Irrigation System of India

Chapter · July 2020

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Orissa University of Agriculture & Technology

Advances in Agriculture Sciences

Volume - 26

<u>Chief Editor</u>

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AkiNik Publications
New Delhi

Published By: AkiNik Publications

AkiNik Publications
169, C-11, Sector - 3,
Rohini, Delhi-110085, India
Toll Free (India) – 18001234070
Phone No. – 9711224068, 9911215212
Email – akinikbooks@gmail.com

Chief Editor: Dr. R.K. Naresh

Publication Year: 2020

Pages: 187

ISBN: 978-93-90420-30-8

Book DOI: https://doi.org/10.22271/ed.book.919

Price: ₹ 794/-

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Chapter - 7

Irrigation System of India

Dr. L.K. Das and Dr. R.K. Rout

Abstract

Agriculture, though just about 17% of GDP, is a key to sustained growth and macroeconomic stability of the Indian economy. First, sixty percent of India's population derives its livelihood from agriculture. That includes majority of poor in the country. Second, the sector is vital for food security. Third, with a weight of agricultural products at 23% of Wholesale Price Index (WPI), the performance of the sector, essentially, determines inflationary trends in the economy. This study presents a Irrigation System of India. The diversified nature of land use pattern, cropping intensity, irrigation intensity and cropping pattern of all state have increased the cropping intensity of the land. The present cropping intensity of 139 percent has registered an increase of only 28 percent since 1950-51. The net sown area increased significantly, i.e., by about 18 percent, from 118.75 million hectares in 1950- 51 to 139.93 million hectares in 2012-13, whereas the cropping intensity increased from 111 percent to 139 percent during the same period. The net irrigated area was 60.10 million ha in 2012-13, whereas the irrigation intensity increased from 17.56 percent in year 1950-51 to 47.24 percent in year 2012-13 during the same period.

Keywords: commanded area, irrigation intensity, agriculture, major project, sprinkler irrigation system and drip irrigation system

Introduction

Agriculture, though just about 17% of GDP, is a key to sustained growth and macroeconomic stability of the Indian economy. First, sixty percent of India's population derives its livelihood from agriculture. That includes majority of poor in the country. Second, the sector is vital for food security. Third, with a weight of agricultural products at 23% of Wholesale Price Index (WPI), the performance of the sector, essentially, determines inflationary trends in the economy. Finally, a sustained growth in agriculture is seen as a prerequisite for attaining the overall growth of 9% per annum projected for the Eleventh Plan period. Both from the point of view of ensuring growth and social justice, thus, the agricultural sector in India will be a major driver. Irrigation is perhaps the most important input in the agriculture production function. It plays an important complementary role in the production process. The other key inputs, namely, seed and fertilizer cease to realize their full benefit unless combined with irrigation. Also, in an economy where the supply of land is highly inelastic and the net sown area growth has leveled off, the future growth of agriculture is heavily dependent on intensive cultivation of the existing land. Irrigation greatly facilitates this by enabling farmers to grow multiple crops on the same plot of land across different agricultural seasons. Irrigated agriculture contributes to about 40 percent of the global food production from an estimated 20 percent of agricultural land, or about 300 million hectares globally. It also has a very long historical tradition of irrigated crops. Some of the Indian irrigation systems are more than ten centuries old. India has the largest irrigated area in the world. Irrigated farmland typically generates three times the production of an equivalent area farmed under dry-land systems. Lessons from the past and from the new modernized irrigation networks in India need to be analyzed and shared with the newly emerging communities of enlightened and empowered organized irrigators.

The water requirement of crops as well as the total water required at the entrance to a field of crops. It also gives an idea of the water that is required to be supplied at the head of a channel that is conveying water to more than one field. In fact, water supply to such a cluster of fields with perhaps many sowing different crops is what is termed as an “irrigation scheme”. In the first part of this lesson, we shall be discussing about the ways in which various water sources may be utilized to meet the demand of irrigation or the gross irrigation requirement. In the later portion of this section, different procedures adopted for applying the water to the field of crops is discussed. Agricultural growth is a pre-requisite for the economic and social development of our country. Agriculture contributes 28% of GNP, about 60% of employment and is the primary source of livelihood in rural areas which account for 75% of India's population and 80% of its poor. The irrigated agriculture, contributes nearly 56% of agricultural output. Addressing the irrigation sector's current performance problems will thus be a central element of future strategy for agricultural development. India has now nearly reached the ceiling of available land suitable for cultivation. India’s total geographical area is 329 million hectares. Out of this, 195 million hectare is gross cropped area and 141 million hectare is net sown area. On the other hand, net irrigated area is only 65.3 million hectares. Rest of the land is rainfed. From 1970-71 to till today, net sown area remained virtually unchanged (from 140.27 to 139.93 m.ha.). Hence, increase in production is attributable to an increase in yields through increase in cropping intensity and utilization of better inputs. The increase in irrigation intensity has contributed to the growth in the overall cropping intensity (including rainfed crops) which increased from 111.07% in 1950-51 to 138.93% in 2012-13.

