Unit 1

Introduction

Defination:-

Irrigation is the application of controlled amounts of water to plants at needed intervals. Irrigation helps grow agricultural crops, maintain landscapes, and revegetate disturbed soils in dry areas and during periods of less then average rainfall. Irrigation also has other uses in crop production, including frost protection,[1] suppressing weed growth in grain fields[2] and preventing soil consolidation.[3] In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed or dry land farming.

Irrigation systems are also used for cooling livestock, dust suppression, disposal of sewage, and in mining. Irrigation is often studied together with drainage, which is the removal of surface and sub-surface water from a given area.

Necessity of irrigation

Water is necessary for plant growth and maturity. Irrigation, the artificial means of supplying water, becomes important for plant growth in the following cases.

- If rainfall is less than the demand of plants, irrigation is necessary to fulfill the water requirement of plants.
- The difference in water holding capacity of the soil plays important role in the Necessity of Irrigation supply. For example, sandy soil requires frequent irrigation than clay soil.
- If rainfall is sufficient but spatial distribution is not as per requirement, irrigation becomes necessary.
- If rainfall is sufficient, spatial distribution is also good but temporal distribution is not as per requirement, irrigation water is necessary for plants.
- An advanced scientific development like High Yielding Varieties Seeds (HYV) demands irrigation. Actually, irrigation is the most important input for HYV.

History and development of irrigation in India

IRRIGATION ▪

Irrigation is the artificial application of water to the soil usually for assisting in growing crops. ▪ Mainly used to replace missing rainfall in periods of drought. ▪ To supply essential moisture for plant growth, which includes transport of essential nutrients ▪ To leach or dilute salts in soil. ▪ Helps in cooling the soil and atmosphere to create more favourable environment for crop growth ▪ Supplements the supply of water received from precipitation and other types of atmospheric water, flood waters and ground water.

History of Irrigation in India GRAND ANICUT IRRIGATION TANK • Vedas, Ancient Indian writers and ancient Indian scriptures have references of wells, canals, tanks and dams. • In the south, perennial irrigation had begun with construction of the Grand Anicut by the Cholas as early as second century to provide irrigation from the Cauvery River. • The central and southern India is studded with numerous irrigation tanks which have been traced back to many centuries before the beginning of the Christian era • Indus Civilization flourished on the banks of rivers and the water was harnessed for sustenance of life • Irrigation technologies during the Indus Valley Civilization were in the form of small and minor works like digging well

Irrigation during Medieval India ▪ Rapid advances took place in the construction of canals. ▪ Water was blocked by constructing bunds across steams ▪ Ghiyasuddin Tughluq is credited to be the first ruler who encouraged digging canals. Fruz Tughlug is considered to be the greatest canal builder. ▪ Irrigation is said to be one of the major reasons for the growth and expansion of the Vijayanagar Empire in southern India in the fifteenth century. ▪ As agricultural income was the pillar of the economy, irrigation systems were paid special attention during this period.

BUND FORMATION
WALLS OF GABAR BUNDS • Babur, in his memoirs called 'Baburnamah' gave a vivid description of prevalent modes of irrigation practices in India at that time. • The Gabar Bunds, presently in Sindh, Pakistan, captured and stored annual runoff from surrounding mountains and river Sindhu (Indus) to be made available to tracts under cultivation

Renovation, improvement and extension of existing works. ▪ New projects, like the Upper Ganga Canal, the Upper Bari Doab Canal and Krishna and Godavari Delta Systems. ▪ Major canal works like the Sirhind, the Lower Ganga, the Agra and the Mutha Canals, and the Periyar Dam and canals. UPPER GANGA CANAL PERIYAR CANAL SYSTEM PERIYAR DAM GODAVARI DELTA SYSTEM♣Irrigation in British India

Major, medium and minor irrigation proects :-

Irrigation works have been classified as major, medium and minor, depending on their culturable command area.

1. Major Irrigation:
Culturable command area (CCA) more than 10,000 hectares.

2. Medium Irrigation:
Culturable command area more than 2,000 hectares but less than 10,000 hectares.

3. Minor Irrigation:
Culturable command area up to 2,000 hectares.

Whereas major and medium irrigation works are meant for tapping surface water (e.g., rivers), minor irrigation mainly involves ground water development, e.g., tube-wells, boring works, etc.

Unit 2

Water Requirement Of crops

Principal crops in India and their water requirements

India is top producer country of many crops. The major crops in India can be divided into four categories viz. Food grains (Rice, Wheat, Maize, Millets and Pulses), Cash Crops (Cotton, Jute, Sugarcane, Tobacco, and Oilseeds), Plantation Crops (Tea, Coffee, Coconut and, Rubber) and Horticulture crops such as Fruits and Vegetables.

Rabi, Kharif and Zaid Crops in India Kharif crops:

KHARIF CROP:-The Kharif crop is the summer crop or monsoon crop in India. Kharif crops are usually sown with the beginning of the first rains in July, during the south-west monsoon season. Major Kharif crops of India include Millets (Bajra & Jowar), Cotton, Soyabean, Sugarcane, Turmeric, Paddy (Rice), Maize, Moong (Pulses), Groundnut, Red Chillies, etc.

Rabi Crops :- The Rabi crop is the spring harvest or winter crop in India . It is sown in October last and harvested in March April every year. Major Rabi crops in India include Wheat, Barley, Mustard, Sesame, Peas etc.

Zaid Crop:- This crop is grown in some parts of country during March to June. Prominent examples are Muskmelon, Watermelon, Vegetables of cucurbitacae family such as bitter gourd, pumpkin, ridged gourd etc.

Water requirements of crops

1. 1. Water Requirements of Crop
2. 2. Functions of Irrigation Water Soil furnishes the following for the plant life: 1. To supply water partially or totally for crop need 2. To cool both the soil and the plant 3. Provides water for its transpiration. 4. Dissolves minerals for its nutrition. 5. Provides Oxygen for its metabolism. 6. Serves as anchor for its roots. 7. To enhance fertilizer application- fertigation 8. To Leach Excess Salts 9. To improve Groundwater storage 10. To Facilitate continuous cropping
3. 3. Preparation of Land for Irrigation The uncultivated land should be properly prepared, as following, before irrigation water is applied upon it. (i) Removal of thick jungle, bushes etc., from the raw land. The roots of the trees should be extracted and burnt. The land should thereafter be properly cleaned. (ii) The land should be made level. High patches should be scraped and depression filled. Unless this is done, water will fill the depression and duty may be too high. (iii) The land should be provided with regular slope in the direction of falling gradient. (iv) The land should be divided into suitable plots by small levees according to the method of irrigation to be practiced. (v) Permanent supply ditches and water courses should be excavated at regular spacing which facilitate proper distribution of the water to the entire field. (vi) A drain ditch which carries the waste water should also be excavated. . (vii) Proper drainage measures should be adopted where the danger of water logging may become eminent after the introduction of canal irrigation 3Water Requirement of Crops
4. 4. Crop Period or Base Period The time period that elapses from the instant of its sowing to the instant of its harvesting is called the crop-period. The time between the first watering of a crop at the time of its sowing to its last watering before harvesting is called the Base period. Crop period is slightly more than the base period, but for all practical purposes, they are taken as one and the same thing, and generally expressed in B days. 4Water Requirement of Crops
5. 5. SOME DEFINITIONS
6. Gross Commanded Area (GCA) The total area lying between drainage boundaries which can be commanded or irrigated by a canal system or water course is known as gross commanded area.

