IRRIGATION ENGINEERING

LECTURE 01

Irrigation can be defined as human manipulation of the hydrologic cycle to improve crop production and quality and and to decrease economic efforts of drought.

Irrigation is the artificial application of water to plants for their growth and maturity. Irrigation water is supplied to supplement the water available from rainfall and the contribution of soil moisture from ground water. Necessity of irrigation, advantages and disadvantages of irrigation are described briefly below.

Necessity of Irrigation

Necessity of irrigation is generally because of the following situations.

1. Rainfall is less than the water requirement of the plants.
2. Rainfall is sufficient, but the spatial distribution of rainfall is not as per requirement.
3. Rainfall is sufficient and the spatial distribution is also good, but the temporal distribution is not as per requirement.
4. Advanced scientific development (HYV-High yield variety).

Advantages and Disadvantages of Irrigation

Some of the advantages of irrigation are as follows.

- Increase of food production.
- Modify soil or climate environment – leaching.
- Lessen risk of catastrophic damage caused by drought.
- Increase income & national cash flow.
- Increase labor employment.
- Increase standard of living.
- Increase value of land.
- National security thus self sufficiency.
- Improve communication and navigation facilities.
- Domestic and industrial water supply.
- Improve ground water storage.
- Generation of hydro-electric power.

Disadvantages of Irrigation

The following are the disadvantages of irrigation.

- Water logging.
- Salinity and alkalinity of land.
- Ill aeration of soil.

- Pollution of underground water.
- Results in colder and damper climate causing outbreak of diseases like malaria.

Benefits of irrigation

With the introduction of irrigation, there have been many advantages, as compared to the total dependence on rainfall. These may be enumerated as under:

1.Increase in crop yield:

The production of almost all types of crops can be increased by providing the right amount of later at the right time, depending on its shape of growth. Such a controlled supply of water is possible only through irrigation.

2. Protection from famine

The availability of irrigation facilities in any region ensures protection against failure of crops or famine due to drought. In regions without irrigation, farmers have to depend only on rains for growing crops and since the rains may not provide enough rainfall required for crop growing every year, the farmers are always faced with a risk.

3. Cultivation of superior crops

With assured supply of water for irrigation, farmers may think of cultivating superior variety of crops or even other crops which yield high return. Production of these crops in rain-fed areas is not possible because even with the slight unavailability of timely water, these crops would die and all the money invested would be wasted.

4.Elimination of mixed cropping

In rain-fed areas, farmers have a tendency to cultivate more than one type of crop in the same field such that even if one dies without the required amount of water, at least he would get the yield of the other. However, this reduces the overall production of the field. With assured water by irrigation, the farmer would go for only a single variety of crop in one field at anytime, which would increase the yield.

5. Economic development

With assured irrigation, the farmers get higher returns by way of crop production throughout the year. The government in turn, benefits from the tax collected from the farmers in base of the irrigation facilities extended.

6.Hydro power generation:

Usually, in canal system of irrigation, there are drops or differences in elevation of canal bed level at certain places. Although the drop may not be very high, this difference in elevation can be used successfully to generate electricity. Such small hydro electric generation projects, using bulb-turbines have been established in many canals, like Ganga canal, Sarada canal, Yamuna canal etc.

