CE8603 IRRIGATION ENGINEERING

UNIT-1 CROP WATER REQUIREMENT

IRRIGATION DEFINITION:

- **Irrigation may be defined as the process of artificially supplying water to soil for raising crops. It is a science of planning and designing an efficient, low-cost, economic irrigation system to fit for natural conditions.**
- **It is the engineering of controlling and harnessing the various natural sources of water, by construction of dams and reservoirs, canals and head works and finally distributing the water to agricultural fields.**
- **Irrigation engineering includes the study and design of works in connection with river control, drainage of water-logged areas, and generation of hydroelectric power.**

NECESSITY

- **India is an agricultural country, and all its resources depend on the agricultural output. Water is the most vital element in the plant life. Water is naturally supplied to the plants by nature through rainfall.**
- **Total rainfall in a particular area is insufficient or ill-timed. To get the maximum yield, it very essential to supply the optimum quantity of water, and correct timing of water. This is possible through a systematic irrigation system.**

SYSTEMATIC IRRIGATION SYSTEM

It is the process of collecting water during the periods of excess rainfall and releasing it to the crops when it is needed.

REASONS

- **Less rainfall – Total rainfall is less than for the crop, artificial supply is necessary. In this case irrigation works constructed where more water is available.**

EXAMPLE: Rajasthan canal – it conveys water to arid zones of Rajasthan, where the annual rainfall hardly exceeds 100 to 200mm.

- **Non-Uniform rainfall – Rainfall in particular area may not be uniform over the crop period.**

  EXAMPLE: The early period crops rainfall will be available but at the end there will no rain fall and at last the plants may die altogether. During the early rainfall period we can collect the excess rainfall period and then the collected water is supplied to the crops during the no rainfall.

- **Growing a number of crops during a year – Rainfall in particular area it can be sufficient to raise only one type of crops during the rainy seasons.**

  EXAMPLE: Kharif crops – no irrigation may be required.

  Rabi crops – the provision of irrigation facilities in that area, crops can be raised in other season.

- **Growing perennial crops – Perennial crops such as sugar cane etc, this crop need water throughout the year, this can be achieved by provision of irrigation facilities in the area.**

- **Commercial crops with Additional Water – Rainfall in particular area may be sufficient to raise the usual crops, but more water is necessary for raising commercial and cash crops.**

- **Controlled water supply – Construction of proper distribution system, the yield of ccrops may be increased because of controlled supply water.**

IMPORTANCE OF IRRIGATION – STATED BY SHRI N.D. GULATI:

> **"Irrigation in many countries is an old art – as old as civilization- but for the whole world it is modern science – the science of survival".**

ADVANTAGES OF MODERN METHODS:

- **Supply the moisture essential for the plant growth.**
- **Save the crops from drying during short duration droughts**
- **Cools the soil and atmosphere**
- **Make more favourable environment for plant growth**
- **Dilutes salts in the soil.**
- **Reduces the hazard of soil piping.**
- **Softens the tillage pans.**

SCOPE OF IRRIGACE SCIENCE:

- **It deals with all aspects and problems extending from the watershed to the agricultural farms.**
- **It deals with the design and construction of all works, such as dams, weirs, head regulators etc.**

KNOWLEDGE OF IRRIGATION ENGINEER:

An irrigation engineer must have the required knowledge of cultivation of various crops, their maturing and protection from pests.

CLASSIFICATION:

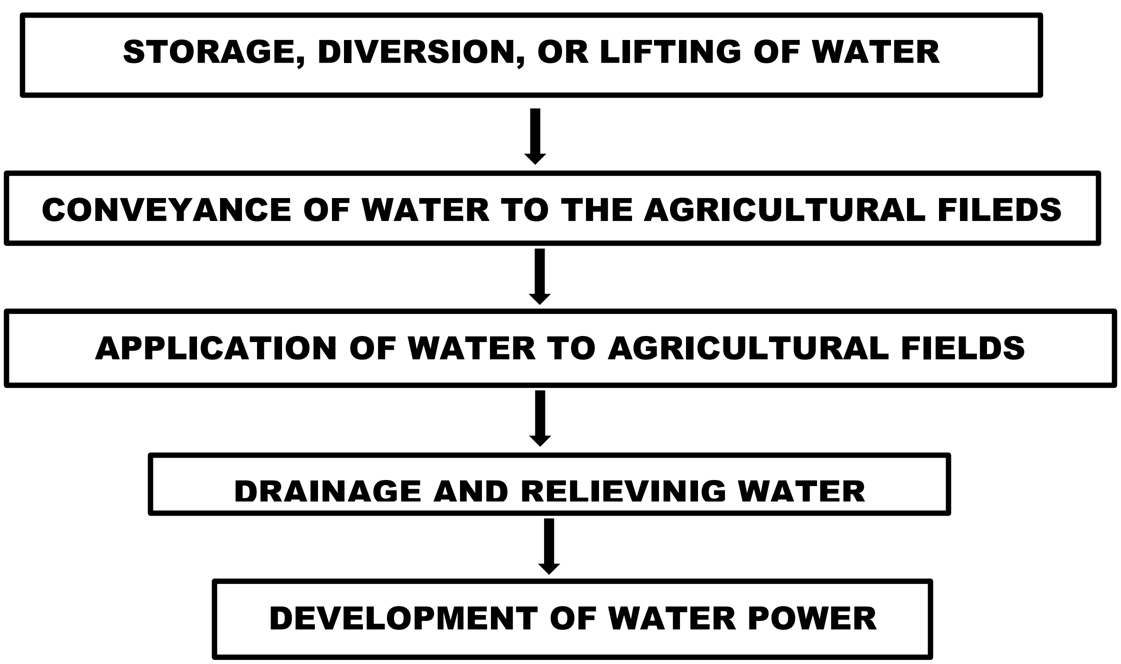
(A) Engineer Aspect:

- **Storage or lifting of water is the first phase of irrigation engineering. By the construction of a dam across the river, a suitable reservoir can be created and water can be stored. Water can be lifted and fed to small channels or pipes.**
- **Conveyance of water to agricultural fields that is stored water can be distributed through some distribution of system. This is**

the second phase includes the design and construction of suitable canal system, along with various regulatory works such as head regulators, cross regulators, fall, etc. for the efficient work working of the canal.

