces labour cost.

1.6.2 Disadvantages of Sprinkler Irrigation

- High initial cost
- Requires constant energy
- Poor application efficiency under high wind and temperature
- Leaf burning due to high salinity of water in temperature higher than 95°F
- Uneconomical in cases where land is already levelled and developed
- Loss of water due to evaporation

1.6.3 Types of Sprinkler Irrigation:

1.Center Pivot irrigation

Center pivot irrigation, is a technique of irrigation where the crops are watered with sprinklers through an equipment that rotates around a pivot. This method is also called water wheel or circle irrigation.

2. Lateral move irrigation

In lateral move irrigation, the water is distributed through a series of pipes and sets of sprinklers. It is to be noted that Centre Pivot systems are anchored at one end and rotate around a fixed central point whereas Lateral systems are not anchored and both ends of the machine move at a constant speed up and down a hutch.

3. Sub-irrigation

Sub-irrigation is an irrigation practice used in areas with relatively high water tables or where the water table can be artificially raised to allow the soil to be moistened from below the root zone through a system of pumping stations, canals, weirs, gates and ditches.

1.4.4 Working of Sprinkler Irrigation:

Water flow passes around through a system of pipes mainly by pumping. It is then separated through sprinklers so that it splits up into tiny water drops that fall to the ground. Spray heads at the terminals distribute the water over the entire soil surface.

Steps to be taken for reducing the salt deposits on leaves and fruits during sprinkler irrigation

- Irrigate at night
- Increase the speed of the sprinkler rotation
- Decrease the frequency of irrigation
- Salts are removed by leaching and crop removal.

1.7 Micro irrigation:

Micro irrigation methods are precision irrigation methods of irrigation with very high irrigation water efficiency. In many parts of the country there is decline of irrigation water and conventional methods are having low water use efficiency. To surmount the problem, micro irrigation methods has recently been introduced in Indian agriculture. These methods save a substantial amount of water and helps increase crop productivity particularly valuable cash crops like vegetables.

Micro irrigation is the slow application of continuous drips, tiny streams or miniature sprays of water above or below the soil surface. In this Session, you will learn about the main features of micro irrigation system and its classification. Micro irrigation system is effective in saving water and increasing water use efficiency as compared to the conventional surface irrigation method. Besides, it helps reduce water consumption, growth of unwanted plants (weeds), soil erosion and cost of cultivation. Micro irrigation can be adopted in all kinds of land, especially where it is not possible to effectively use flooding method for irrigation. In flooding method of irrigation, a field is flooded with water. This results in significant run-off, anaerobic conditions in the soil and around the root zone, and deep irrigation below the root zone, which does not supply sufficient water to the plants. It is, therefore, one of the most inefficient surface irrigation methods. Micro irrigation can be useful in undulating terrain, rolling topography, hilly areas, barren land and areas having shallow soils. According to depth, soil types can be classified as shallow (depth less than 22.5 cm), medium deep (22.5–45 cm) and deep soil (more than 45 cm).

Features of micro irrigation system:

- Water is applied via pressurised piping system. Microirrigation requires pumps for developing the required pressure for delivering water through pipelines, regardless of whether the source of water is surface or underground.
- Water is applied drop-by-drop for a long period in case of drip irrigation system.
- Water is applied at a low rate to maintain the optimum air–water balance within the root zone.
- Water is applied at frequent intervals as per the requirement of plants.
- Water is supplied directly to the plants and not to the other areas of the field, thus, reducing wastage.
- Soil moisture content is always maintained at ‘field capacity’ of the soil. Hence, crops grow at a faster rate, consistently and uniformly.

Field capacity is the moisture or water content present in the soil after excess water has drained away and the rate of downward movement has decreased, which takes place within 2–3 days after a spell of rain or irrigation. It means that after drainage stops, the large soil pores are filled with both air and water, while the smaller ones are still filled with water. At this stage, the soil is said to be at field capacity and is considered to be ideal for crop growth.

Classification of micro irrigation system:

Micro irrigation system can be broadly classified into two categories:

(1) Drip irrigation system

(2) Sprinkler irrigation system

However, there are distinct differences in the water flow rate, operating pressure requirement and measurement of the wetted area between drip and sprinkler irrigation systems. Water flow rate means the amount of water discharged in an area at a particular time. It is expressed in litre/minute (lpm) or gallons/ minute (gpm). The system operating pressure must compensate for pressure losses through system components and field elevation effects.