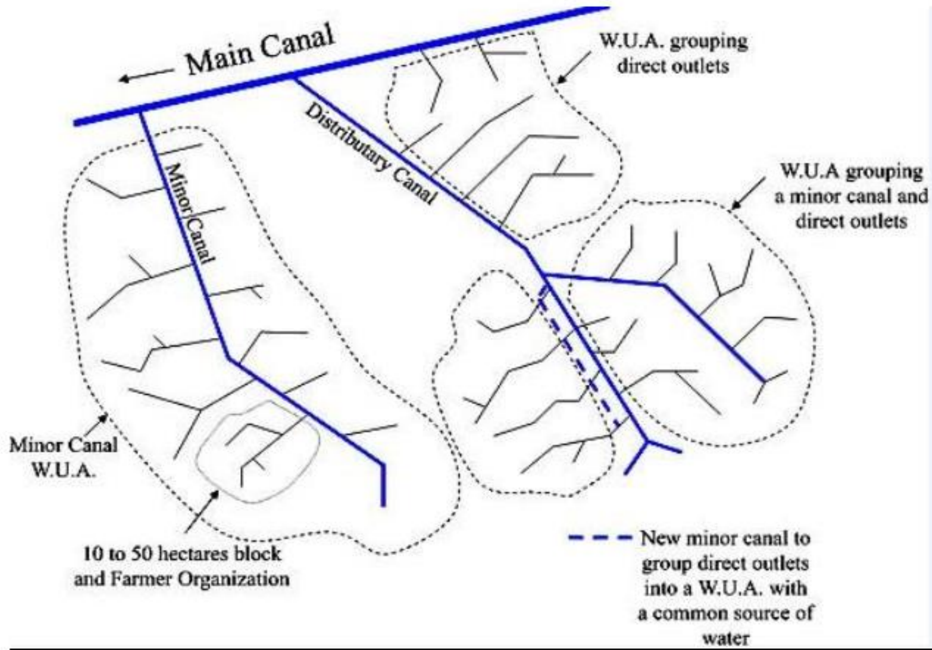
7.Domestic and industrial water supply

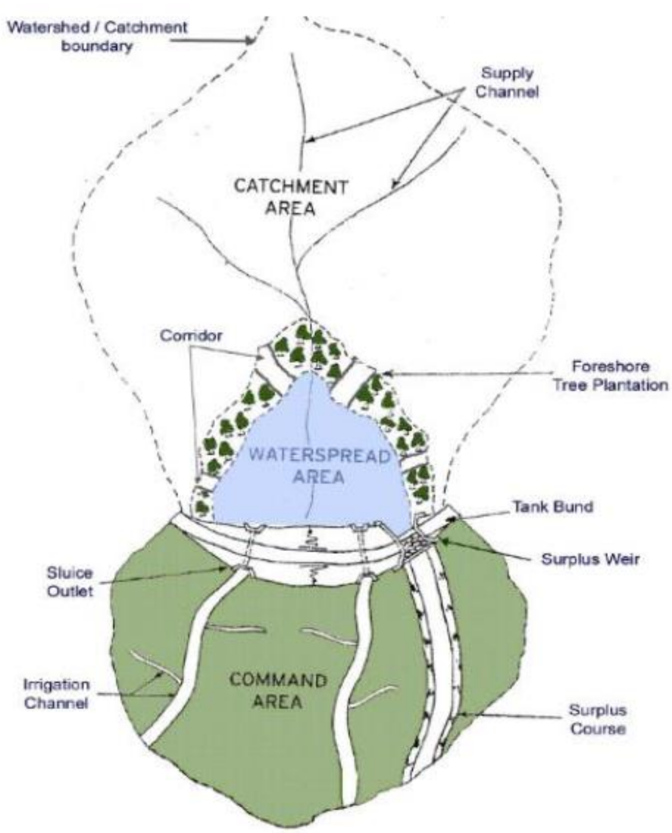
Some water from the irrigation canals may be utilized for domestic and industrial water supply for nearby areas. Compared to the irrigation water need, the water requirement for domestic and industrial uses is rather small and does not affect the total flowmuch. For example, the town of Siliguri in the Darjeeling district ofWest Bengal, supplies its residents with the water from Teesta Mahananda link canal.

Irrigation in India

It includes a network of major and minor canals from Indian rivers, groundwater well based systems, tanks, and other rainwater harvesting projects for agricultural activities. Of these groundwater system is the largest. In 2010, only about 35% of total agricultural land in India was reliably irrigated. About 2/3rd cultivated land in India is dependent on monsoons.

Irrigation in India helps improve food security, reduce dependence on monsoons, improve agricultural productivity and create rural job opportunities. Dams used for irrigation projects help produce electricity and transport facilities, as well as provide drinking water supplies to a growing population, control floods and prevent droughts.


Main Canal
W.U.A. grouping
direct outlets
Distributary Canal
Minor Canal
W.U.A grouping
a minor canal and
direct outlets
Minor Canal
W.U.A.
10 to 50 hectares block
and Farmer Organization
New minor canal to
group direct outlets
into a W.U.A. with
a common source of
water


Watershed / Catchment
boundary
Supply
Channel
CATCHMENT
AREA
Corridor
Foreshore
Tree Plantation
WATERSPREAD
AREA
Tank Bund
Surplus Weir
Sluice
Outlet
Irrigation
Channel
COMMAND
AREA
Surplus
Course

A tank complex comprises the catchment area, supply channels, water spread area, earthen bunds, outlet structures (sluices), field irrigation channels, surplus weir and the command area. The land from which the surface runoff drains into any stream or reservoir is called the catchment basin and the area of this tract is its catchment area. Supply channels direct the water from the catchment basin to the tanks Water spread area is the area over which the runoff spreads on the upstream side of an embankment. Tank bund is a mud mound formed across a sloping land to store the surface runoff Sluice is the water regulator to control the outflow .Surplus weir is a sub-system through which excess water flows out of the tanks. Field irrigation channels direct irrigation water from the sluice outlet to the fields

Development of Irrigation

Archaeological investigation has identified as evidence of irrigation where the natural rainfall was insufficient to support crops for rainfed agriculture.