- The water is applied to the crop by flooding, furrows, corrugations, subsoil irrigation or by sprinkling.
- Drainage and relieving water-logging is the proper disposition of excess water by suitable drainage methods is very important. The design of surface and sub-surface drainage system is of vital importance in maintaining the high productivity of irrigated lands.
- Development of water power associated with the irrigation projects with the generation of hydroelectric power at dam site or canal falls.

FLOW PROCESS



(B) AGRICULTURAL ASPECT

- **Proper depths of water necessary in single application of water for various crops.**
- **Distribution of water uniformly and periodically.**
- **Capacities of different soil for irrigation of water and flow of water in soils.**
- **Reclamation of waste and alkaline lands, where this can be carried out through the agency of water.**

BENEFITS OF IRRIGATION:

All irrigation schemes are designed that they increase the food production of the country.

- **Increase in food production**
- **Protection from famine**
- **cultivation of cash crops**
- **elimination of mixed cropping**
- **addition to the wealth of the country**
- **increase in prosperity of people**
- **Generation of hydro-electric power**
- **domestic and industrial water supply**
- **inland navigation**
- **canal plantations**
- **improvements in the ground water storage**
- **aid in civilization**
- **general development of the country**

ILL-EFFECTS OF IRRIGATION:

Excess irrigation and unscientific use of irrigation may give rise to ill-effects they are:

- **Breeding places of mosquitoes: caused by leakage of water, ponds and depressions get filled up with water and create** breeding places for mosquitoes. Then if canal is leaky, mosquitoes breed all along the canal and spread malarial conditions.

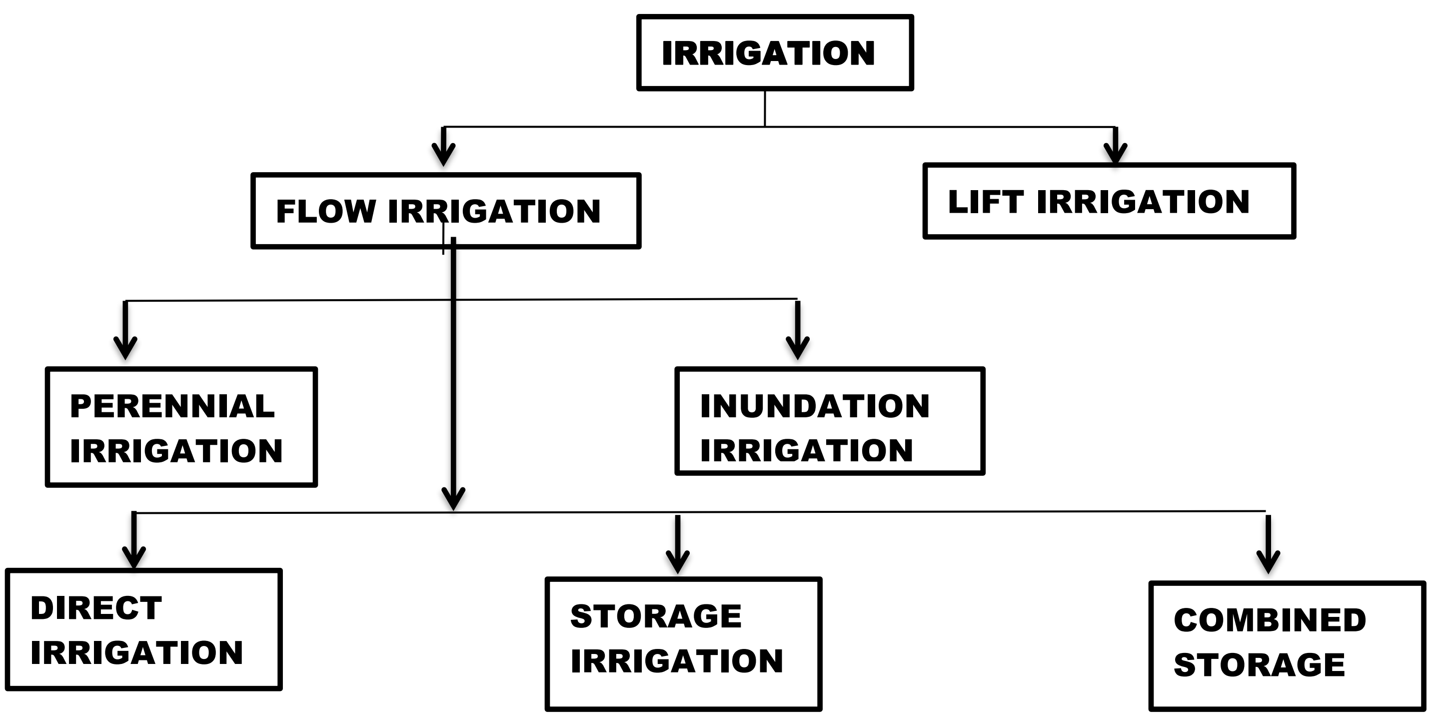
- **Water-logging:** water table is near the ground surface, over irrigation my raise the water table. This saturates the crop root-zone completely, causes efflorescence and the whole area become water logged.
- **Damp climate:** The areas which are already damp and cold, become damper and colder due to irrigation.