Drip irrigation system: Drip irrigation system, also known as 'trickle irrigation system', is a method of applying the required amount of water directly to the root zones of plants through drippers or emitters at frequent intervals. In this system, water is applied drop-by-drop or by a micro jet on the soil surface or sub-surface at a rate lower than the infiltration rate of the soil. The emitters dissipate pressure from the distribution system by means of orifices, vortexes and tortuous or long flow paths, thus, allowing a limited volume of water to be discharged. Most emitters are placed on ground but they can also be buried. The emitted water moves within the soil system largely by unsaturated flow. The water moves into the soil and wets the root zones of plants vertically by gravity and laterally by capillary action. The lateral movement of water beneath the surface is greater in medium to heavy soil as compared to sandy soil. The wetted soil area for widely spaced emitters will, normally, be elliptical in shape. Drip irrigation can be used on windy days and during various land operations.

Figure: 1.12 Drip irrigation system

Crops suitable for drip irrigation system:

- Orchard Crops. Grapes, Banana, Pomegranate, Orange
- Vegetables. Tomato, Chilly, Capsicum, Cabbage
- Cash Crops. Sugarcane, Cotton
- Flowers. Rose, Carnation, Gerbera, Anthurium
- Plantation. Tea, Rubber, Coffee, Coconut etc.
- Spices. Turmeric, Cloves, Mint etc,
- Oil Seed.

Types of drip irrigation system:

Drip irrigation system can be classified into the following:

(i) Surface drip irrigation

(ii) Sub-surface drip irrigation

(iii) Family drip

(iv) Online drip

(v) In-line drip

(i) Surface drip irrigation:

Surface drip irrigation is used to irrigate perennial crops (plants that live for more than two years) and annual crops (plants that germinate, produce seeds, flower and die in one year). Typical surface drip irrigation system consists of the following.

Pump unit: It comprises a pump and a power unit to supply electricity to the pump. The pump draws water from the source and provides the right pressure for its delivery into the pipe system.

Head control unit: It consists of shut-off, air and check (non-return) valves to control the discharge and pressure of water in the entire system. A pressure relief valve is installed after the pump unit to return excess water when the system is not operated at its full capacity. It may also have filters to clear the water. The filters remove sediment and debris, which can clog the system. Disc filters are commonly used to filter water from ponds, reservoirs, tanks and other sources that contain algae. Some head control units contain a fertiliser or nutrient tank to supply fertiliser solution to plants.

Tubings: It consists of a main line, sub-main lines or sub-mains and laterals. The main line conveys water from the source and distributes it to the sub-mains. The sub-mains convey water to the laterals, which in turn supply it to the emmiters or drippers. The laterals are, usually, 13–32 mm in diameter and supply water into fields through the head control unit.

(ii) Sub-surface drip irrigation:

Sub-surface drip irrigation is a method of irrigating crops through buried plastic tubes, containing embedded emitters located at regular spacings. A subsurface drip irrigation system has a similar design as surface drip irrigation system. But in this case, the drip tubes are typically located 38–84″ (97–213 cm) apart and 6–10″ (15–25 cm) below the soil surface. In sub-surface drip irrigation, evaporation is minimised and water is used more efficiently as compared to surface irrigation.

In sub-surface irrigation, the effects of surface infiltration like crusting, water losses via evaporation and surface run-off are eliminated. Water is applied directly to the root zone of a crop as opposed to surface irrigation, in which most weed seeds hibernate. Water application is efficient and uniform in this system. Sub-surface drip irrigation helps in water conservation in open field agriculture, often resulting in saving up to 25–50 per cent water as compared to the flood irrigation system.

(iii) Family drip or gravity fed drip irrigation:

Family drip or ‘gravity fed drip irrigation’ system is a low-cost system developed for small family plots. It is suitable for house gardening and peri-urban agriculture. It can also be used to demonstrate the working of drip irrigation system. Family drip system is designed for areas measuring 500–1000 m2. It consists of five components — elevated tank, shut-off valve, filter, main line and drip line. Generally, a family drip irrigation system comprises a drum, control or shut-off valve, filter (small disc or screen filter), main line and drip laterals. The drip outlets are spaced at 30 cm. No central pressurised water system or power source is required in this system. Therefore, it is cheap, easy to install and operate.