Perennial irrigation was practiced in the Mesopotamian plain whereby crops were regularly watered throughout the growing season by coaxing water through a matrix of small channels formed in the field.

The earliest mentions of irrigation are found in Rig Veda and various ancient literatures. Later, the 4th-century BCE Indian scholar Patanjali, mentions tapping several rivers for irrigation. Texts from the Maurya Empire era (3rd century BCE) mention that the state raised revenue from charging farmers for irrigation services from rivers.

Patanjali, in Yogasutra of about the 4th century, explains a technique of yoga by comparing it to "the way a farmer diverts a stream from an irrigation canal for irrigation". In Tamil Nadu, the Grand Anicut (canal) across the Kaveri river was implemented in the 3rd century CE, and the basic design is still used today.

Waterworks were undertaken during the Delhi Sultanate and the Mughal Empire era from the 12th to 18th centuries. However, these were primarily to supply water to the palaces and parks of the sultans and other officials.

Colonial era

Ganges irrigation canal built during the colonial era, and inaugurated in 1854.In 1800, some 800,000 hectares was irrigated in India.The British Raj by 1940 built significant number of canals and irrigation systems in Uttar Pradesh, Bihar,Punjab, Assam and Orissa. The Ganges Canal reached 350 miles from Haridwar to Kanpur in Uttar Pradesh. In Assam, a jungle in 1840, by 1900 had 4,000,000 acres under cultivation, especially in tea plantations. In all, the amount of irrigated land multiplied by a factor of eight.

Much of the increase in irrigation during British colonial era was targeted at dedicated poppy and opium farms in India, for exports to China. Major irrigation canals were built after millions of people died each in a series of major famines in the 19th century in British India. In 1900, British India (including Bangladesh and Pakistan) had about 13 million ha under irrigation. By 1947, this had increased to about 22 million ha of irrigation. Arthur Cotton led some irrigation canal projects in the Deccan peninsula, and landmarks are named after him in Andhra Pradesh and Tamil Nadu. However, much of the added irrigation capacity during the colonial era was provided by groundwater wells and tanks, operated manually.

Irrigation trends since 1947

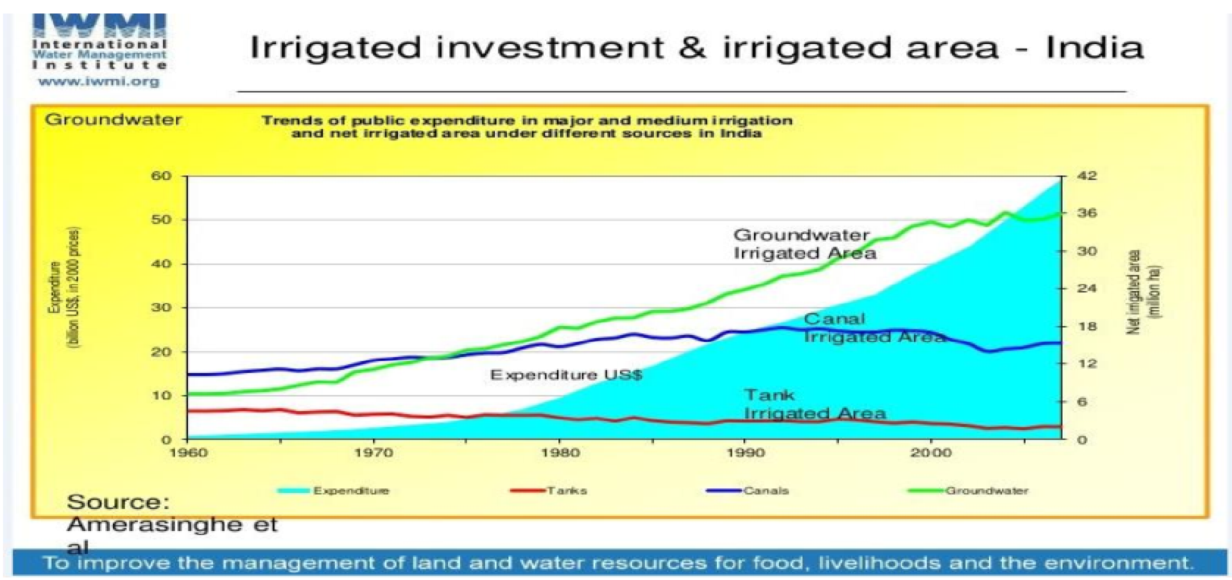
One of the sections of Bhakra Canal system in north India. This canal network irrigates over 4 million hectares of land.