Objectives

On completion of this lesson, the students come to know of the following:

- The classification of irrigation projects in India
- Direct and Storage methods of irrigation
- Structures necessary for implementing irrigation projects
- The methods employed for application of water to irrigate
- Surface and subsurface methods of irrigation
- Drip and Sprinkler irrigation systems

Classification of irrigation projects

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

1. **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 hectares
2. **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
3. **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

Each of the two classifications is explained in subsequent sections. But before that, it may be worthwhile to discuss here a few terms related to irrigation projects which may also be called irrigation schemes.

Commanded area (CA): 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: 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.) are expressed as a percentage of the CCA which represents the intensity of irrigation for the crop season. By adding the intensities of irrigation for all crop seasons the yearly intensity of irrigation to be obtained. As such, the projects with a CCA of more than 2000 hectare are grouped as major and medium irrigation projects. The ultimate irrigation potential of our country from major and medium projects has been assessed as 58.46 M-hectare. The increase in irrigation intensity has contributed to the growth in the overall cropping intensity (including rainfed crops) which increased from 111.07% in 1950-51 to 138.93% in 2012-13.

As per the report of the Ministry of Water Resources, Government of India the plan wise progress of irrigation of creation of irrigation potential through major and medium projects is as follows. The following table (from the Planning Commission's report) provides a list of the State-wise irrigation types, capacity and actual.

State-wise irrigation types, capacity and actual

State	Total crop area (Mha)	Groundwater irrigation crop area (Mha)	Canal irrigation crop area (Mha)	Total crop area Actually irrigated crop area (Mha)
All India	159.6	39.43	22.48	58.13
Rajasthan	21.1	3.98	1.52	5.12
Maharashtra	19.8	3.12	1.03	3.36
Uttar Pradesh	17.6	10.64	4.21	14.49
Andhra Pradesh	16.6	2.5	2.7	4.9
Madhya Pradesh	15.8	2.74	1.7	4.19
Karnataka	12.2	1.43	1.33	2.38
Gujarat	9.9	3.1	0.5	3.2
Tamil Nadu	6.5	1.61	1.43	2.66
Bihar	6.4	2.2	1.3	3.5
West Bengal	5.5	2.09	1.22	2.98
Chhattisgarh	5.1	0.17	0.74	0.85
Odisha	4.9	0.17	1.07	1.24
Punjab	4	3.06	0.94	3.96
Haryana	3.6	1.99	1.32	3.26
Assam	3.2	0.13	0.1	0.22
Jharkhand	3.2	0.11	0.13	0.24
Kerala	1.5	0.18	0.21	0.39
Nagaland	1.1		0.1	0.07
Himachal Pradesh	1	0.02	0.09	0.11
Jammu & Kashmir	0.9	0.02	0.38	0.37
Uttarakhand	0.8	0.22	0.14	0.35
Arunachal Pradesh	0.4		0.07	0.05
Meghalaya	0.3		0.06	0.06
Tripura	0.3	0.02	0.05	0.07
Manipur	0.2		0.05	0.05

Goa	0.1		0.1	0.1
Mizoram	0.1		0.01	0.01
Sikkim	0.1		0.01	0.01

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 81.43 M hectare. 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. The importance of irrigation in the Indian agricultural economy be appreciated at a glance of the following table showing state wise details of net sown areas and the area that is irrigated (net irrigated areas) for states like Punjab the area irrigated is more than 90 percent followed by Haryana (87.6 percent) and Uttar Pradesh (75.9 percent). The national average is low, at around 48.3 percent.