7. **Culturable Commanded Area (CCA):** Gross commanded area contains some unfertile barren land, local ponds, villages, graveyards etc which are actually unculturable areas. The gross commanded area minus these unculturable area on which crops can be grown satisfactorily is known as Culturable Commanded Area. CCA = GCA – Unculturable Area Culturable Cultivated Area The area on which crop is grown at a particular time or crop season. Culturable Uncultivated Area The area on which no crop is grown at a particular time or crop season 5Water Requirement of Crops

8. **6. Intensity of Irrigation (I.I**): Percentage of CCA that is cultivated in a particular season. Kor depth and kor period The distribution of water during the base period is not uniform, since crops require maximum water during first watering after the crops have grown a few centimeters. During the subsequent watering the quantity of water needed by crops gradually decreases and is least when crop gains maturity. The first watering is known as kor watering, and the depth applied is known as kor depth. The portion of the base period in which kor watering is needed is known as kor period. While designing the capacity of a channel, kor water must be taken into account since discharge in the canal has to be maximum during this time. Crop ratio The ratio of area irrigated in Rabi season to that irrigated in Kharif season is known as crop ratio. The crop ratio is so selected that the discharge in the canal during both the seasons may be uniform. 6Water Requirement of Crops

9. 7. **Outlet factor** It is defined as the duty at the outlet. Time factor The time factor of a canal is the ratio of the number of days the canal has actually run to the number of days of irrigation period. For example, if the number of days of irrigation period = 12, and the canal has actually run for 5 days, the time factor will be 5/12. (Note: A day has a period of 24 hours (i.e. it includes the night also). Capacity factor This is the ratio of the mean supply discharge to the full supply discharge of a canal. 7Water Requirement of Crops

10. **8. Delta** Each crop requires a certain amount of water after a certain fixed interval of time, throughout its period of growth. The depth of water required every time, generally varies from 5 to 10 cm depending upon the type of the crop. If this depth of water is required five times during the base period, then the total water required by the crop for its full growth, will be 5 multiplied by each time depth. The final figure will represent the total quantity of water required by the crop for its full-fledged nourishment. The total quantity of water required by the crop for its full growth may be expressed in centimeter (inches) or hectare-metre (Acre-ft) or million cubic meters (million cubic ft). This total depth of water (in cm) required by a crop to come to maturity is called its delta (Δ). 8Water Requirement of Crops

11. **9. Duty of Water** The duty of water is the relationship between the volume of water and the area of the crop it matures. This volume of water is generally expressed as, “a unit discharge flowing for a time equal to the base period of the crop, called Base of a duty”. If water flowing at a rate of one cubic metre per second, runs continuously for B days, and matures 200 hectares, then the duty of water for that particular crop will be defined as 200 hectares per cumec to the base of B days. Hence, duty is defined as the area irrigated per cumec of discharge running for base period B. The duty is generally represented by the letter D. Mathematically, D = A / Q The duty of water can be expressed as one of the following four ways: (i) By the number of hectare (or acre,) that one cumec (or cusec) of water can irrigate during the base period, e.g. 1700 hectares/cumec (or 120 acres/cusec). . (ii) By total depth of water (or Delta) i.e. 1.20 metres. (iii) By number of hectare, (or acres) that can be irrigated by a million cubic metre (or million cu.ft) of stored water. This system is used for tank irrigation. (iv) By the number of hectare-metres (or acre-ft) expended per hectare (or acre) irrigated. This is also used in tank irrigation. 13Water Requirement of Crops

12. **10. Relation between Duty, Delta and Base period**

Let, base period of the crop be B days, and one cumec of water be applied to this crop on the field for B days. Now, volume of water applied to this crop during B days = V = (1 x 60 x 60 x 24 x B) m3 = 86,400 B m3 By definition of duty (D), one cubic meter supplied for B days matures D hectares of land. :. This quantity of water (V) matures D hectares of land or 104 D sq. m of area. Total depth of water applied on this land = Volume/area = 86400 B / 104 D = 8.64 B / D metres By definition, this total depth of water is called delta (Δ), Δ = 8.64 B / D meter Δ = 864 B / D cm where, Δ is in cm, B is in days ; and D is duty in hectares/cumec. 17Water Requirement of Crops

13. **11. METHODS OF IMPROVING DUTY** When once the various factors affecting duty are properly understood, the duty can be improved by making those factors less effective which tend to reduce the duty. 1. Suitable method of applying water to the crops should be used. 2. The land should be properly ploughed and leveled before sowing the crop. It should be given good tilth. 3. The land should be cultivated frequently, since frequent cultivation reduces loss of moisture specially when the ground water is within capillary reach of ground surface. 4. The canals should be lined. This reduces seepage and percolation losses. Also, water can be conveyed quickly, thus reducing, evaporation losses. 5. Parallel canals should be constructed. If there are two canals running side by side, the F.S.L. will be lowered, and the losses will thus be reduced. 6. The idle length of the canal should be reduced. 7. The alignment of the canal either in sandy soil or in fissured rock should be avoided. 8. The canal should be so aligned that the areas to be cultivated are concentrated along it. 33Water Requirement of Crops

Unit 3

Hydrological Cycle Catchment Area and Run-off

Rain gauge:

A **rain gauge** (also known as an udometer, pluviometer, or an ombrometer) is an instrument used by meteorologistsand hydrologists to gather and measure the amount of liquid precipitation over a set period.

Types of Rain Gauges:

1. Non-Recording Type Rain-Gauge:

It gives only total rainfall occurred during particular time period. Recording type rain-gauge gives hourly rainfall. Under non-recording type rain-gauges, one most commonly used in Symon's rain-gauge. This type is mentioned below. It is the simplest in principle, construction and working.

Principle:

From the definition of unit rainfall it is clear that the definition is independent of extent of area. So far as only measurement of rainfall is concerned area under consideration may be large or small.

Now taking smallest possible area, if the water, which comes down as rainfall, is collected before the losses take place or water runs off then the depth of this water over the small area can be quite accurately determined to give the amount of rainfall occurred in proper units (centimeters). The small area should be selected in such a way that its meteorological characteristics are similar to that particular large area which it represents.

Construction:

It consists of a funnel and a receiver mainly. The receiver is a cylindrical (zinc) metal bottle. The diameter of the bottle and the topmost diameter of funnel is 127 mm. The funnel is fitted in the neck of the bottle. Both are then placed in a metal casing with suitable packing's. The base of the metal casing is enlarged to 210 mm.

The capacity of the bottle is such as to measure extremes of rainfall likely to occur in 24 hours. Zinc receivers hold 175 mm to 1000 mm according to size. Gauge is provided with one measuring graduated jar which measures the water in mm. The smallest division on the jar is 0.2 mm. The rainfall should be estimated to the nearest 0.1 mm. See Fig. 2.4.

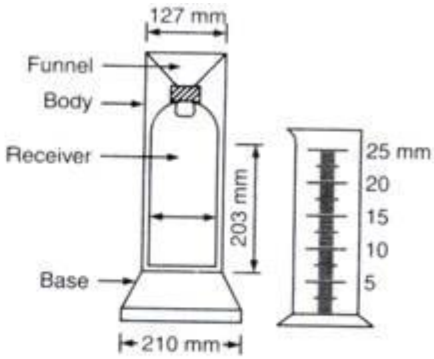


Fig. 2.4. Symons non-recording type rain-gauge

At the site where rainfall is to be measured concrete block us constructed. The base of the gauge is permanently fixed in the block in such a way that the top of the casing is about 30 cm above natural surface level. While fixing the base of the gauge precaution is taken to level it perfectly. The rain-gauging station is protected by barbed wire fencing with a gate. The size of the concrete foundation block should be 60 cm x 60 cm.

The necessity to keep the rim of the funnel above the natural surface by 30 cm is twofold:

(i) It prevents splashing of water into the funnel almost to a negligible amount.

(ii) If the height is kept more than 30 cm the amount of rain water collected decreases owing to wind eddies set up by the gauge itself.

Working:

The gauge is adjusted every day for measurement of rainfall. When rainfall occurs the rainwater covering area of the funnel passes to the receiver before any sort of loss takes place. After every 24 hours the rainfall is measured. Usually the measurement is taken at 0830 hr. I.S.T. The received water is poured carefully in the measuring jar to measure daily rainfall. If it is raining at the time of observation, it is necessary to do the measurements very quickly.

If found essential spare receiver may be placed immediately in the body after previous receiver is taken out. The total amount of rainfall measured during the previous 24 hours should invariably be entered against the date of measurement irrespective of the fact whether the rainfall was received on the date of measurement or on the previous date after yesterday's measurement.

Totaliser:

Sometimes unavoidably rain-gauge is to be installed at such a location which is not easily accessible in un-favourable climate. Then it is not possible to measure the rainfall every day at 0830 hr. I.S.T. In such cases a different type of non- recording gauge is used. It is called totaliser. It is in the form of a can.

To accommodate 1220 mm of rain upper and lower diameter of the can is kept 203 mm and 610 mm respectively. Since, the observer goes at a longer interval it is essential to provide some arrangement to minimise evaporation loss. Generally a wind screen is mounted on the can to stop evaporation loss. Sometimes a thin layer of oil is also kept floating at the water surface in the can to reduce evaporation loss.