India's irrigation covered crop area was about 22.6 million hectares in 1951, and it increased to a potential of 90 mha at the end of 1995, inclusive of canals and groundwater wells. However, the potential irrigation relies of reliable supply of electricity for water pumps and maintenance, and the net irrigated land has been considerably short. According to 2001/2002 Agriculture census, only 58.1 million hectares of land was actually irrigated in India. The total arable land in India is 160 million hectares (395 million acres). According to the World Bank, only about 35% of total agricultural land in India was reliably irrigated in 2010.

The ultimate sustainable irrigation potential of India has been estimated in a 1991 United Nations' FAO report to be 139.5 million hectares, comprising 58.5 Mha from major and medium river-fed irrigation canal schemes, 15 Mha from minor irrigation canal schemes, and 66 Mha from groundwater well fed irrigation.

India's irrigation is mostly groundwater well based. At 39 million hectares (67% of its total irrigation), India has the world's largest groundwater well equipped irrigation system (China with 19 Mha is second, USA with 17 Mha is third).

India has spent Rs. 16,590 crore on irrigation development between 1950 and 1985. Between 2000-2005 and 2005-2010, India proposed to invest a sum of Rs. 1,03,315 crore and 2,10,326 crore on irrigation and flood control in India.



IRRIGATION ENGINEERING

Tamil Nadu

The areas covered by different types of irrigation are extensive in certain districts and negligible in others. Wide variations are seen in the net area irrigated in the different districts. Thanjavurleads with 4.5 lakh ha under irrigation and Nilgris has the least extent with about 500 ha only. This is due to absence of natural resources like rivers. The existence of big river contribute to the development of flow irrigation as in Thanjavur. The soils of South Arcot, North Arcot and Chengai are very permeable, the rainfall is very generous and these have contributed to a high underground water table. Lift irrigation from wells has developed here.

Sources of Irrigation

Water is an important determinant factor of production of crops in agriculture sector. Intensive and extensive cultivation of land depend mainly on the availability of water. Medium and minor irrigation schemes are implemented in the state for augmenting the irrigation for agriculture.The various sources of irrigation are canals, tanks, tube wells, Open wells and springs.

Area Irrigated

The net area irrigated by different sources during 09-10 was 2863866 ha as against 2931113 ha in 08-09 showing a decrease of 67247 ha or 2.3% over the previous year. The net area irrigated during 09-10 constituted 56.8% of the net area sown in the state. Villupuram district is at the top with 236484 ha net area irrigated. However the highest percentage of the net area irrigated to the net area sown was recorded in Thiruvarur District with 97.4% followed by Thanjavur District with 85.6% and Kancheepuram with 85.0% whereas the lowest percentage was recorded in The Nilgiris district with 0.5%.

Canals (Including System Tanks)

Canals are the major source of irrigation in TamilNadu. As the system tanks get supply from a permanent storage like reservoirs, dams etc. the area irrigated by this -source is classified under canals. During 09-10, Canal irrigation accounted for 26.4% the net area irrigated by all sources in the state. The net area irrigated by canals including system tanks during the year was 757090 ha as against 765527 ha in 08-09 recording an decrease of 8437 ha i.e. 1.1%. The net area irrigated by canals is the highest in Thiruvarur district with 150564 ha (19.9%) followed by Thanjavur district with 134554 ha (17.8%) and Nagapattinam district with 123696 ha (16.3%) of the total net area irrigated by canals in the State.

Tanks (Non-System Tanks Only)

The non-system tanks which are fed partly from their independent catchment areas and partly from the diversion of river water and jungle streams depend fully on rain. The net area irrigated by non-system tanks during the year 09-10 is 503491 ha as against 540281 ha in 08-09 registering a decrease of 36790 ha or 6.8% over previous year. The extent of area irrigated by tanks during the year is the highest in Pudukottai district with 14.9% followed by Kancheepuram district with 13.6% and Sivagangai district with 12.8%.

Wells

Wells are the principal source of irrigation in Tamilnadu. During the year under review, open wells and tube-wells/bore-wells continued to be the principal source of irrigation. The net area irrigated by open wells and tube-wells / bore-wells together accounted for 1593968 ha (about 55.7 % of the total net area irrigated) in 09-10 as against 1614082 ha in 08-09 showing a decrease of 20114 ha i.e. 1.2%. The net area irrigated by wells during the year 09-10 was the highest in Villupuram district with 11.3% of the total net area irrigated by the wells in the state followed by 7.7% in Thiruvannamalai district and 6.4% in Salem district.