State wise irrigation coverage and productivity

State	Agricultural Production (Million Tonnes)	Percentage of total Production	Productivity (tonnes per hectare)	Percent of cultivated area under irrigation
All India	234.4	100	1.9	48.3
Andhra Pradesh	20.4	8.7	2.7	63.9
Assam	4.1	1.7	1.5	4.9
Bihar	12.2	5.2	1.7	63.4
Chhattisgarh	5.1	2.2	1	27.6
Gujarat	6.4	2.7	1.5	44.7
Haryana	15.6	6.6	3.3	87.6
Jharkhand	1.7	0.7	1.7	5.4
Karnataka	11.2	4.8	1.5	28.5
Madhya Pradesh	13.9	5.9	1.1	44.5
Maharashtra	11.4	4.8	1	16.8
Orissa	7.4	3.1	1.3	33.6
Other States	6.3	2.6	NA	NA
Punjab	27.3	11.6	4.2	98.1
Rajasthan	16.6	7.1	1.2	26.4
Tamil Nadu	7.1	3	2.2	63.1

Uttar Pradesh	46.7	19.9	2.3	75.9
Uttarakhand	1.7	6.7	1.7	42.9
West Bengal	16.3	6.9	2.4	48.2

State-wise details of net irrigated area (NIA), net sown area (NSA) and percentage of NIA to NSA

(In thousand hectares)

SL. No.	States	Net sown area (NSA)	Net irrigated area (NIA)	% of NIA. To NSA
1	Andhra Pradesh	11115	4528	40.73
2	Arunachal Pradesh	164	42	25.61
3	Assam	2734	170	6.22
4	Bihar	7437	3625	48.74
5	Chhattisgarh	4763	984	20.66
6	Goa	141	23	16.31
7	Gujarat	9443	2979	31.55
8	Haryana	3526	2958	83.90
9	Himachal Pradesh	555	126	22.70
10	Jammu & Kashmir	748	311	41.58
11	Karnataka	10410	2643	25.40
12	Kerala	2206	381	17.27
13	Madhya Pradesh	14664	4135	28.20
14	Maharashtra	17636	2959	16.78
15	Manipur	140	65	46.43
16	Meghalaya	230	54	23.48
17	Mizoram	94	9	9.57
18	Nagaland	300	72	24.00
19	Orissa	5829	1933	33.16
20	Punjab	4264	3602	84.47
21	Rajasthan	15865	4907	31.00
22	Sikkim	95	17	17.89
23	Tamil Nadu	5303	2888	54.50
24	Tripura	280	37	13.21
25	Uttar Pradesh	17612	12814	72.76
26	West Bengal	5417	2354	43.45
	Total States	140971	54616	38.74
	Total Uts	130	66	50.77
	Grand Total	141101	54682	38.75

Note: Figures are as per Land Use Statistics brought out by Ministry of Agriculture for 2000-01 (latest) and are Provisional.

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 off taking channels from the river carries water throughout 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 1.