TYPES OF IRRIGATION:

Irrigation can be classified into two types they are:

(A) Flow Irrigation (B) Lift Irrigation

FLOW CHART:



FLOW IRRIGATION

It is the type of irrigation in which supply of water available is at such a level that it is conveyed on to the land by the gravity flow.

Flow irrigation is further classified into two divisions they are:

(A) Perennial irrigation system (B) Inundation or flood irrigation system

(A) PERENNIAL IRRIGATION:

- **The water required for irrigation is supplied in accordance with the crop requirements throughout the crop period.**
- **For such a system some storage heads works, such as dams and storage weirs or barrages are required to store the excess water during floods and release it to the crops and when it is required.**

(B) INUNDATION IRRIGATION:

- **It is carried out by deep flooding and thorough saturation of the land to be cultivated which is then drained off prior to the planting of the crop.**

Depending on the source of water is drawn flow irrigation can be further subdivided into three types:

- **Direct irrigation(River canal irrigation): Diversion scheme**
- **Storage irrigation(Reservoir or tank irrigation): Storage scheme**
- **Combined storage and diversion scheme**

(1) DIRECT IRRIGATION:

- **Water is directly diverted to the canal without attempting to store the water. For such a system a low diversion weir or diversion barrage is constructed across the river. This raises the water level in the river and thus diverts the water to the canal taking off upstream of the weir.**

- **Generally a direct irrigation scheme is of a smaller magnitude, since there are no rigid controls over the supplies. One or two main canals may take off directly from the river.**
- **Cross-drainage works are constructed wherever natural drains or distributary streams cross the canals. In a bigger scheme, there may be branch canal taking of from the main canal.**

(2) STORAGE IRRIGATION OR TANK IRRIGATION:

- **In storage irrigation system, a solid barrier, such as a dam or a storage weir is constructed across the river and water is stored in the reservoir or lake so formed.**
- **Depending upon the water requirements of crops, or hydroelectric power generation, and upon the flow of water in the river, the volume of storage required is decided. From the contour plan of the basin at the site of construction, the elevation storage curve for the reservoir is known.**
- **The height of the dam is then decided from this curve, corresponding to the storage-volume required. In India, most of the irrigation schemes fall under this category.**

(3) COMBINED SYSTEM

- **We have seen that in the storage irrigation system, water is stored in the reservoir, since the river is not perennial, while in the direct irrigation system, the river is perennial and hence the water is diverted from the river to the canal.**
- **Sometimes, a combined scheme is adopted in which the water is first stored in the reservoir formed at the upstream side of the dam, and this water is used for the water power generation.**
- **The discharge from the power house is fed back into the river, to the downstream side of the dam. Thus, sufficient quantity of flow is again available in the river.**

- **At a suitable location in the downstream, a pick-up weir is constructed. This weir diverts the water from the river to the canal.**
- **One typical example of such a scheme is the Kota dam and Kota barrage on Chambal river in Rajasthan.**

(B) LIFT IRRIGATION:

- **Lift irrigation is practiced when the water-supply is too low level to run by gravitation onto the land. In such a circumstances water is lifted up by mechanical means.**
- **Irrigation from wells is an example of lift irrigation, in which sub-soil water is lifted up to the surface and is then conveyed to the agricultural fields.**

UNIT-2 IRRIGATION METHODS

TANK IRRIGATION:

Tank irrigation may be defined as the storage irrigation scheme, which utilizes the water stored on the upstream side of a smaller earth dam, called bund. These bund reservoirs are called as tanks, specifically iin South India.

There is no technical difference between a ‘reservoir’ and a ‘tank’ except that a large-sized tank will be termed as a reservoir. Reservoir will generally formed by dams of any material such as masonry dam, concrete dam, or earth dam.

A tank is generally formed by earth dams only and these earthen bunds, spanning across the streams, are called tank bunds or tank banks.

DEPTH OF TANKS:

Tanks of south India possess a maximum depth of 4.5m and few as deep as 7.5 to 9m and only few exceptional ones exceed 11m in depth. When the depth of the tank exceeds 12m or so, the tank is generally referred as reservoir.

DEFINITION:

Tank irrigation can be defined as a miniature version of large dam. Water is impounded behind an earthen embankment to be released through sluices into canals be further distributed to irrigation lands.

ADVANTAGES OF TANK IRRIGATION:

- Appropriate irrigation devices in the cultivation of paddy.
- Flood control device
- Insurance against low rainfall periods and also recharged ground water

- Device to protect the ecosystem.

TANK DESIGN:

A tank with the least length for the maximum depth of the embankment would provide maximum storage per unit length would cause least submergence and most economical

Generally tanks are prepared for paddy cultivation and shapes, length of embankment determine the cost of construction of a tank.

During British period some tanks were constructed but they were constructed for drinking purpose or leisure spot and tanks were also constructed based on the requirements of farmers. Based on water availability and rainfall pattern.

LEARNING:

Traditional technique - some cases are as good as modern technique and modify traditional technique to suit local situation. Then need to preserve traditional techniques.

WELL IRRIGATION:

A well is a small hole dug in the ground from which sub-soil water is taken out for irrigation. An ordinary well is about 3to 5 metres deep, but can reach up to a depth of 15 metres. This well irrigation is widely practiced in those areas where sufficient sweet ground water is available.

CLASSIFICATION:

Wells are classified into two types:

- **Open wells (Dug wells)**
- **Tube wells**

OPEN WELL:

Open wells which have comparatively large diameters and lower discharges. Usually they have discharge of 20 m3/hr but if constructed by efficient planning it gives discharge of 200-300 m3/hr. They are constructed of diameter of about 1-10m and have depth of about 2-20m. They are constructed by digging therefore they are also known as dug wells.