Classification of irrigation projects

Irrigation projects are classified in different ways, however, in Indian context it is usually classified as follows:

• **Major project:** This type of project consists of huge surface water, storage reservoirs and flow diversion structures. The area envisaged to be covered under irrigation is of the order over 10000 hectare.

• **Medium project:** These are also surface water projects but with medium size storage and diversion structures with the area under irrigation between 10000 hectare and 2000 hectare.

• **Minor project**: The area proposed under irrigation for these schemes is below 2000Ha and the source of water is either ground water or from wells or tube wells or surface water lifted by pumps or by gravity flow from tanks. It could also be irrigated from through water from tanks.

The major and medium irrigation projects are further classified as

• Direct irrigation method

• Storage irrigation method.

Terms related to irrigation projects which may also be called irrigation schemes.

Commanded area (CA):

It is defined as the area that can be irrigated by a canal system, the CA may further be classified as under:

Gross command area (GCA):

This is defined as total area that can be irrigated by a canal system on the perception that unlimited quantity of water is available. It is the total area that may theoretically be served by the irrigation system. But this may include inhibited areas, roads, ponds, uncultivable areas etc which would not be irrigated.

Culturable command area (CCA)

This is the actually irrigated area within the GCA.

However, the entire CCA is never put under cultivation during any crop season due to the following reasons:

• The required quantity of water, fertilizer, etc. may not be available to cultivate the entire CCA at a particular point of time. Thus, this is a physical constraint.

• The land may be kept fallow that is without cultivation for one or more crop seasons to increase the fertility of the soil. This is a cultural decision.

• Due to high water table in some areas of the CCA irrigated water may not be applied as the crops get enough water from the saturation provide to the surface water table.

During any crop season, only a part of the CCA is put under cultivation and this area is termed as culturable cultivated area. The remaining area which is not cultivated during a crop season is conversely termed as culturable uncultivated area.

Intensity of irrigation is defined as the percentage of the irrigation proposed to be irrigated annually. Usually the areas irrigated during each crop season (Rabi, Kharif, etc) is expressed as a percentage of the CCA which represents the intensity of irrigation for the crop season. The ultimate irrigation potential of our country from major and medium projects has been assessed as 58.46 M-hectare.

As for the minor irrigation schemes mostly using ground water sources are primarily developed through individual and cooperative efforts of the farmers with the help of institutional finance and their own savings.

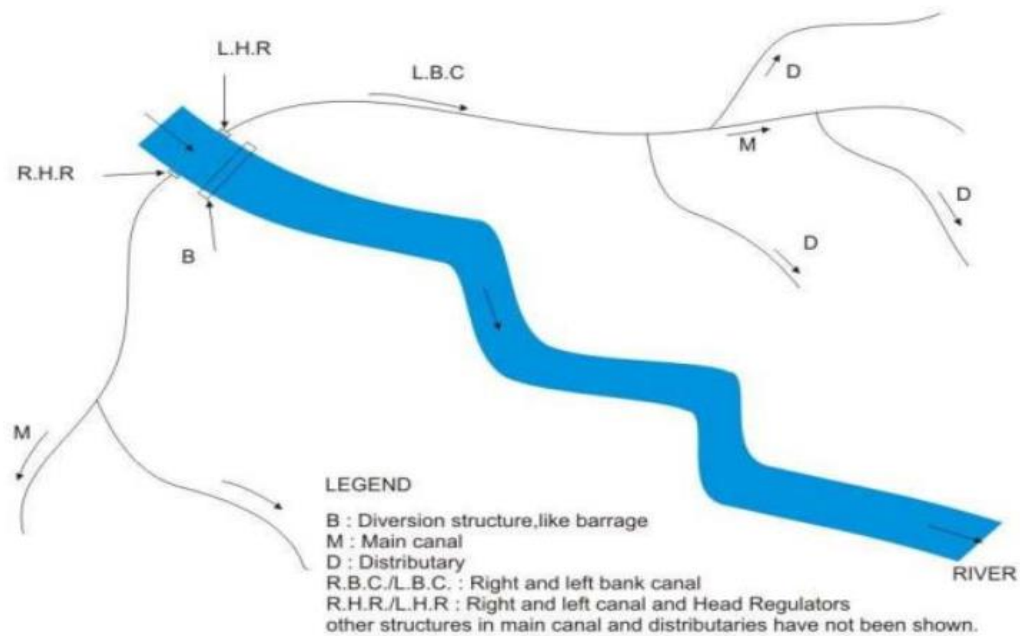
Surface water minor irrigation schemes (like lifting water by pumps from rivers) are generally funded from the public sector outlay. The ultimate irrigation potential from minor irrigation schemes has been assessed as 81.43hectare. The development of minor irrigation should receive greater attention because of the several advantages they possess like small investments, simpler components has also being labour incentive quick money and most of all farmers friendly.