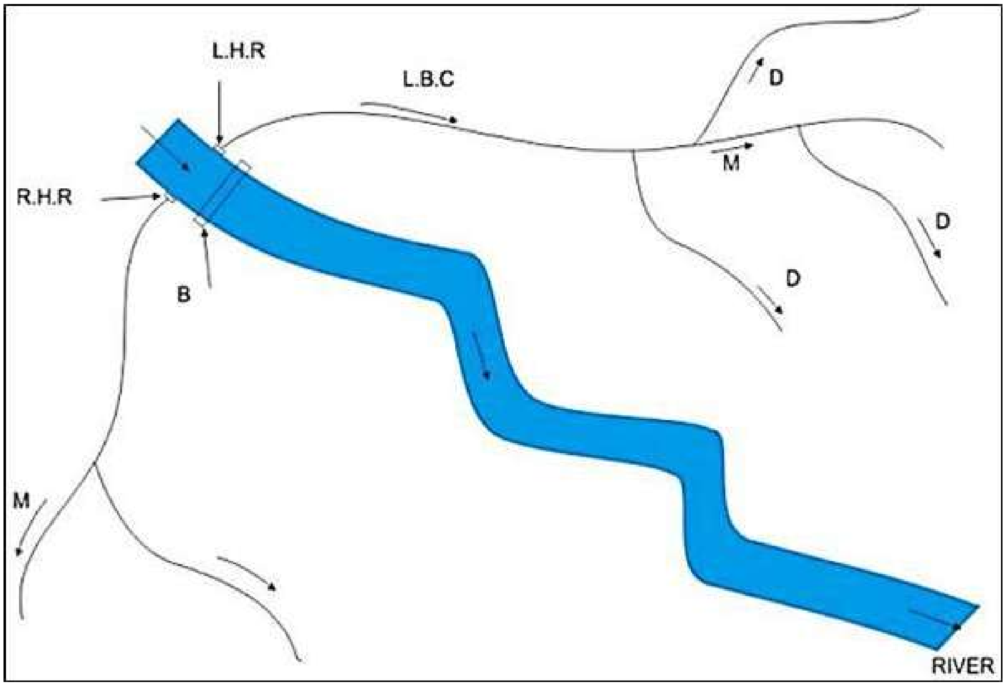


Fig 1: An example of a Direct Irrigation scheme

Legend

B: Diversion structure. Like barrage

M: Main canal

D: Distributary

R.B.C./L.B.C.: Right and left bank canal

R.H.R./L.H.R: Right and left canal and Head Regulators other structures in main canal and distributaries have not been shown

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 Damodar River 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 otherwise 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 Figure 2.

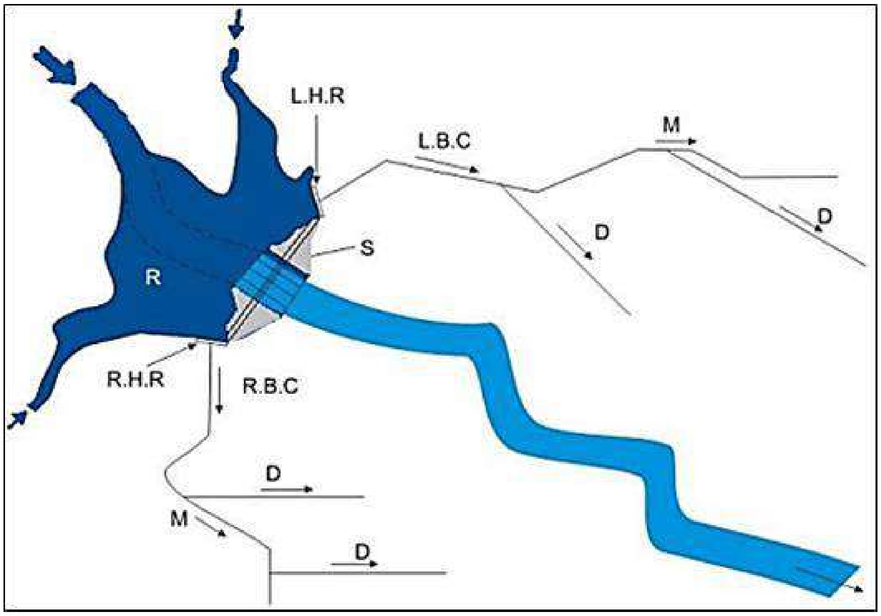


Fig 2: A typical layout for a storage Irrigation scheme incorporating a dam

Legend

R: Reservoir

S: Storage Dam

M: Main Canal

D: Distributary

RBC/LBC: Right and left bank canals

R.H.R/L.H.R: Right and left canal head regulators

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 multipurpose project. Another type of storage irrigation method envisages the storage of water at some place in the hilly terrain of the river where the construction of the dam is possible. A barrage is constructed at some downstream location, where the terrain is flatter and canals take off as in a usual direct irrigation method. A general layout of such scheme could be represented as in Figure 3.