2. Recording Type Rain-Gauge:

The recording gauge consists of a funnel 127 mm in diameter fixed on one side of a rectangular box. It is called receiver also. In the rectangular box a float is adjusted. The float is connected by means of a float rod to a pin point (or a recording pen). The pin point touches a graph paper mounted on a rotating drum.

The drum is mounted on the top of the receiver on the other side. A clockwork arrangement revolves the drum once in 24 hours. At the bottom the box is connected to a siphon. The siphon comes into action and releases the water as soon as box is filled to a certain level. Figure 2.5 shows complete arrangement, it is called natural siphon type recording rain-gauge.

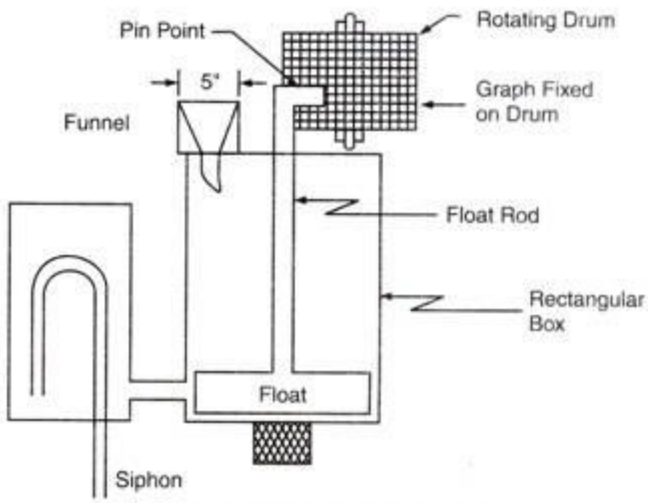


Fig. 2.5. Recording type rain-gauge

As the rainfall starts rain water passes through the funnel into the box. As the water level in the box rises the float is also raised. In turn the pin point moves on the graph to plot a mass curve of rainfall. When the box is filled to such an extent that the float touches the top, the siphon starts working and the rainwater collected in the box is drained out.

Mass Curve Principle of Integrating Rain-Gauge:

The recording type rain-gauge is also called integrating rain-gauge. The reason is that the curve obtained on the graph is a cumulative curve in respect of rainfall. On y-axis we get accumulated or integrated rainfall and on x-axis we have equal time increment. This type of curve in which one ordinate gives accumulated values is called a mass curve. On the graph mounted on the rotating drum we get the mass curve of rainfall (Fig. 2.6).

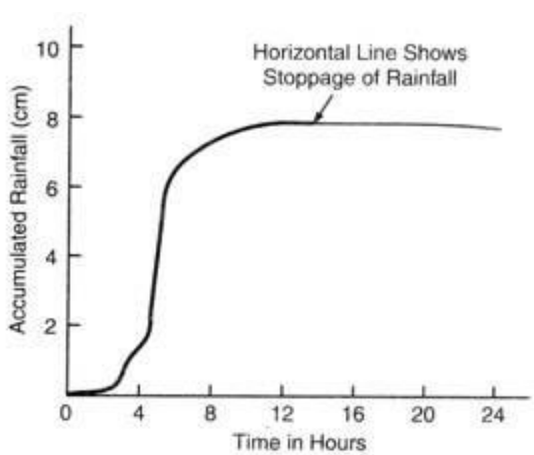


Fig. 2.6. Mass curve of rainfall

Tipping Bucket Type Rain-Gauge for Remote Recording:

To facilitate remote recording of rainfall a new type of rain-gauge is used. It is called tipping bucket type rain-gauge. In this type a pair of tipping buckets is placed below a funnel. The bucket gets filled up by 0.25 mm of rainfall and immediately it tips and empties the water into a chamber below. At that very instant other bucket comes below the funnel to receive rainwater. The tipping of the bucket actuates an electrical circuit which moves a pointer to register the rainfall on a graph. The water collected in the chamber below could also be measured by a measuring jar.

Catchment area :

A catchment area is a hydrological unit. Each drop of precipitation that falls into a catchment area eventually ends up in the same river going to the sea if it doesn't evaporate. However, it can take a very long time. Catchment areas are separated from each other by watersheds. A watershed is natural division line along the highest points in an area. Catchments are divided into sub catchments, also along the lines of elevation.

Types of catchments:

1. Drainage Baasins
2. Pits
3. Ponds

Unit Hydrograph:

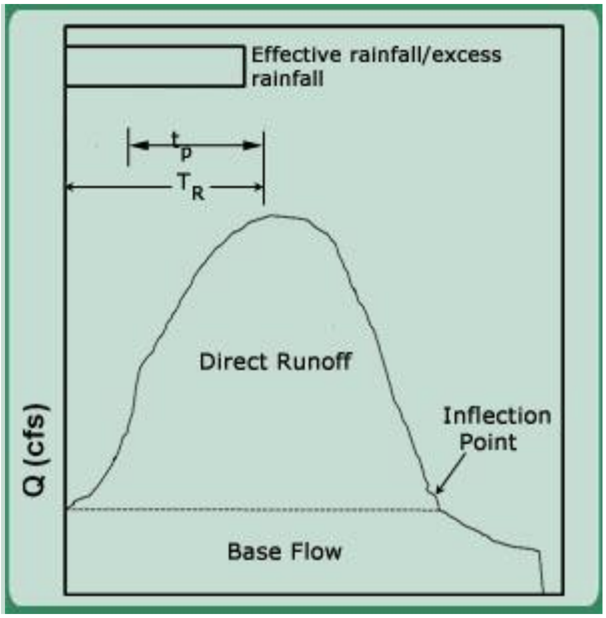
Unit hydrograph (UH)

- The unit hydrograph is the unit pulse response function of a linear hydrologic system.
- First proposed by Sherman (1932), the unit hydrograph (originally named unit-graph) of a watershed is defined as a direct runoff hydrograph (DRH) resulting from 1 in (usually taken as 1 cm in SI units) of excess rainfall generated uniformly over the drainage area at a constant rate for an effective duration.
- Sherman originally used the word "unit" to denote a unit of time. But since that time it has often been interpreted as a unit depth of excess rainfall.
- Sherman classified runoff into surface runoff and groundwater runoff and defined the unit hydrograph for use only with surface runoff.

Derivation of UH : Gauged watershed

Terminologies

1. **Duration of effective rainfall** : the time from start to finish of effective rainfall
2. **Lag time** (L or t_p): the time from the center of mass of rainfall excess to the peak of the hydrograph
3. **Time of rise (T_R)**: the time from the start of rainfall excess to the peak of the hydrograph
4. **Time base (T_b)**: the total duration of the DRO hydrograph



Type of Irrigation Technique in India:

In India, the irrigated area consists of about 36 per cent of the net sown area. There are various techniques of irrigation practices in different parts of India. These methods of irrigation differ in how the water obtained from the source is distributed within the field. In general, the goal of irrigation is to supply the entire field homogeneously with water, so that each plant has the amount of water it needs, neither too much nor too little. Irrigation in India is done through wells, tanks, canals, perennial canal, and multi-purpose river valley projects.

Surface Irrigation:

In this technique water flows and spreads over the surface of the land. Varied quantities of water are allowed on the fields at different times. Therefore, flow of water under surface irrigation comes under wobbly flow. Consequently, it is very difficult to understand the hydraulics of surface irrigation. However, suitable and efficient surface irrigation system can be espoused after taking into consideration different factors which are involved in the hydraulics of surface irrigation.