Direct and Indirect (Or Storage) Irrigation Methods

The major and medium surface water schemes are usually classified as either direct or indirect irrigation projects and these are defined as follows:

Direct Irrigation method

In this project water is directly diverted from the river into the canal by constructing a diversion structure like weir or barrage across the river with some pondage to take care of diurnal variations. It also effects in raising the river water level which is then able to flow into the off taking channel by gravity. The flow in the channel is usually controlled by a gated structure and this in combination with the diversion structure is also sometimes called the headworks. If the water from such headworks is available throughout the period of growth of crops irrigated by it, it is called a perennial irrigation scheme. In this type of projects, the water in the offtaking channels from the river carries water through out the year. It may not be necessary, however, to provide irrigation water to the fields during monsoon. In some places local rainfall would be sufficient to meet the plant water needs. In case of a non-perennial river the off taking channel would be carrying water only for certain period in a year depending upon the availability of supply from the source. Another form of direct irrigation is the inundation irrigation which may be called river-canal irrigation. In this type of irrigation there is no irrigation work across the river to control the level of water in the river. Inundation canal off-taking from a river is a seasonal canal which conveys water as and when available in the river. This type of direct irrigation is usually practiced in deltaic tract that is, in areas having even and plane topography. It is feasible when the normal flow of river or stream throughout the period of growth of crop irrigated, is never less than the requirements of the irrigated crops at any time of the base period. A direct irrigation scheme of irrigation using river water diversion head works typically be laid out as in Figure shown below

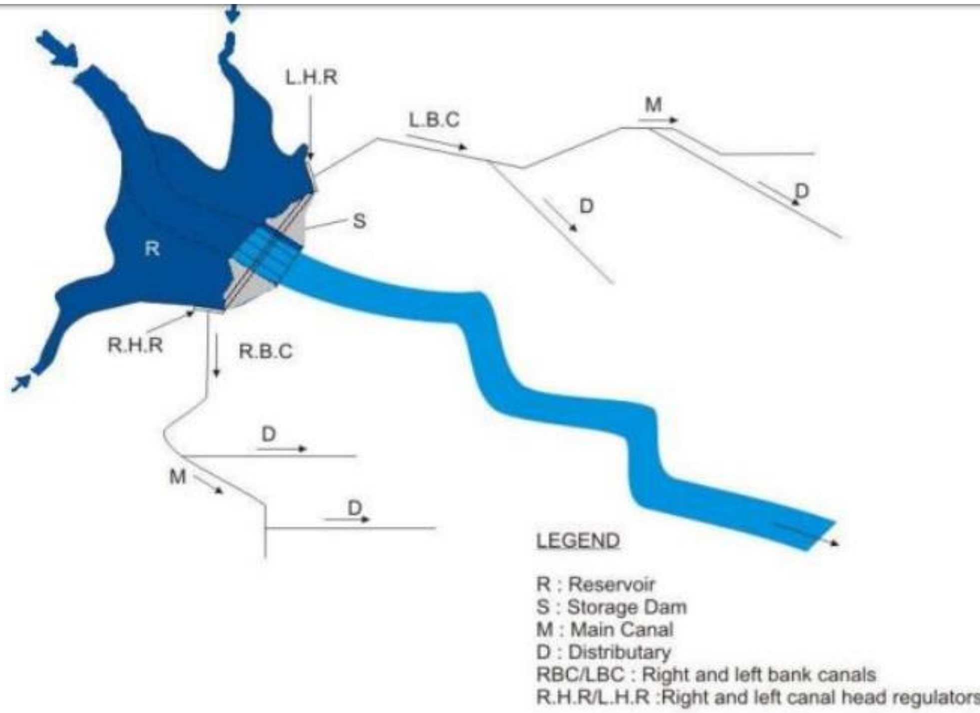


An example of a Direct Irrigation scheme

Though the diversion structure raises the river water level and is just sufficient to force some water into the channel, the stored water in the pond created behind doesn't have sufficient storage volume it may however be able to take care of any diurnal variation in the river water. An example of this scheme is the DVC irrigation project on the Damodarriver with the barrage located at Durgapur.

Storage Irrigation Method

For this type of irrigation schemes part of the excess water of a river during monsoon which other wise would have passed down the river as a flood is stored in a reservoir or tank found at the upstream of a dam constructed across a river or stream. This stored water is then used for irrigation is adopted when the flow of river or stream is in excess of the requirements of irrigated crops during a certain part of the year but falls below requirements or is not available at all in the river during remaining part of the year. Since the construction site of a storage reservoir is possible in regions of undulating topography, it is usually practiced in non deltaic areas. A general layout of this irrigation scheme may typically be laid out as shown in the following Figure.