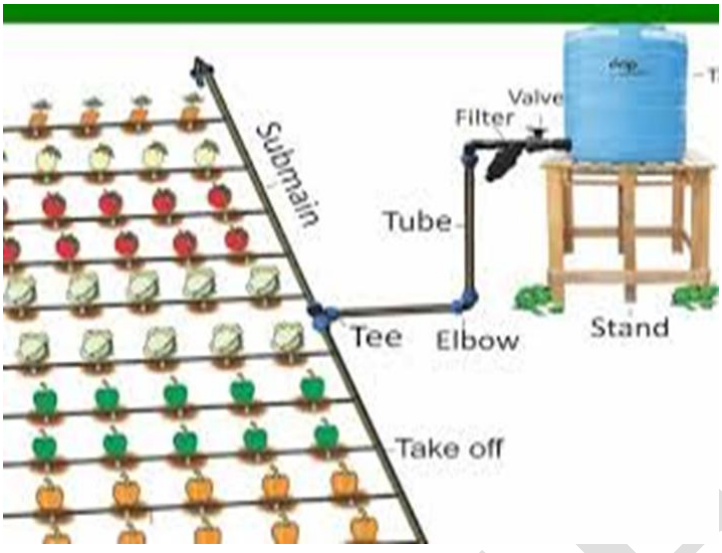

Figure: 1.13 Family drip irrigation

(iv) Online drip irrigation:

- Online drip irrigation is a type of micro-irrigation system in which each plant or tree has an individual emitter connected directly to the main or sub-main line, rather than using laterals that serve multiple plants.
- Main Components
- Water source – well, tank, or reservoir
- Pump – to maintain pressure
- Filters – to prevent clogging
- Main / sub-main pipeline – pressurized pipe network
- Online emitters / drippers – connected directly to the pipe for each plant
- Valves and pressure regulators – to control flow

Figure: 1.14 online drip irrigation

(v) In-line drip irrigation:

In this system, drippers are fixed in the lateral tube at designed spacings at the time of manufacturing to meet the requirement of various crops. It is effective for row crops like cotton, sugarcane, groundnut, vegetables and flowering crops. Dripper spacing depends on the water

Figure: 1.15 online and inline drip irrigation

Advantages:

1. Water saving - losses due to deep percolation, surface runoff and transmission are avoided. Evaporation losses occurring in sprinkler irrigation do not occur in drip irrigation.
2. Uniform water distribution
3. Application rates can be adjusted by using different size of drippers
4. Suitable for wide spaced row crops, particularly coconut and other horticultural tree crops
5. Soil erosion is reduced
6. Better weed control
7. Land saving
8. Less labour cost

Disadvantages:

1. High initial cost
2. Drippers are susceptible to blockage
3. Interferes with farm operations and movement of implements and machineries
4. Frequent maintenance
5. Trees grown may develop shallow confined root zones resulting in poor anchorage.

Drip Irrigation Vs. Sprinkler Irrigation: There are two types of agriculture systems based on the source of water supply. If an agriculture system is totally based on the rainfall, it is known as rain fed

agriculture. Other system, which does not receive enough rainfall to cultivate, needs artificial water supply for irrigation, and it is known as irrigated agriculture. Irrigation systems are used in commercial agriculture in order to provide sufficient moisture content to the crop. It also can be defined as an artificial application of water to a land or a soil. Irrigation systems are classified in several ways based on different criteria. Basically, they are categorized in two different ways as surface irrigation system and localized irrigation system. Surface irrigation systems are mostly applied in traditional agriculture, whereas the localized system is used in developed commercial agriculture. Drip irrigation system and sprinkler irrigation system are two of the well-known localized irrigation methods.

Difference between drip irrigation and sprinkler irrigation:

- ❖ Dripping valves are present in drip system while spray guns and nozzles are used in sprinkler system.
- ❖ Only the root area is wetted by drip irrigation, whereas one sprinkler wets an area of a circle, which covers a number of plants. Therefore, most of the area in a given field will be wetted by this system.
- ❖ Drip irrigation prevents the spreading of diseases that caused by contact of water, whereas sprinkler system does not.
- ❖ Run off and evaporation is higher in sprinkler method than drip irrigation. Ultimately, the effectiveness and efficiency is higher in drip irrigation than sprinkler.