CLASSIFICATION OF OPEN WELL BASED ON DEPTH:

SHALLOW OPEN WELL:

These are the wells resting on the water bearing strata and gets their supplies from the surrounding materials.

DEEP OPEN WELL:

These are the wells resting on the impervious layer known and Mota layer and gets their supply from this layer.

CLASSIFICATION BASED ON TYPE OF WALL:

KACHHA WELLS: These types of wells are only constructed when water table is high as these high as these type of wells sometimes collapses.

WELLS WITH IMPREVIOUS LINING: These are most suitable and stable type of open well. These are constructed by first digging a pit then a curb which is a circular ring with sharp bottom is inserted. Then a masonry wall up to some distance above ground is constructed, then as excavation proceeds it sinks blow and then masonry is further extended and well is constructed. As water enters from the bottom type of flow is potential.

WELL WITH PERVIOUS LINING:

These types of wells are suitable in coarse formations these are constructed by masonry of dry bricks or stones without any binding materials. So the water supply enters from the wall of well therefore the flow is radial. Such wells are provided with bottom plug on the flow is not combination of radial and spherical.

TUBE WELLS:

A tube well is a long pipe sunk is ground intercepting one or more water bearing strata. As compared to open well there diameter is less about 80-600mm.

CLASSIFICATION BASED ON DEPTH:

SHALLOW TUBE WELL: These are the tube which has depth limited to 30 meters and maximum have discharge of 20m3/hour.

DEEP TUBE WELL: These are the tube wells which have maximum depth of about 600m and may give discharge more then 800m3/hour.

CLASSIFICATION BASED ON SUPPLY SYSTEM:

STRAINER TYPE TUBE WELL:

These are most commonly used tube such that in general a tube well means strainer tube well. In this type well a strainer which a wire mesh with small openings is wrapped around the main pipe which also has large openings such that area of opening in strainer and main pipe remains same. Annual space is left between two strainer so that the open area of pipe perforation is not reduced. The type of flow is radial.

CAVITY TUBE WELL:

A cavity tube well consists of pipe sunk in ground up to the hard clay layer. It draws water from the bottom of well. In initial stages fine sand is also pumped with water and in such manner a cavity is formed at the bottom so the water enters from the aquifer into the well through this cavity.

IRRIGATION METHODS:

Irrigation water may be applied to the crops by three basic methods:

(a) SURFACE IRRIGATION: Just flooding water – about 90% of the irrigated areas in the world are by this method.

(b) SPRINKLER IRRIGATION: Applying water under pressure - about 5% of the irrigated areas by this method.

(c) SUB-SURFACE IRRIGATION: Flooding water underground and allowing it to come up by capillarity to crops roots.

CHOICE OF IRRIGATION METHODS:

The following criteria should be considered:

- **Water supply available**
- **Topography of area to be irrigated**
- **Climate of the area**
- **Soils of the area**
- **crops to be grown**
- **economics**
- **Local traditions and skills**

INFORMATION TO BE COLLECTED ON VISIT A PROPOSED IRRIGATION SITE:

(A) SOIL PROPERTIES:

Texture and structure, moisture equilibrium points, water holding capacity, agricultural potential, land classification, kinds of crops that the soil can support.

(B) WATER SOURCE:

Water source availability e.g. surface water, boreholes etc, hydrologic data of the area, water quantity, water quality, e.g. sodium adsorption

ratio, salt content, boron, etc; possible engineering works necessary to obtain water.

(C) WEATHER DATA:

Temperature, relative humidity, sunshine hours and rainfall.

(D) TOPOGRAPHY E.G. SLOPE:

This helps to determine the layout of the irrigation system and method of irrigation water application suited for the area.

(E) HISTORY OF PEOPLE AND IRRIGATION IN THE AREA:

Check past exposure of the people to irrigation and land tenure and level of possible re-settlement.

(F) INFORMATION ABOUT CROPS GROWN IN THE AREA:

Check preference by people, market potential, adaptability to area, water demand, growth schedules and planting periods.

SURFACE IRRIGATION METHODS:

Their main classification of surface methods is as follows:

- Free flooding
- border flooding
- check flooding
- basin flooding
- furrow irrigation
- drip irrigation

(1) FREE FLOODING:

Free flooding can be defined as ditches are excavated in the field either on the contour or up and down the slope. It is also called wild flooding, since no attempt is made to control the flow by means of levees, etc.

CHARACTERISTICS:

- **Land preparation cost is low**
- **Labour requirements are usually high**
- **Water application efficiency is also low.**
- **Most suitable for close growing crops, pastures, etc, particularly where the land is steep.**
- **Spacing between contour ditches/laterals/subsidiary ditches is kept 20 to 50 m.**

(2) BORDER FLOODING OR BORDER STRIP METHOD:

In this method, the land is divided into a number of strips, separated by low levees called borders. Strip size: 10 to 20m wide, and 100 to 400m long.

To prevent water from concentrating on either side of the border, the land should be leveled perpendicular to the flow. Water is made to flow from the supply ditch into each strip. The water flows slowly towards the lower end, and infiltrates into the soil as it advances.

When the advancing water reaches the lower end of the strip, the supply of water to the strip is turned off. The supply ditch also called irrigation stream may either be in the form of an earthen channel or an underground concrete pipe having risers at intervals.

The size of the supply ditch depends upon the infiltration rate of the soil, and the width of the border strip. Coarse textured soils with high infiltration rates will require high discharge rate and therefore larger supply ditch, in order to spread water over the entire strip rapidly and

to avoid excessive losses due to deep percolation at the upper reaches.