A typical layout for a storage irrigation scheme incorporating a dam

In third type of scheme the storage head works or the dams has to be equipped with ancillary structure like outlet, sluice, spillway, log chutes, etc. The storage created by the dam behind the reservoir is substantial compared to that behind a barrage and may inundate a large tract of land, depending on the topography. The capacity of the reservoir is generally determined systematically by knowing possible withdrawal demands (in this case for irrigation) over the weeks and months of a year and corresponding expected inflows. An example for this type of scheme is the Indira Sagar project on the Narmada River. Of course, apart from serving irrigation demand the project also generates electricity. Hence it is actually a multi purpose project.

Methods of Field Water Application

Irrigation water conveyed to the head or upstream point of a field must be applied efficiently on the whole area such that the crops growing in the either fields gets water more or less uniformly. Naturally it may be observed that a lot depends on the topography of the land since a large area with uneven topography would result in the water spreading to the low lying areas. The type of crop grown also immensely matter as some like rice, require standing water depths at almost all stages of its growth. Some, like potato, on the other hand, suffer under excess water conditions and require only the right amount of water to be applied at the right time. Another important factor determining the way water is to apply in the fields is the quantity of water available at any point of time. If water is scarce, as what is actually happening in many parts of the country, then it is to be applied through carefully controlled methods with minimum amount of wastage. Usually these methods employ pressurized flow through pipes which is either sprinkled over the crop or applied carefully near the plant root. On the other hand when water is rather unlimited during the crop growing season as in deltaic regions, the river flood water is allowed to inundate as much area as possible as long the excess water is available. Another important parameter dictating the choice of the irrigation method is the type of soil. Sometimes water is applied not on the surface of the field but is used to moist the root zone of the plants from beneath the soil surface. Thus, in effective the type of irrigation methods can be broadly divided as under:

Surface irrigation method

• Subsurface irrigation method

• Sprinkler irrigation system

• Drip irrigation system

Each of these methods has been discussed in the subsequent section of this lesson.

Surface Irrigation Methods

In this system of field water application the water is applied directly to the soil from a channel located at the upper reach of the field.

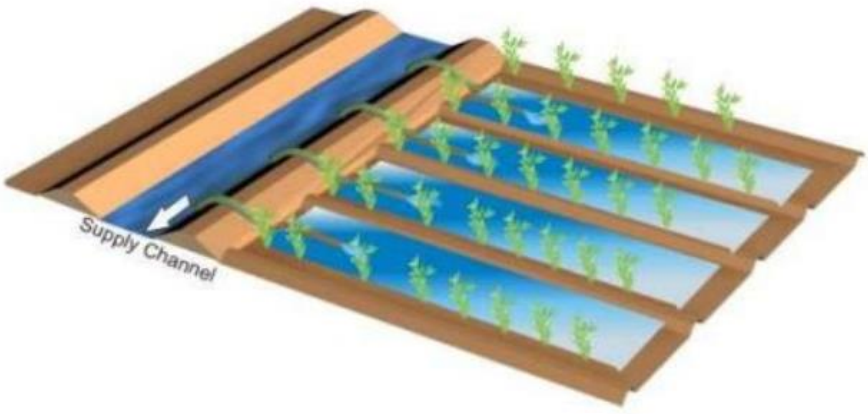
It is essential in these methods to construct designed water distribution systems to provide adequate control of water to the fields and proper land preparation to permit uniform distribution of water over the field. One of the surface irrigation methods is flooding method.

Flooding method

Where the water is allowed to cover the surface of land in a continuous sheet of water with the depth of applied water just sufficient to allow the field to absorb the right amount of water needed to raise the soil moisture up to field capacity,. A properly designed size of irrigation stream aims at proper balance against the intake rate of soil, the total depth of water to be stored in the root zone and the area to be covered giving a reasonably uniform saturation of soil over the entire field. Flooding method has been used in India for generations without any control what so ever and is called uncontrolled flooding. The water is made to enter the fields bordering rivers during folds. When the flood water inundates the flood plane areas, the water distribution is quite uneven, hence not very efficient, as a lot of water is likely to be wasted as well as soils of excessive slopes are prone to erosion. However the adaptation of this method doesn't cost much. The flooding method applied in a controlled way is used in two types of irrigation methods as under:

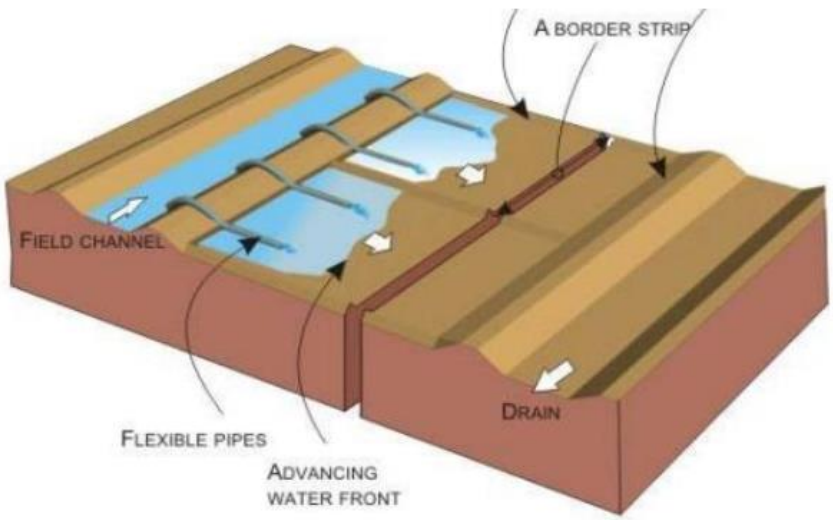
Border irrigation method

Border irrigation Borders are usually long uniformly graded strips of land separated by earth bunds (low ridges) as shown in Figure



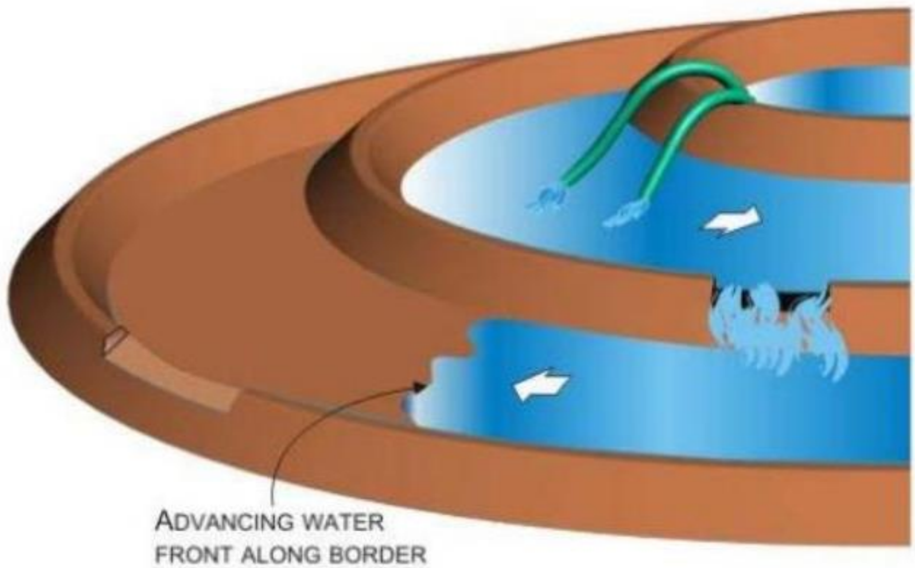
Border irrigation with water being applied to the borders with the help of flexible pipes, acting as siphons

The essential feature of the border irrigation is to provide an even surface over which the water can flow down the slope with a nearly uniform depth. Each strip is irrigated independently by turning in a stream of water at the upper end as shown in the following Figure.



Water entering each border strip independently

The water spreads and flow down the strip in a sheet confined by border ridges. When the advancing water reaches the lower end of the border, the stream is turned off. For uniform advancement of water front the borders must be properly leveled. The border shown in the figures above are called straight borders, in which the border strips are laid along the direction of general slope of the field. The borders are sometimes laid along the elevation contours of the topography when the land slope is excessive. That method of border is called **contour border method of irrigation**



. **Contour border method of irrigation**

The straight border irrigation is generally suited to the larger mechanized farms as it is designed to produce long uninterrupted field lengths for ease of machine operations. Borders can be 800m or more in length and 3 – 30 m wide depending on variety of factors. It is less suited to small scale farms involving hand labour or animal powered cultivation methods. Generally, border slopes should be uniform, with a minimum slope of 0.05% to provide adequate drainage and a maximum slope of 2% to limit problems of soil erosion. As for the type of soil suitable for border irrigation, deep homogeneous loam or clay soils with medium infiltration rates are preferred. Heavy, clay soils can be difficult to irrigate with border irrigation because of the time needed to infiltrate sufficient water into the soil. Basin irrigation is preferable in such circumstances.