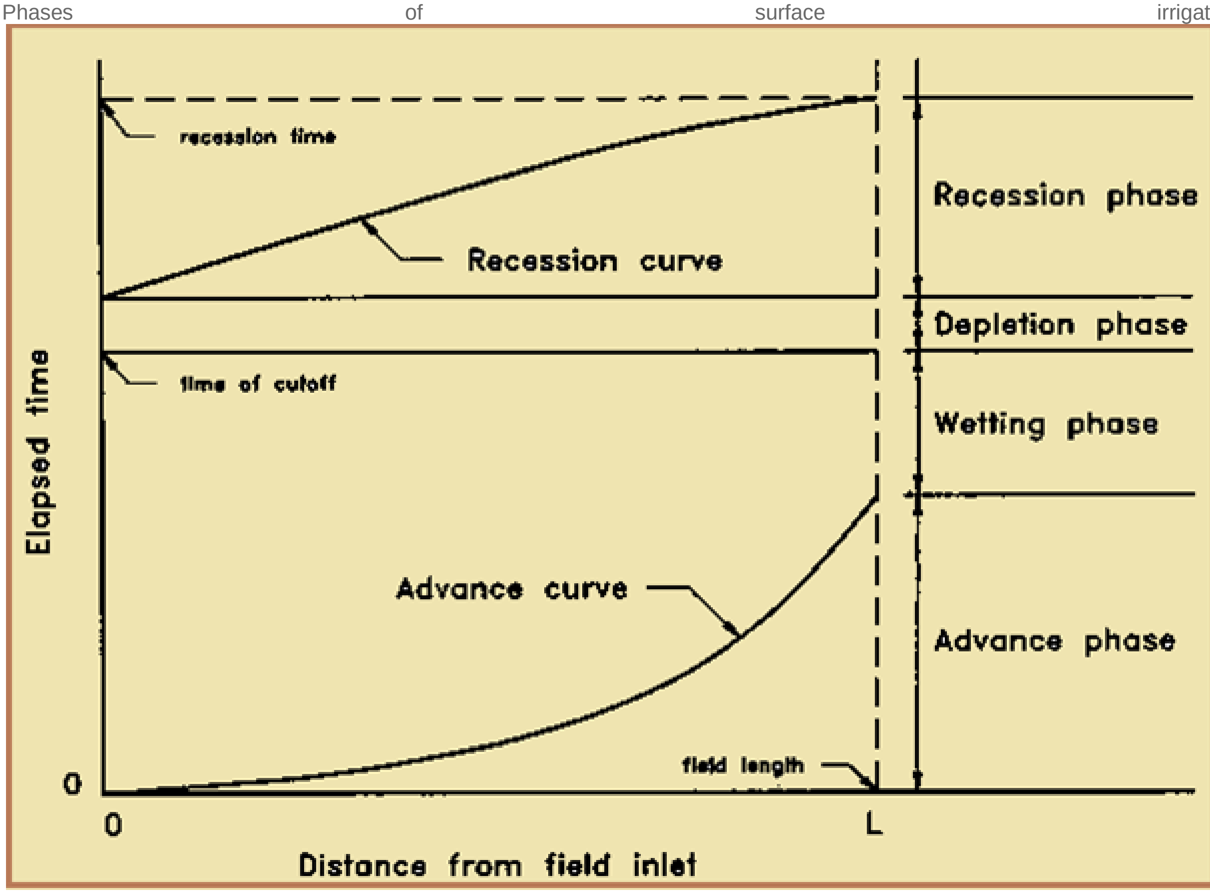
1. Surface slope of the field
2. Roughness of the field surface
3. Depth of water to be applied
4. Length of run and time required
5. Size and shape of water-course
6. Discharge of the water-course
7. Field resistance to erosion

If the surface irrigation method is perfectly selected, it fulfils following requirements:

1. It assists in storing required amount of water in the root-zone-depth.
2. It reduces the wastage of irrigation water from the field in the form of run-off water.
3. It reduces the soil erosion to minimum.
4. It helps applying uniform application of water to the fields.
5. Amount of manual labour required is less.
6. It is suitable to the size of the field and at the same time it uses minimum land for making ditches, furrows, strips, etc.
7. It does not avert use of machinery for land preparation, cultivation, harvesting.

Surface irrigation technique is broadly classified as basin irrigation; border irrigation; furrow irrigation and uncontrolled flooding.

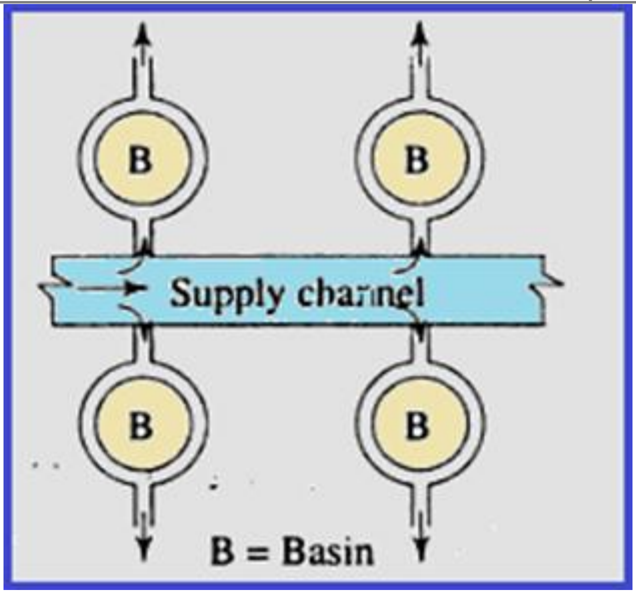
Phases of surface irrigation:



This divided into the four component systems: (1) water supply; (2) water conveyance or delivery; (3) water use; and (4) drainage.

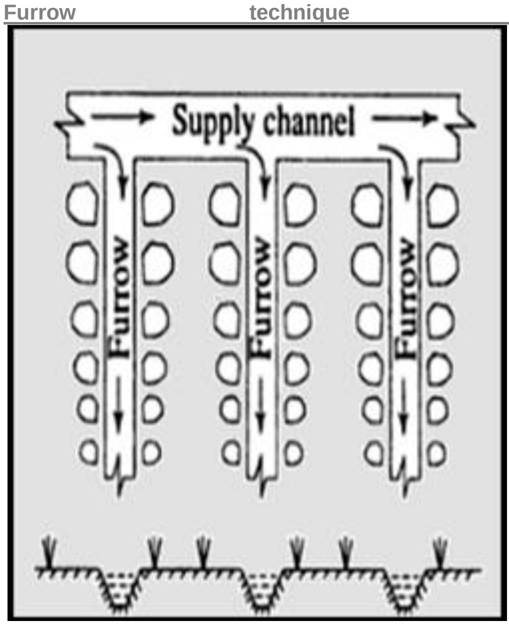
Basin irrigation: Basin irrigation is common practice of surface irrigation. This method is employed for watering orchards (Basak, 1999). It is useful especially in regions with layouts of small fields (Shah et al. 2002). If a field is level in all directions, is encompassed by a dyke to prevent runoff, and provides an undirected flow of water onto the field, it is herein called a basin. A basin is typically square in shape but exists in all sorts of irregular and rectangular configurations. It may be furrowed or ridged, have raised beds for the benefit of certain crops, but as long as the inflow is undirected and uncontrolled into these field modifications, it remains a basin.

Basin Method (Source: Basak, 1999)



Furrow Irrigation: In furrow irrigation technique, trenches or "furrows" are dug between crop rows in a field. Farmers flow water down the furrows (often using only gravity) and it seeps vertically and horizontally to refill the soil reservoir. Flow to each furrow is individually controlled. Furrow irrigation is suitable for row crops, tree crops and, because water does not directly contact the plants, crops that would be damaged by direct inundation by water such as tomatoes, vegetables, potatoes and beans. It is one of the oldest system of irrigation. It is economical and low-tech making it particularly attractive in the developing world or places where mechanized spray irrigation is unavailable or impractical.