On the other hand, fine textured soils with low infiltration rates, require smaller ditches to avoid excessive losses due to run off at the lower reaches.

A relationship between the discharge through the supply ditch (Q), the average depth of water flowing over the strip(Y), the rate of infiltration of the soil(f), the area of the land irrigated(A), and approximate time required to cover the given area with water (t) is given by the equation:

$$t = 2.3\frac{y}{f}log10\left(\frac{Q}{Q - fA}\right)$$

where,

Q= Discharge through the supply ditch

f= Rate of infiltration of soil

y= Depth of water flowing over the border strip

A= Area of land strip to be irrigated

t= Time required to cover the given area A.

(3) CHECK FLOODING:

Check flooding is similar to ordinary flooding except that the water is controlled by surrounding the check area with low and flat levees. Levees are generally constructed along the contours, having vertical interval of about 5 to 10 cm. These levees are connected with cross-levees at convenient places. In check flooding the check is filled with water at a fairly high rate and allowed to stand until the water infiltrates.

This method is suitable for more permeable soils as well as for less permeable soils. The water can be quickly spread in case of high permeable soils, this reducing the percolation losses.

The water can also be held on the surface for a longer time in case of less permeable soils, for assuring adequate penetration. These checks, are sometimes used to absorb water, where the stream-flow is diverted during the periods of high run off.

(4) BASIN FLOODING:

This method is a special type of check flooding and is adopted specially for orchard trees. One or more trees are generally placed in the basin, and the surface is flooded as in check method, by ditch water.

(5) FURROW IRRIGATION METHOD:

In flooding methods water covers the entire surface, while in furrow irrigation method only one-fifth to one-half of the land surface is wetted by water.

It therefore, results in less evaporation, less pudding of soil and permits cultivation sooner after irrigation. Furrows are narrow fields ditches, excavated between rows of plants and carry irrigation water through them.

Spacing of furrows is determined by the proper spacing of the plants. Furrows vary from 8 to 30 cm deep and may be as much as 400m long. Excessive long furrows may result in too much percolation near the upper end, and too little water near the down-slope end. Deep furrows are widely used for row crops.

Small shallow furrows called corrugations are particularly suitable for relatively irregular topography and close growing crops, such as meadows and small grains.

Water may be diverted into the furrows by an opening in the bank of the supply ditch or preferably by using a rubber hose tubing, which can be primed by immersion in the ditch.

The use of hose, prevents the necessity of breaking the ditch bank, and provides a uniform flow into the furrow.

(6) DRIP IRRIGATION METHOD:

Drip irrigation, also called trickle irrigation, is the latest field irrigation technique and is meant for adoption at places where there exists acute scarcity of irrigation water and other salt problems.

In this method, water is slowly and directly applied to the root zone of the plants, thereby minimizing the losses by evaporation and percolation.

Drip irrigation was first introduced in Israel, but practiced in many countries of the world. Along with the irrigation water, nutrients are also fed to the system.

Water is first filtered so that the impurities may not clog the fine holes of the drippers. The whole arrangement consists of the following components:

- a pump to lift water
- a head tank to store the water and to maintain a pressure head of 5 to 7m.
- central distribution system which filters the water, adds nutrients and regulates the pressure and amount of water to be applied.
- mains and secondary line made of polyethylene, polyvinyl chloride or alkathyelene material. The diameter of the piping may vary from 20mm to 40mm. A water meter may be fixed to the beginning of the mains.

- **Trickle lines consisting of 10 to 20mm dia. PVC pipes with perforations at a distance equal to the spacing of the crops. The trickle lines are fitted to the secondary lines at a distance equal to the row spacing of the crops, which may vary between 60cm to 90cm for most of the crops.**
- **Plastic nozzles having perforations attached to the trickle line. The perforations are so designed that water leaves the nozzles at a very slow rate, usually ranging between 2 to 10 liters per hour, depending upon the irrigation requirements of the crops. It is also suitable to all climatic conditions and to all types of soils. However it is most suited coarse sandy formations.**

ADVANTAGES OF DRIP IRRIGATION SYSTEM:

- **Less requirement of irrigation water.**
- **water supply at optimum level**
- **water logging avoided**
- **High yield and cultivation of cash crops**
- **No over-irrigation and variation in application rate**
- **Weed control and increase in net irrigable area.**
- **Nutrients preservation and effective pest control**
- **Reduce labour cost and no soil erosion**
- **Suitablility for saline soils and maintenance of high surface temperature**
- **Suitable for any topography**

DISADVANTAGES PF DRIP IRRIGATION SYSTEM:

- **High initial cost**
- **Danger of blockade of nozzles**
- **change in spacing nozzle**

SPRINKLER IRRIGATION METHOD:

- **In this farm-water application method, water is applied to the soil in the form of a spray through a network of pipes and pumps. It is a kind of an artificial rain and therefore, gives very good results.**
- **It is costly process and widely used in U.S.A. and it can be used for all types of soils, different topographies and slopes.**
- **It can advantageously be used for many crops, because it fulfills the normal requirement of uniform distribution of water. This method possesses great potentialities for irrigating the areas, where other types of surface or sub-surface irrigation are very difficult.**
- **Despite numerous advantages, this method has not become popular in Pakistan for the simple reason of cost and a lot of technical requirements. The correct design and efficient operation are very important for the success of this method.**
- **Special steps have to be taken for preventing entry of slit and debris, which are very harmful for the sprinkler equipment.**
- **Debris-choke nozzle, interfere with the application of water on the land, while the abrasive action of slit causes excessive wear on pump impellers, sprinkler nozzles and bearings.**
- **The system is to be designed in such a way that the entire sprayed water seeps into the soil, and there is no run off from the irrigated area.**
- **In sprinkler irrigation network, we have the mains and the sub-mains though which water under pressure is made of low. Revolving sprinkler heads are then usually mounted on rising pipes attached to the laterals.**
- **The water jets come out through the revolving sprinkler heads, with force. When the sprinkler head are not provided perforations are made in then pipes and they are provided with nozzles, through which water jets out and falls on the ground.**