Drip irrigation:

1) In drip irrigation distributing pipes has holes to supply water.

2) In drip irrigation there is maximum use of available water.

Sprinkler irrigation:

1) In sprinkler irrigation, a nozzle is attached in the pipe.

2) There isn't maximum use of available water.

S.no	Sprinkler System	Drip System
1.	In this method of **irrigation**, water is applied in the form of a spray or artificial rain.	This method includes the application of water gently and directly to the root zones of the plants.
2.	Rotating sprinkler-head systems are mostly utilized for sprinkler irrigation.	Permanently or temporarily buried dripper lines are used for drip irrigation.
3.	Water loss is high.	Less water loss compared to sprinkler irrigation.
4.	It is used when there is no shortage of water.	It is used when there is scarce of water.
5.	The evaporation rate is high.	The evaporation rate is negligible.
6.	Power consumption is high.	Energy-saving.

7.	The wind effect is considerable	The wind effect is not considerable.
8.	Expensive as compared to drip irrigation.	Cheap as compared to sprinkler irrigation.
9.	The water application pattern does not match the planting pattern.	The water application pattern must match the planting pattern.
10.	It wets some plants by moistening.	It wets the only root.
11.	Water runoff is higher as compared to Drip Irrigation.	Water runoff is low as compared to Sprinkler Irrigation.
12.	Sprinkler irrigation moves round in circles or in a same path. Sprinkler irrigation is a process in which a nozzle is attached in the pipe to spread water	Drip irrigation distributes water at your given desirable place drop by drop just above the roots of each plant.
13.	Sprinkler irrigation may have a higher loss of water compared to drip system.	Drip irrigation prevents water loss as water is provided drop by drop just at the point where plant is present.
14.	Sprinkler irrigation supplies water once or twice a day but supply a huge volume at a time.	Drip irrigation waters the plant throughout the day by supplying less water at regular intervals.

1.8 Benefits of Water Conservation

Water conservation is the technique of efficiently utilising water and cutting down its wastage or unnecessary usage. Since fresh, clean water is now considered a limited resource, water conservation has become important and imperative.

Reasons to Conserve Water

Below are some of the main reasons it is important to conserve water.

- **It minimizes the effects of drought and water shortages.** Even though our need for fresh water sources is always increasing because of population and industry growth, the supply we have stays constant. Even though water eventually returns to Earth through the water cycle, it's not always returned to the same spot, or in the same quantity and quality. By reducing the amount of water we use, we can better protect against future drought years.
- **It guards against rising costs and political conflict.** Failing to conserve water can eventually lead to a lack of an adequate water supply, which can have drastic consequences. These include rising costs, reduced food supplies, health hazards, and political conflict.
- **It helps to preserve our environment.** Reducing our water usages reduces the energy required to process and deliver it to homes, businesses, farms, and communities, which, in turn, helps to reduce pollution and conserve fuel resources.

- **It makes water available for recreational purposes.** It's not just swimming pools, spas, and golf courses that we have to think about. Much of our freshwater resources are also used for beautifying our surroundings—watering lawns, trees, flowers, and vegetable gardens, as well as washing cars and filling public fountains at parks. Failing to conserve water now can mean losing out on such uses later on.
- **It builds safe and beautiful communities:** Fire fighters, hospitals, gas stations, street cleaners, health clubs, gyms, and restaurants all require large amounts of water to provide services to the community.

Benefits:

- Growing vegetation in the catchment areas, which will hold water in the soil and allow it to percolate into deeper layers and contribute to formation of ground water.
- Constructing dams and reservoirs to regulate supply of water to the fields, as well as to enable generation of hydroelectricity.
- Sewage should be treated and only the clear water should be released into the rivers.
- Industrial wastes (effluents) should be treated to prevent chemical and thermal pollution of fresh water.
- Judicious use of water in our day-to-day life.
- Rainwater harvesting should be done by storing rainwater and recharging Ground water.
- It minimizes the effects of drought and water shortages.
- It guards against rising costs and political conflict.
- It helps to preserve our environment.
- It makes water available for recreational purposes.
- It builds safe and beautiful communities.
- It reduces or minimizes the pollution and health problems.
- It reduces the need for new waste water treatment facilities.