Furrow technique (Source: Basak, 1999)



In different situations, different furrow methods are used (Surajbhan 1978). They are mainly of five types:

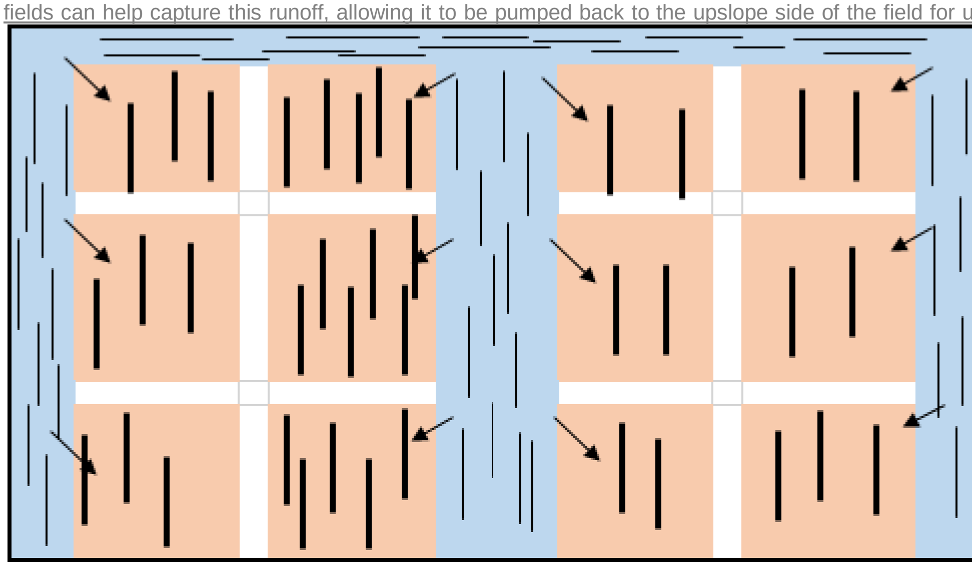
1. Sloppy Furrow
2. Levelled Furrow
3. Contour Furrow
4. Serial Furrow
5. Corrugated Furrow

There are numerous advantages of Furrow technique of irrigation:

1. Large areas can be irrigated at a time.
2. It saves labour since once the furrow is filled, it is not necessary to give water a second time.
3. It is a reasonably cheaper method.
4. Plants get proper quantity of water by this system.

Furrow irrigation is also beneficial for growing of tree crops. In the early stages of tree planting, one furrow alongside the tree row may be sufficient but as the trees develop then two or more furrows can be constructed to provide sufficient water. Sometimes a special zig-zag system is used to improve the spread of water (Basak, 1999).

Major drawback of furrow system of irrigation is ensuring uniform dispersal of water over a given field. To tackle this problem, some farmers engage in field levelling to remove any small hills that would have been bypassed by the gravity flow of the water. Other problem with furrow irrigation is the increased potential for water loss due to runoff. Building retention ponds along the edges of fields can help capture this runoff, allowing it to be pumped back to the upslope side of the field for use in further irrigation cycles.

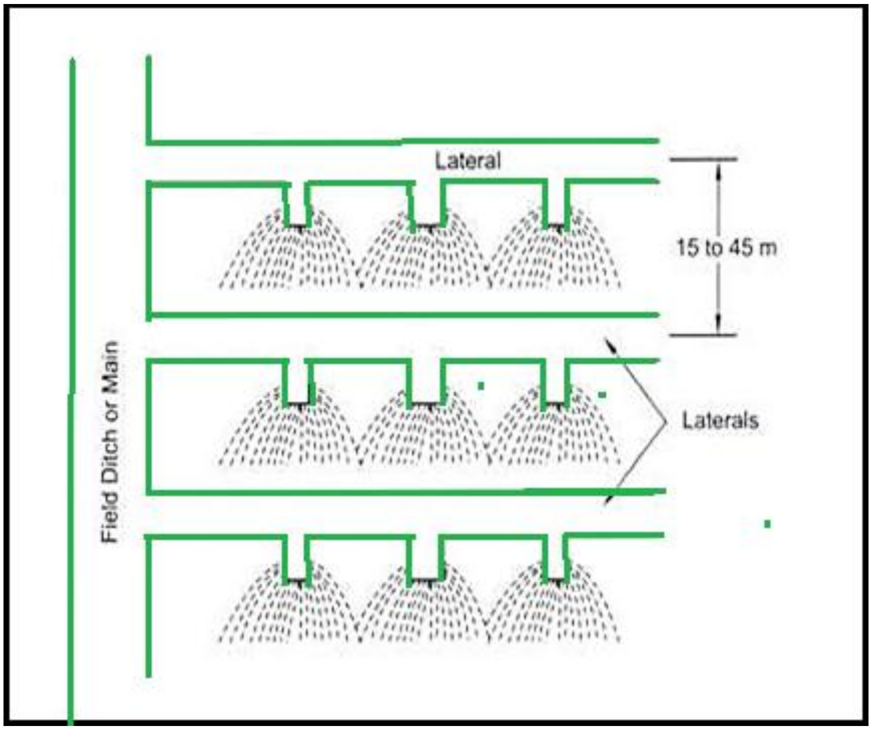


Uncontrolled flooding: There are many cases where croplands are irrigated without regard to efficiency or consistency. These are usually situations where the value of the crop is very small or the field is used for grazing or recreation purposes. Small land holdings are generally not subject to the range of surface irrigation practices of the large industrial farming systems. The assessment methods can be applied if desired, but the design techniques are not generally applicable nor need they be since the irrigation practices tend to be minimally managed.

Free Flooding:

This flooding system of irrigation is used from ancient times. Flooding method consists in applying the water by flooding the land of rather smooth and flat topography. In current irrigation practice, several flooding methods have been developed. In free flooding method, water is applied to the land from field ditches without any check or guidance to the flow. The land is divided into plots or kiaries of suitable size depending on porosity of soil. Water is spread over the field from watercourse. The irrigation operation begins at the higher area and proceeds towards the lower levels. The flow is stopped when the lower end of the field has received the desired depth of water. The field watercourse is properly spaced, the spacing depends on the topography, oil texture, depth of soil and size of stream.

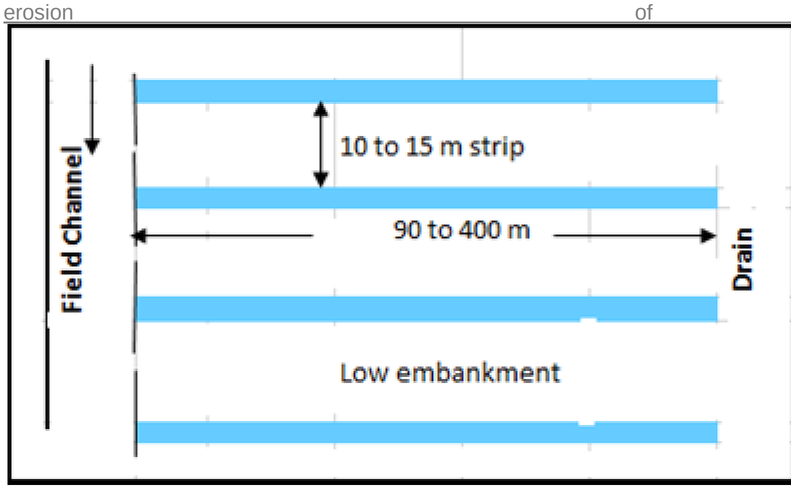
Free Flooding for erodible soil



This technique is beneficial for newly established farms where making furrows is very expensive. This method is economical and can be effectively used where water supply is in plenty. This method is suitable for the fields with irregular surface in which other techniques are difficult to apply. Major drawback of this method is that there is no perfect control over the flow of water to attain high efficiency. Sometimes the flow of water over the soil is too rapid to fulfil soil moisture deficiency. On the other hand, sometimes water is retained on the field for a very long time and consequently the water is lost in infiltration or deep percolation.

Border Strip Method:

In this technique of irrigation, a field is divided into number of strips. The width of strip varies from 10 to 15 metres and length varies from 90 m to 400 m. Strips are separated by low embankments or levees. The water is diverted from the field channel into the strips. The water flows gradually towards lower end, wetting the soil as it advances. The surface between two embankments should essentially be level. It assists in covering the entire width of the strip. There is a general surface slope from opening to the lower end. The surface slope from 2 to 4 m/1000 m is best suited. When the slope is steeper, special arrangement is made to prevent erosion of soil.



Well and Tube Well Irrigation:

A well is a hole dug in the ground to get the subsoil water. Normal well is about 3-5 metres deep but deeper wells up-to 15 metres are also dug. This system of irrigation has been used in India from ancient time. Various methods are used to lift the ground water from the well for irrigation, drinking, bathing and for other purposes. Well irrigation is more popular in those regions where ground water is in ample and where there are few canals. These areas include a large part of the Great Northern Plain, the deltaic regions of the Mahanadi, the Godavari, the Krishna and the Cauvery, parts of the Narmada and the Tapi valleys and the weathered layers of the Deccan Trap and crystalline rocks and the sedimentary zones of the Peninsula. However, the greater part of the Penisnular India is not appropriate for well irrigation due to stony structure, rough surface and lack of underground water. Large dry tracts of Rajasthan, the adjacent parts of Punjab, Haryana, and Gujarat and some parts of Uttar Pradesh have salty ground water which is not suitable for irrigation and human use and hence inappropriate for well irrigation.