- **Generally such a perforated pipe system operates low heads, whereas the revolving head sprinklers operate on high as well as low heads, depending upon the type of rotary head used.**

ADVANTAGES OF SPRINKLER IRRIGATION:

- **Erosion can be controlled.**
- **Uniform application for water is possible**
- **Land preparation is not required.**
- **Small streams of irrigation water can be used efficiently.**
- **Crop damage from frost can be reduced.**
- **It is a stand-by drainage pumping plant.**

LIMITATIONS:

- **Wind may distort sprinkling pattern.**
- **A constant water supply is needed for commercial use of equipment.**
- **Water must be clean and free from sand.**
- **The power requirement is high**

IRRIGATION SCHEDULING CRITERIA:

(a) SOIL WATER REGIME

- **Feel and appearance**
- **Depletion of available soil moisture**
- **Soil moisture tension**

(b) CLIMATOLOGICAL

- **Cumulative pan evaporation**
- **IW/CPE ratio**

(c) Plant indices

- **Visual symptoms and plant population**
- **Growth rate and plant water potential**

UNIT-3 DIVERSION AND IMPOUNDING STRUCTURES

DAMS:

A dam is a hydraulic structure of fairly impervious material built across a river to create a reservoir on its upstream side for impounding water for various purposes. These purposes may be irrigation hydro-power, water supply, flood control, navigation, fishing and recreations.

BASED ON FUCTIONS OF DAMS- CLASSIFICATION:

(1) STORAGE DAMS:

They are constructed to store water during the rainy season when there is a large flow in the river. Many small dams impound the spring runoff for later use in dry summers. Storage dams may also provide a water supply, improved habitat for fish and wildlife.

They may store water for hydroelectric power generation, irrigation or for a flood control project. Storage dams are the most common type of dams and in general the dam means a storage dam.

(2) DIVERSION DAMS:

A diversion dam is constructed for th purpose of diverting water of the river into an off taking canal. They provide sufficient pressure for pushing water into ditches, canals, or othery conveyance systems. Such shorter dams are used for irrigation and for diversion from a stream to a distant storage reservoir.

It is usually of low height and has a small storage reservoir on its upstream. The diversion dam is a sort of storage weir which also diverts water and has a small storage.

(3) DETENTION DAMS:

Detention dams are constructed for flood control. A detention dam retards the flow in the river on its downstream during floods by storing

some flood water. Thus the effect of sudden floods is reduced to some extent. The water retained in the reservoir is later released gradually at a controlled rate according to the crying capacity of the channel downstream of the detention dam. Thus the area downstream of the dam is protected against flood.

(4) DEBRIS DAMS:

A debris dam is constructed to retain debris such as sand, gravel and drift wood flowing in the river with water. The water after passing over a debris dam relatively clear.

(5) COFFER DAMS:

It is an enclosure constructed around the construction site to exclude water so that the construction can be done in dry. A coffer dam is thus temporary dam constructed for facilitating construction.

BASED ON STRUCTURE AND DESIGN DAMS CAN BE CLASSIFIED AS FOLLOWS:

(1) GRAVITY DAMS:

A gravity dam is a massive sized dam fabricated from concrete or stone masonry. They are designed to hold back large volume of water. By using concrete, the weight of the dam is actually able to resist the horizontal thrust of water pushing against it. This is why it is called a gravity dam. Gravity is essentially hold sthe dam down to the ground. Stopping water from toppling it over.

Gravity dams are well suited for blocking rivers ini wide valleys or narrow gorge ways. Since gravity dams must rely on their own weight to hold back water. It is necessary that they are built on a solid foundation of bedrock.

EXAMPLES:

GRAND COULEE DAM (U.S.A.), Nagarjuna Sagar (INDIA) AND Itaipu dam.

FORCES ACTING ON A GRAVITY DAM:

- **Water pressure**
- **Weight of dam**
- **uplift pressure**
- **ice pressure**
- **Slit pressure**
- **Wave pressure and wind pressure.**

DESIGN OF THE EARTH DAMS:

Earthen dams have been constructed from long past. They are constructed with the natural materials. The construction of earthen dam, upto 1930, was based mostly on experience. But now with the advance knowledge soil mechanics, these dams are designed and constructed on scientific basis. With the increased knowledge the behavior of soils and the development of earth moving machinery earth dams can be constructed economically even up to the height o 250m to 300 m.

MATERIALS OF EARTHEN DAMS:

Earthen dam require very large quantity of materials. It is necessary to utilize the soils available in large quantities near the site. In general earth dams can be designed to fulfill its unction satisfactorily with any type of material available.

The following materials are commonly used:

- **Clayey material**
- **Black cotton soil, silty clayey loam, for heating and cutoff.**
- **Sandy material**
- **Murum, soft rock, sandy silt, for casting rock**
- **For pitching and riprap, rock masonry, etc.**

- **Sand and filters, seepage drain and masonry**
- **Cement, steel, lime, and other building materials in small quantities for the construction of spillway, outlets, etc.**

TYPES OF EARTHEN DAMS:

Depending upon the mode of construction earthen dams are classified as

- **Homogeneous Type**
- **Zone Type**

ARCH DAMS:

An arch dam is a solid dam made of concrete that is curved upstream in plan. The arch dam is designed so that the force of the water against it, known as hydrostatic pressure, presses against the arch, compressing and strengthening the structure as it pushes into its foundation or abutments.

An arch dam is most suitable for narrow gorges or canyons with steep walls of stable rocks to support the other dam types, they require much less construction material, making them economical and practical in remote areas.

CLASSIFICATION:

In general arch dams are classified based on the ratio of the base thickness of the structural height as thin for breath or height less than 0.2. Medium-thick for b/h between 0.2 and 0.3 and thick for b/h ratio over 0.3

Arch dams classified with respect to their structural height are:

- **Low dams up to 100 feet**
- **Medium high dams between 100-300 feet**
- **High dams are above 300 feet.**

LOADS:

The main loads for which an arch dam is designed are:

- **Dead load**
- **Hydrostatic load generated by the reservoir and the tail water**
- **Temperature load**
- **Earthquake load**

DIVERSION OF HEAD WORKS:

An hydraulic structure which supplies water to the off-taking canal is called a head work.

CLASSIFICAION:

Head work may be divided into two

(a) Storage head work

(b) Diversion head work

(a) STORAGE HEAD WORK:

Dam is constructed across a river valley to form storage reservoir, known as storage head works. Water is supplied to the canal from this reservoir through canal regulator.

(b) Diversion head work

Weir or barrage is constructed across a perennial river to raise water level and to divert he water o canal, is known as diversion head work. Flow of water in the canal is controlled by canal head regulator.

UNIT-4 CANAL IRRIGATION

CANALS:

A canal is an artificial channel, generally trapezoidal in shape constructed on the ground to carry water to the fields either from the river or from a tank or reservoir.

CLASSIFICATION based on the nature of source of supply:

- **Permanent canal**
- **Inundation canal**

CLASSIFICATION based on financial output:

- **Productive canal**
- **Protective canal**

CLASSIFICATION based on function of the canal:

- **Irrigation canal**
- **Feeder canal**
- **Power canal**
- **Carrier canal**
- **Navigation canal**

CANAL REGULATION AND CROSS DRAINAGE WORKS

The available natural ground slope is steep than the designed bed slope of the channel, the difference is adjusted by constructing vertical "falls" or drops in the canal bed at suitable intervals. Such drop in a natural canal bed will not be stable and therefore a masonry structure is constructed. Such structure called a canal drop.

TYPES OF CANAL FALL:

Depending on the ground level conditions and shape of the fall the various types of fall are:

OGEE FALL:

The Ogee fall was constructed by Sir Proby Caultey on the Ganga canal. This type of fall has gradual convex and concave surfaces they are in the ogee form.

STEPPED FALL:

It consists of a series of vertical drops in the form of steps. The steps is suitable in places where sloping ground is very long and require a long glacis to connect the higher bed level with lower bed level.

CANAL ESCAPE:

It is a side channel constructed to remove surplus water from an irrigation channel into a natural drain. The water in the irrigation channel may become surplus due to mistakes, excessive rainfall in the upper reaches and difficulties in regulation at the head.

CANAL DRAINAGE WORKS:

Irrigation canals carrying water from head works to crop field, have to cross few natural drainage streams, to cross those drainage safely by the canals, some suitable structures are required to construct drainage called Cross Drainage Works (CDWs).

TYPES OF CROSS DRAINAGE WORKS:

Type 1 – irrigation canal passes over the drainage

- Aqueduct
- Siphon Aqueduct

Type 2 – Drainage passes over the irrigation canal

- Super passage
- Siphon super passage

Type – 3 Drainage and canal intersection each other of the same level

- **Level crossing**
- **Inlet and outlet**

SELECTION OF TYPES OF CROSS DRAINAGE WORK

- **Relative bed levels**
- **Availability of suitable foundation**
- **Economical consideration**
- **Discharge of the drainage**
- **Construction problems**

CANAL INLET AND OUTLET:

When irrigation canal meets a small stream or drain at same level, drain is allowed to enter the canal as inlet. At some distances from this inlet point a part of water is allowed to drain as outlet which eventually meets the original stream. Some pitching is required at the inlet and outlet. The bed and banks between the inlet and outlet are also protected by stone pitching. This type of CDW is called inlet and outlet.

CANAL ALIGNMENT:

A canal has to be aligned in such a way that it covers the entire area proposed to be irrigated, with shortest possible length and at the same time it cost including cost of drainage works is a minimum.

TYPES OF CANAL ALIGNMENT:

- **Ridge/watershed canal**
- **Contour canal**
- **Side slope canal**

NECESSIY OF CANAL LINING:

- **Maximum velocity limited to prevent erosion**
- **Seepage of water into the ground and possibility of vegetation growth in banks, leading to increased friction**
- **Possibility of bank failure either due to activities of burrowing animals**
- **To avoid water logging**
- **To avoid movement of contaminated group.**

KENNEDY THEORY:

RG Kennedy an executive engineer of Punjab PWD carried out extensive investigations on some of the canal reaches in the upper Bari Doab canal system he selected some straight reaches of the canal section which had not posed any silting and scouring problems during the previous 30 years.

From the observation he concluded that the slit supporting power in a channel cross section was mainly dependent upon the generation of the eddies rising to the surface. The eddies are generated due to the friction of the following water with the channel surface the vertical component of these eddies try to move the sediment up while weight of the sediment tries to bring it down. If the well is sufficient to generate eddies as keep the sediment just in suspension silting will be avoided based on this concept he defined critical velocity.

According to Kennedy the critical velocity ratio Vc in a channel may be defined as the mean velocity of flow which will just keep the channel free from silting or scouring.