Tube well: A tube well is a deeper well (generally over 15 metres deep) from which water is lifted with the help of a pumping set operated by an electric motor, a diesel engine or solar power. A tube well cannot be constructed in all places and requires some geographical conditions favouring its installation. The main factors for Tube well construction are:

1. There should be enough quantity of ground water because a tube well can generally irrigate 2 hectares per day against 0.2 hectares per day irrigated by an ordinary well.
2. The water level should be nearly 15 metres. If the water table is more than 50 metres deep the cost of pumping out water from the tube well becomes uneconomic.
3. There should be normal supply of cheap electricity or diesel so that water from the tube well can be taken out at the hour of need.
4. The soil in the immediate neighbourhood of the tube-well should be productive so that there is demand for irrigation and the cost involved in the construction and operation of the tube well can be recovered by the increased farm production.

Advantages of Well and Tube Well Irrigation:
Well is simplest and cost effective source of irrigation and the poor Indian farmer can easily afford it. Well is an independent source of irrigation and can be used as and when the necessity arises. Several chemicals such as nitrate, chloride, sulphate, etc. are generally found mixed in well water. They make soil fertility when they reach the agricultural field along with well water. It is more reliable during periods of famine when surface water dries up.

Disadvantages of well and Tube Well Irrigation: With these methods, only limited area can be irrigated. Normally, a well can irrigate 1 to 8 hectares of land. The well may dry up and may be rendered ineffective for irrigation if excessive water is taken out. In the drought situation, the ground water level falls and enough water is not available in the well when it is needed the most.

Tube wells can draw a lot of groundwater from its neighbouring areas and make the ground dry and not suitable for agriculture. Well and tube well irrigation is not possible in areas of salty groundwater.

Canal Irrigation:

Canals are most important source of irrigation from the period of 1960s, but in the 1970s, they yielded first place to wells and tube wells and now constitute the second most important source of irrigation in India. Canals are most effective techniques of irrigation in areas of low level relief, deep fertile soils, perennial source of water and extensive command area. Therefore, the main concentration of canal irrigation is in the northern plain of India, especially the areas comprising Uttar Pradesh Haryana and Punjab.

The digging of canals in stony and uneven areas is difficult and unprofitable. Thus the canals are practically absent from the Peninsular plateau area. However, the coastal and the delta regions in South India do have some canals for irrigation.

Canals in India are of two types:
Inundation canals, which are taken out from the rivers without any regulating system like weirs at their head. Such canals supply irrigation mainly in the rainy season when the river is in flood and there is excess water. When the rainy season is over, the flood in the river subsides, the level of water falls below the level of the canal head and the canal dries up. Some canals taken off from the Satluj in Punjab were of this type. Since irrigation from this type of canals is unsure, they have been converted in perennial canals.

Perennial Canals are those which are taken off from perennial rivers by constructing a barrage across the river. Most of the canals in India today are perennial.

Advantages of Canal Irrigation: Most of the canals provide perennial irrigation and supply water as and when required. This saves the crops from drought conditions and helps in increasing the farm production. Canals carry a lot of residue brought down by the rivers. This sediment is deposited in the agricultural fields which make soil more fertile. Some of the canals are parts of multipurpose projects and, therefore, provide inexpensive source of irrigation. Although the initial cost involved in canal irrigation is more, it is quite cheap in the long run.

Drawbacks of Canal Irrigation: The canal water soaks into the ground and results in water-logging along the canal route. Excessive flow of water in the fields raises the ground water level. Capillary action brings alkaline salts to the surface and makes large areas unfit for agriculture. Huge areas in Panjab, Haryana and Uttar Pradesh suffer from the problem caused by canal irrigation. The muddy areas near the canals act as reproduction grounds of mosquitoes which result in widespread malaria. Many canals overflow during rainy season and flood the surrounding areas. Canal irrigation is suitable in plain areas only.

Tank Irrigation:

A tank act as an irrigation storage system which is developed by constructing a small bund of earth or stones built across a stream. The water impounded by the bund is used for irrigation and for other purposes. Some tanks are built partly as dugouts and partly by enclosing bunds. Tanks are of varying size but most of the tanks are of small size and are built by individual farmers or groups of farmers. Tank irrigation is more suitable in the peninsular plateau area such as Andhra Pradesh (Including Telangana) and Tamil Nadu.

Andhra Pradesh is the largest state of tank irrigation which has about 29 per cent of tank irrigated area of India. About 16 per cent of the total irrigated area of the state is irrigated by tanks. The drainage areas of the Godavari and its tributaries have large number of tanks. Nellore and Warangal are the main districts of tank irrigation.

According to reports, Tamil Nadu has the second largest area which is over 23 per cent of tank irrigated area of India and about one-fifth of the total irrigated area of the state. Tanks comprise an important source of irrigation in the Karnataka Plateau, eastern Madhya Pradesh, eastern Maharashtra, interior Orissa and Kerala. Outside the Peninsular plateau, West Bengal, Bihar, Bundelkhand area of Uttar Pradesh, Rajasthan and Gujarat have tank irrigation.

Advantages of Tank Irrigation: Most of the tanks are natural and not expensive for their construction. Even an individual farmer can have his own tank. Tanks are normally constructed on rocky bed and have long life. In many tanks, fishing is also done. This supplements both the food resources and income of the farmer.

Drawbacks of Tank Irrigation: Major problem with tanks water storage is that tanks dry up during the dry season and fail to provide irrigation when it is needed the most. Silting of the tank bed is a serious problem and it requires de-silting of the tank at regular intervals. Much water is evaporated from the large expanse of shallow water and is therefore not available for irrigation. Tanks cover large areas of cultivable land. In many areas, other sources of irrigation have been adopted and the dry beds of tanks have been reclaimed for agriculture. Furthermore, lifting of water from tanks and carrying it to the fields is a tiring and expensive effort which discourages the use of tanks as a source of irrigation.

Micro-Irrigation or Localized irrigation:

Drip irrigation:

In the area of irrigation process, drip irrigation is modern technique. It is also called trickle irrigation, which was originally developed in Israel in the early 1960s and became popular in areas of water scarcity. The drip irrigation is the most competent and it can be practised in array of crops, especially in vegetables, orchard crops, flowers and plantation crops (Mamata Swain, 1999).

Drip irrigation was used to the ancient custom in certain parts of India of irrigating a tulsi plant kept in the courtyard. During the summer months, the plant was irrigated by a hanging pitcher containing water and a minute hole at its bottom to allow the trickling of water on to the plant. The tribal farmers of Arunachal Pradesh practised a primitive form of drip irrigation system using a slender bamboo as the conduit for water flow. The use of drippers in sub-surface irrigation network was first experimented in Germany in 1869. The noticeable growth of the petrochemical industry during and after the 1950s aided manufacturing of plastic pipes at a cost much cheaper than the cost of metallic or cement concrete pipes. Plastic pipes are convenient for water conveyance under pressure and the plastic material are easily formed into the desired configuration. These features of plastic made the field-scale use of drip irrigation practicable. The drip system was developed for field crops in Israel in the early 1960s and in Australia and North America in the late 1960s. The area under drip irrigation system in the USA is about 1 M ha, followed by India, Spain, and Israel. In India, there has been a tremendous growth in the area under drip irrigation during the last 15 years. At present, around 3.51akh ha area is under drip irrigation with the efforts of the Government of India, while it was only 40 ha in 1960. Maharashtra (94,000 ha), Karnataka

(66,000 ha) and Tamil Nadu (55,000 ha) are some of the states where large areas have been brought under drip irrigation. Many crops are irrigated by the drip method in India with the tree crops occupying the maximum percentage of the total area under drip irrigation, followed by vine crops, vegetables, field crops, flowers and other crops.

In drip irrigation, water is applied near the plant root through emitters or drippers, on or below the soil surface. The soil moisture is kept at an optimum level with frequent irrigations. In this method irrigation water is conveyed on the surface in 12 to 16 mm diameter tubing's fed from large feeder pipes. The water is allowed to drip or trickle slowly through the nozzle or orifices at practically zero pressure. In this way the soil in the root-zone of crops is constantly kept wet. Drip irrigation results in a very high water application efficiency of about 90-95 per cent.