$V_c = 0.55.m.d^{0.64}$

m= critical velocity

LACEY REGIME THEORY:

Lacey an eminent engineer of up irrigation department carried out extensive investigations on the design of stable channel in Alluviums on the basics of his research work. He found many drawbacks in Kennedy theory and he put forward its new theory. He differentiated between three regime conditions.

- **True regime**
- **Initial regime**
- **Final regime**

A channel will be in true regime if these conditions are satisfied:

- **Discharge is constant**
- **Flow is uniform**
- **Slit charge is constant**
- **Slit grade is constant**

Lacey's theory:

Slit factor = f = 1.76 $\sqrt{m}$

where,

m = mean particle size, mm

UNIT-5 WATER MANAGEMENT IN IRRIGATION

INTRODUCTION

The role of irrigation in India in expanding crop production and food f production will become increasingly over 55% of agricultural output from irrigated lands and production from rainfed areas is faced with lack of land for expansion and the prevailing risk of drought.

IRRIGATION IN INDIA:

The total geographical area of land in India is 329 m.ha. which is 2.45% of the globe land area. India has 16% of the world population as compared to only 4% of average annual runoff in the rivers.

IRRIGATION IN PLANNING COMMSION:

Irrigation was given the first priority in first second and third five year plans. Share of irrigation in the expenditure was more than 25% during sixth, seventh and eight five year plans.

During these plans, the irrigated area is increased in 2.4 million ha per year. The maximum potential is estimated around 140 million ha which is the target for achievement by the year 2025.

METHODS:

- **Sprinkler irrigation system**
- **Drip irrigation system**
- **Tank modernization**
- **Farmer participation**
- **Re-use of waste water**
- **Inter-basin transfers**

SPRINKLER IRRIGATION SYSTEM:

This system prevent the seepage losses and to have controlled irrigation. Many seed farms and nurseries are being successfully raised under this system. 30-40% water is saved under this system.

DRIP IRRIGATION SYSTEM:

In India wells nearly contribute to 30% of the total irrigated area in the country. In many states the ground water table is fast depleting. AS a result many wells have become dry and abandoned. Drip irrigation system is becoming popular in Madhya Pradesh and Maharastra. Banana, grapes, vegetables, and sugar cane, etc are being successfully grown. 40-70% of water is saved and crop yield is increased from 10-100%.

PATICIPATORY IRRIGATION MANAGEMENT:

Participation of irrigation users in the management of the irrigation system, at all levels and in all aspects of management.

Management types in irrigation:

- **Government dominates users help**
- **Farmers do everything**
- **Users dominate Government facilities.**

WATER RESOURCES ASSOCIATIONS:

A water management paradigm refers to a set of basic assumptions about the nature of the system to be managed, the goals of management and the ways in which these management goals can be achieved. The paradigm is shared by epistemic community of the actors involved in water management. The paradigm is manifested in are facts such as technical infrastructure, planning approaches, regulations, engineering practices, etc.

HISTORY OF IRRIGATION DEVELOPMENTS IN INDIA:

- **Vedas, Ancient Indian writers and ancient Indian scriptures have references of wells, canals, tanks and dams.**
- **In the south, perennial irrigation and begun with construction of the Grand Ancient 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 wells.**

IRRIGATION DURING MEDIEVAL INDIA:

- **Rapid advances took place in the construction of canals.**
- **Water was blocked by constructing bunds across the streams.**
- **Ghiyasuddin Tughluq is credited to be the first ruler, who encouraged digging canals. Fru Tughlug is considered to be the fifteenth century.**
- **As agricultural income was the pillar of the economy, irrigation systems were paid special attention during this period.**
- **Babur, in his memoirs call "BABUMAMAH" 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 tracks under cultivation.**

IRRIGATION IN BRITISH INDIA:

- **Rennovation, improvements and extension of works takes place.**

- **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.**
- **Significant protective works constructed during the period were the Betwa Canal (MP), the Nira Left Bank Canal (Maharastra), the Gokak Canal (Karnataka) and the Rushikulya Canal (odisha).**

IRRIGATION DEVELOPMENT AFTER INDEPENDENCE:

- **To achieve set targets of economic development, the responsibility of irrigation development was given to the Union Ministry of Water Resources.**
- **It took initiatives from time to time on water resources development and for technical assistance to the states on irrigation, multipurpose projects, ground water exploration and exploitation, drainage, flood control, water logging, sea erosion problems, dam safety and hydraulic structures for navigation and hydro power.**
- **Overseas the regulation and development of inter-State rivers.**

IRRIGATION DEVELOPMENT PROGRAMS UNDERTAKEN:

(A) Command Area Development & Water Management (CADWM):

To provide central assistance for development of infrastructure to facilitate use of sprinkler or drip irrigation systems as an alternative to construction of field channels. The assistance is limited to construction of stilling tank, pump house and laying of conveyance pipes up to farmer's fields.

(B) Accelerated Irrigation Benefits Program (AIBP):

The ABIP was conceived the year 1996 by the government of India inorder to provide financial assistance to States to complete various ongoing projects in the country so that envisaged irrigation potential

of the project could be created and thereby extend irrigation to more areas.

FUTURE POSSIBILITIES OF IRRIGATION DEVELOPMENT:

- **Micro-irrigation methods need to be adopted wherever possible. (Drip irrigation, sprinkler, etc)**
- **Revival of Diverse and community – Based irrigation systems**
- **Inter basin transfer of water (Interlinking of Rivers)**
- **Special measures needed to revitalize the tank irrigation.**
- **Gap between potential created and utilized needs to be reduced (Completion of Canal Networks)**
- **Use of sewage water for irrigation**
- **Drainage improvements**
- **Scope for improving crop yields.**
- **Options for equitable and efficient water distribution need to be evolved.**
- **Choosing appropriate cropping pattern for sustainable development.**