The area under drip irrigation system in the USA is about 1 M ha, followed by India and other countries.

Major component of drip irrigation:

1. Pump station
2. By pass assembly
3. Control valves.
4. Filtration system
5. Fertilizer tank/venturi
6. Pressure gauge
7. mains/Sub mains
8. Laterals
9. Emitting devices
10. Micro tubes.

Pump station takes water from the source and provides the right pressure for delivery into the pipe system.

Control valves control the discharge and pressure in the entire system.

Filtration system cleans the water. Common types of filter include screen filters and graded sand filters which remove fine material suspended in the water.

Fertilizer tank/venturi slowly add a measured dose of fertilizer into the water during irrigation. This is one of the major advantages of drip irrigation over other methods.

Mainlines, submains and laterals supply water from the control head into the fields. They are usually made from PVC or polyethylene hose and should be buried below ground because they easily degrade when exposed to direct solar radiation. Lateral pipes are usually 13-32 mm diameter.

Emitters or drippers are devices used to control the discharge of water from the lateral to the plants. They are typically spaced more than 1 metre apart with one or more emitters used for a single plant such as a tree. For row crops more closely spaced emitters may be used to wet a strip of soil. Many different emitter designs have been produced in recent years. The basis of design is to produce an emitter which will provide a specified constant discharge which does not vary much with pressure changes, and does not block easily.

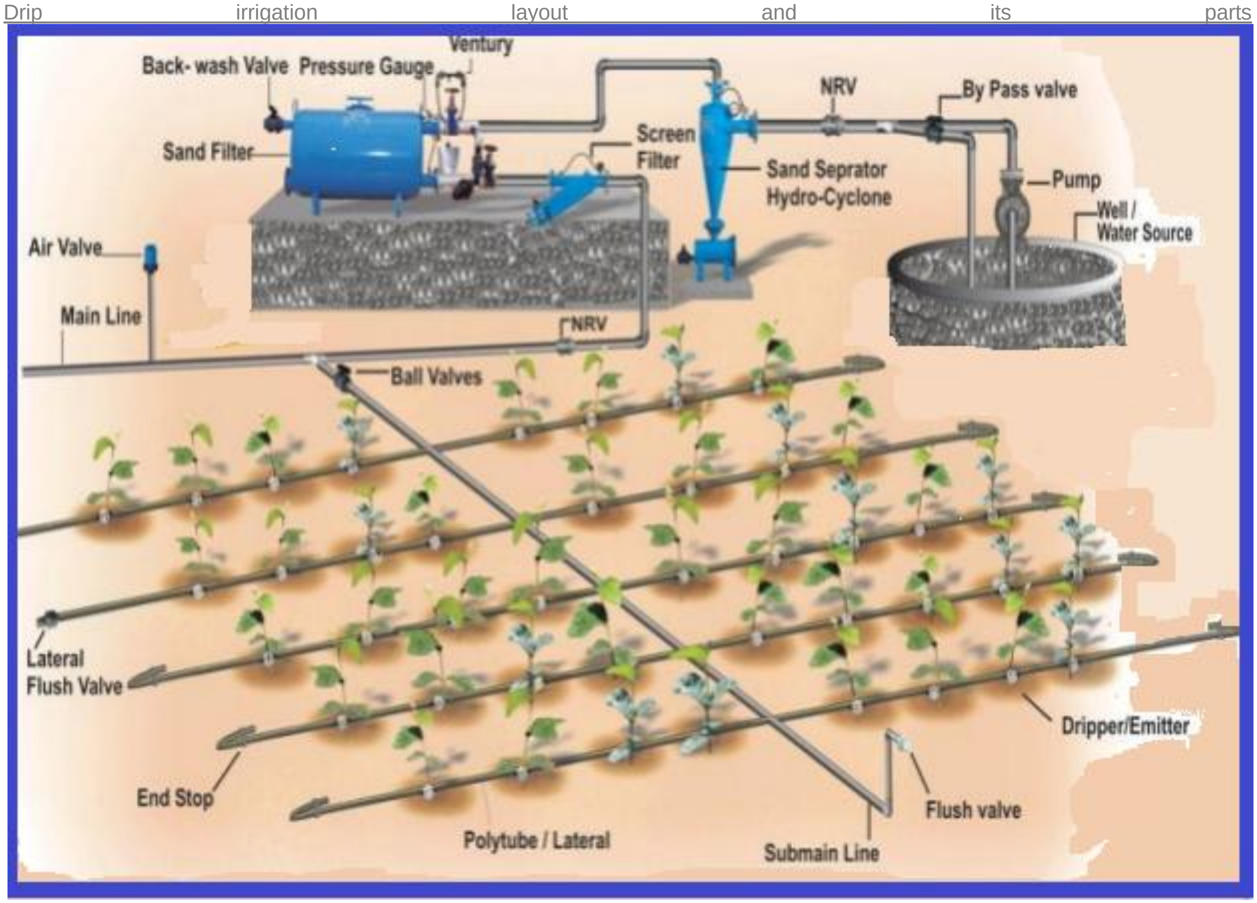
In India, there has been a fabulous growth in the area under drip irrigation during the last many years. At present, major area is under drip irrigation with the help of the Government of India. Reports indicated that Maharashtra (94,000 ha), Karnataka (66,000 ha) and Tamil Nadu (55,000 ha) are some of the states where large areas have been brought under drip irrigation. Many crops are irrigated by the drip method in India with the tree crops occupying the maximum percentage of the total area under drip irrigation, followed by vine crops, vegetables, field crops, flowers and other crops.

Crop suitable for drip irrigation:

1.	Orchard Crops	Grapes, Banana, Pomegranate, Orange, Citrus, Mango, Lemon, Custard Apple, Sapota Guava, Pineapple, Coconut, Cashewnut, Papaya, Aonla, Litchi, Watermelon, Muskmelon etc.
2.	Vegetables	Tomato, Chilly, Capsicum, Cabbage, Cauliflower, Onion, Okra, Brinjal, Bitter Gourd, Ridge Gourd, Cucumber, Peas, Spinach, Pumpkin etc.
3.	Cash Crops	Sugarcane, Cotton. Arecanut, Strawberry etc.
4.	Flowers	Rose, Carnation, Gerbera, Anthurium, Orchids, Jasmine, Dahilia, Marigold etc.
5.	Plantation	Tea, Rubber, Coffee, Coconut etc.
6.	Spices	Turmeric, Cloves, Mint etc,
7.	Oil Seed	Sunflower, Oil palm, Groundnut etc.
8.	Forest Crops	Teakwood, Bamboo etc.

The National Committee on Plasticulture Applications in Horticulture (NCPAH), Ministry of Agriculture, Government of India, has approximate a total of 27 million hectares area in the country that has the potential of drip irrigation application. Through this method, crops can be grown productively over the saline lands also. This technique has been beneficial in reclaiming and developing desert and arid areas. The main disadvantage of this method is that it is expensive. But with growing realisation of the value of water this method has been introduced in other countries of the world particularly in desert areas. The method is still in preliminary stages of development in nation.

Drip irrigation layout and its parts



The advantages of drip irrigation are under:

1. Possibility of using soluble fertilizers and chemicals.
2. Fertilizer and nutrient loss is minimized due to localized application and reduced leaching.
3. Water application efficiency is high.
4. Field levelling is not necessary. Fields with irregular shapes are easily accommodated.
5. Recycled non-potable water can be safely used.
6. Soil type plays less important role in frequency of irrigation.
7. Soil erosion is lessened.
8. Weed growth is lessened.
9. Water distribution is highly uniform, controlled by output of each nozzle.
10. Labour cost is less than other irrigation methods.
11. Variation in supply can be regulated by regulating the valves and drippers.
12. Plants remains dry, reducing the risk of disease.
13. Usually operated at lower pressure than other types of pressurised irrigation, reducing energy costs.

The shortcomings of drip irrigation are:

1. Initial cost can be more in this technique.
2. The sunrays can affect the tubes used for drip irrigation, shortening their usable life.
3. If the water is not properly filtered and the equipment not suitably maintained, it can result in blockage.

4. For subsurface drip the irrigator cannot see the water that is applied. This may lead to the farmer either applying too much water (low efficiency) or an insufficient amount of water, this is particularly common for those with less experience with drip irrigation.
5. Drip irrigation might be inadequate if herbicides or top dressed fertilizers need sprinkler irrigation for activation.
6. Drip tape causes extra clean-up costs after harvest. Users need to plan for drip tape winding, disposal, recycling or reuse.
7. Waste of water, time and harvest, if not installed properly. These systems require careful study of all the relevant factors like land topography, soil, water, crop and agro-climatic conditions, and suitability of drip irrigation system and its components.
8. In lighter soils subsurface, drip may be unable to wet the soil surface for germination. Requires careful consideration of the installation depth.

One of the main purposes of drip irrigation is to decrease the water consumption by reducing the leaching factor. However when the available water is of high salinity or alkalinity, the field soil becomes gradually unsuitable for cultivation due to high salinity or poor infiltration of the soil. Consequently, drip irrigation converts fields in to fallow lands when natural leaching by rain water is not adequate in semi-arid and arid regions.

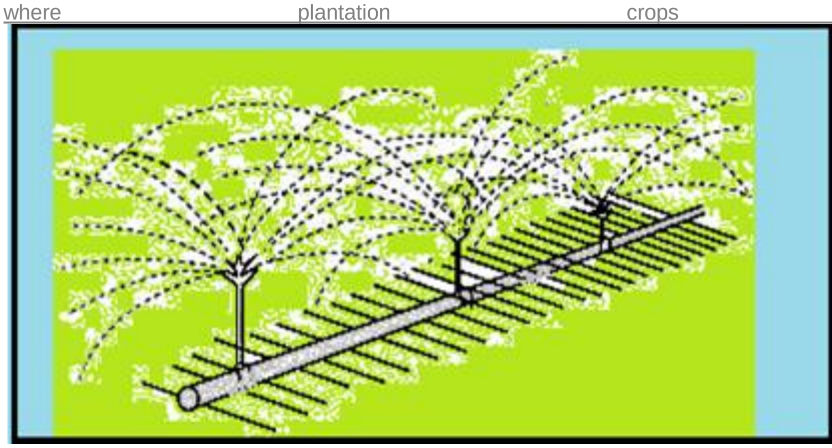
Most drip systems are designed for high efficiency and have little or no leakage. Without sufficient leaching, salts applied with the irrigation water may build up in the root zone. On the other hand, drip irrigation avoids the high capillary potential of traditional surface-applied irrigation, which can draw salt deposits up from deposits below. Drip irrigation systems cannot be used for damage control by night frosts.

Sprinkler Irrigation:

In the sprinkler technique of irrigation, water is sprinkled into the air and allowed to fall on the ground surface just like rainfall. The spray is done by the flow of water under pressure through small orifices or nozzles. The pressure is generally obtained by pumping. Through proper selection of nozzle sizes, operating pressure and sprinkler spacing the amount of irrigation water required to refill the crop root zone can be applied almost uniform at the rate to suit the infiltration rate of soil. In agriculture, almost all crops are suitable for sprinkler irrigation system except crops such as paddy and jute. The dry crops, vegetables, flowering crops, orchards, plantation crops like tea, coffee are all suitable and can be irrigated through sprinklers techniques of irrigation.

The sprinkler irrigation is categorized according to the functions which are mentioned as under:
1. The main irrigation system
2. The supplementary irrigation system
3. The protective irrigation system

The sprinkler irrigation system is effective for irrigation on uneven lands and on shallow soils. It is also suitable to coarse sandy terrain where the percolation loss is more and where as a consequence, the frequency of irrigation required is more. The sprinkler irrigation system is appropriate in rising and falling land where land shaping is expensive or technically not practicable. The elimination of fertile soil cover by land shaping is not advisable. Sprinkler irrigation system can also be espoused in hilly regions where plantation crops are grown.



Historical facts signified that though sprinkler irrigation system is known since 1946, yet the farmers started adopting it in huge scale only since 1980s. It began in the hilly areas of Western Ghats in states of Kerala, Tamil Nadu and Karnataka and in the North eastern states mainly for plantation crops like coffee, tea, cardamom, rubber. Gradually it spreads to the water scarcity and light soil states of Rajasthan and Haryana in addition to the black soil area of Madhya Pradesh.

Advantages of sprinkler irrigation:

1. Elimination of the channels for conveyance, therefore no conveyance loss.
2. It is Suitable to all types of soil apart from heavy clay.
3. It is appropriate technique for irrigating crops where the plant population per unit area is very high. It is most suitable for oil seeds and other cereal and vegetable crops.
4. It saves water.
5. With this technique of irrigation, there is control of water application convenient for giving light and frequent irrigation and higher water application efficiency.
6. Sprinkle irrigation increases in yield.
7. There is a mobility of system.
8. It may also be used for undulating area.
9. It saves land as no bunds are required.
10. This technique influences greater conducive micro-climate.
11. Areas located at a higher elevation than the source can be irrigated.
12. In this technique there is a possibility of using soluble fertilizers and chemicals.
13. In this method of irrigation there is less problem of clogging of sprinkler nozzles due to sediment laden water.
14. The overall cost of labour is generally reduced in this method of irrigation.
15. Erosion of soil cover which is common in surface irrigation can be reduced.

Disadvantages of sprinkler system:

1. In this technique, initial cost of implementation is high.
2. High and constant energy requirement for operation.
3. Under high wind condition and high temperature distribution and application efficiency is poor.
4. Highly saline water causes leaf burning when temperature is higher than 95 F.
5. When lands have been already levelled and developed for surface or other irrigation methods sprinkler irrigation is not so economical.
6. There is loss of water due to evaporation from the area during irrigation.

Other Irrigation methods:

Surge Irrigation: Surge Irrigation is an alternative of furrow irrigation where the water supply is pulsed on and off in planned time periods (e.g. on for 1 hour off for 1½ hour). The wetting and drying cycles reduce infiltration rates resulting in faster advance rates and higher uniformities than constant flow.

Ditch Irrigation: Ditch Irrigation is type of traditional method, where ditches are dug out and seedlings are planted in rows. The plantings are watered by placing canals or furrows in between the rows of plants. Siphon tubes are used to move the water from the main ditch to the canals.

Subirrigation or seepage irrigation: It is a system of irrigation where water is allowed to the plant root zone from below the soil surface and absorbed upwards. The excess may be collected for reuse. Subirrigation is used in growing field crops such as tomatoes, peppers, and sugar cane in areas with high water tables. Major benefits of this system are water and nutrient conservation, and labour-saving. The outfitting cost is comparatively high. Main problems include possibility of increased presence of disease in recycle water.

To summarize, Irrigation is a technique of supplying water to the dry land as a supplementation of rain water. It is mainly aimed for farming. There are various types of systems of irrigation practices in different parts of India. Irrigation in India is carried on through wells, tanks, canals, perennial canal, multi-purpose river valley projects. The irrigation engineer should be acquainted with the type of soil moisture, quality of irrigation water, frequency of irrigation for the proper implementation of irrigation system

CANAL:-

A canal is an artificial channel generally trapezoidal in shape constructed on the ground to carry water to the field either from the river of from a reservoir.

Classification of CANAL:-

➢Classification based on the nature of source of supply:-

1. Permanent Canal.
2. Inundation Canal.

➢Classification based on the financial output:-

1. Productive Canal
2. Protective Canal

Classification of CANAL:-

➢ Classification based on function of the canal:-

1. Irrigation Canal
2. Carrier Canal
3. Feeder Canal
4. Navigation Canal
5. Power Canal

➢ Classification based on boundary surface of canal:-

1. Alluvial Canal
2. Non- Alluvial Canal
3. Rigid Boundary Canal

Canal Lining

• It is the treatment given to the canal bed and banks to make the canal section impervious. The lineds

• **Canal lining** is the process of reducing seepage loss of irrigation water by adding an impermeable layer to the edges of the trench.

• Seepage can result in losses of 30 to 50 percent of irrigation water from canals, so adding lining can make irrigation systems more efficient. Common lining materials include compacted earth, concrete, and plastic membranes.

Advantages of Lining

- **Canal linings increase available head for power generation.**
- **Canal linings make the canal section stable.**
- **Canal linings prevent bank erosion and breaches.**
- **Canal linings assure economical water distribution**
- **Canal linings reduce maintenance costs**