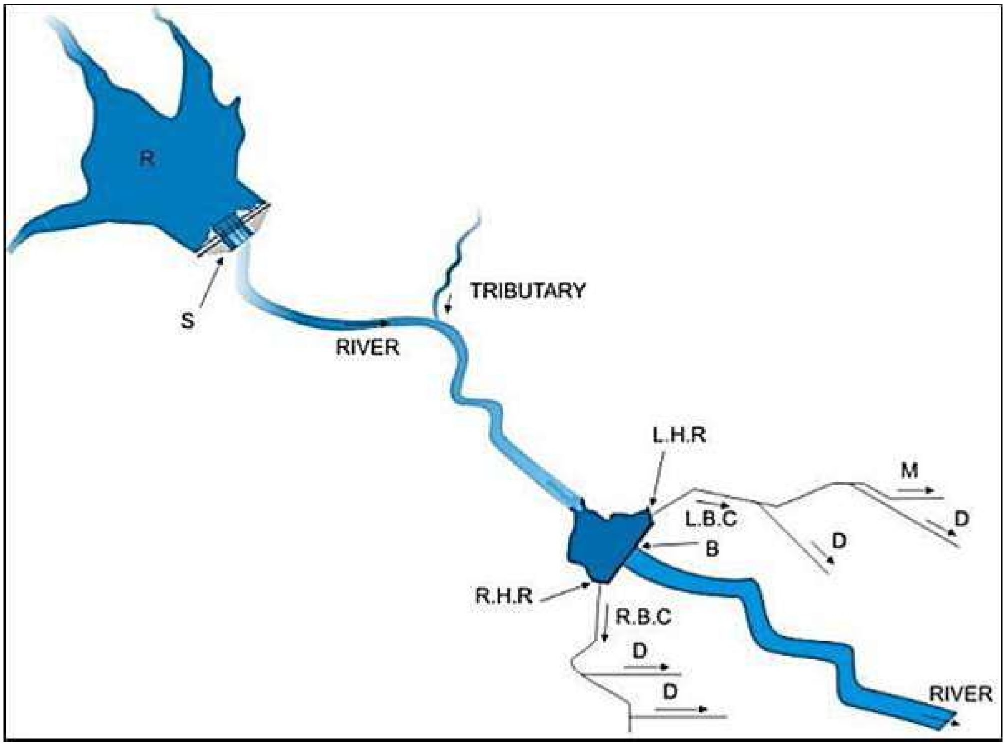


Fig 3: A typical layout of a storage irrigation scheme incorporating a dam with a barrage on its downstream

Legend

R: Reservoir

S: Storage Dam

B: Diversion structure, like barrage

M: Main canal

D: Distributary

RBC/LBC: Right and left bank canals

R.H.R/L.H.R: Right and left canal head regulators

An example for this type of scheme is the Bhakra-dam Nangal-barrage combination on the river Sutlej.

Irrigation project structures

As might have been noticed from the irrigation scheme plans in the previous section, a number of structures are required for the successful implementation of a project. Some of these are: Storage structure and appurtenant works.

- Dams
- Spillways and energy dissipators
- Sluices and outlets

Diversion structure and appurtenant works

- Barrage (weirs are not commonly used these days for sizeable projects)
- Canal head regulator
- River training works Canal water conveyance structures
- Canal sections and layout
- Cross regulators
- Drops
- Turnouts

Also, for an irrigation scheme to be successful, it is important that only the right amount of water be applied to the fields at any point of time. Hence, excess water carried by the canals, as during rainy season, needs to be removed through a drainage network of channels and returned back to the river. Construction of such drainage channels form an important part of a properly designed irrigation network. All the above structures are discussed in detail in the subsequent lessons. However, ultimately aim of irrigation planning is to distribute the water meant for irrigation that is stored in storage reservoirs, diverted through diversion structures, conveyed through canal network and discharged to the fields through turnouts to be properly distributed throughout the field. Depending on the type of crop to be grown, the terrain topography and soil characteristics, climate and other local factors different ways and means have been evolved for field water application. These methods of irrigation are discussed in subsequent sections.

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 method is 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.

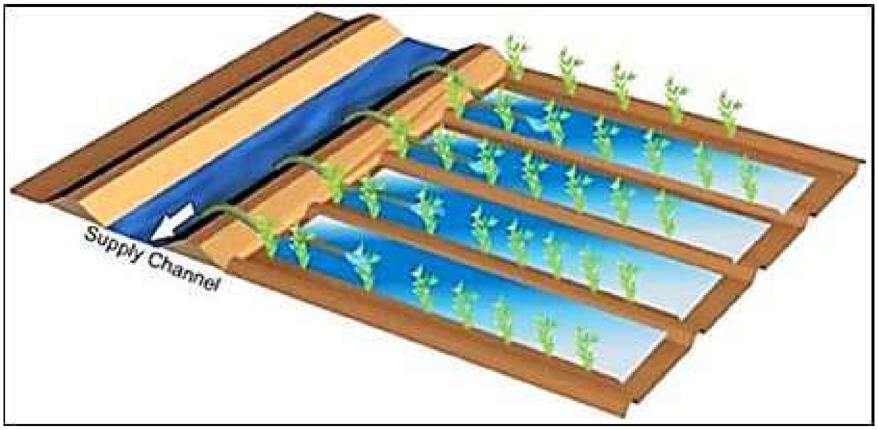


Fig 4: Border irrigation with water being applied to the borders with the help of flexible pipes, acting as siphons

The water is made to enter the fields bordering rivers during folds. When the flood water inundates the flood plain 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
- Basin irrigation method

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 Figure 5.

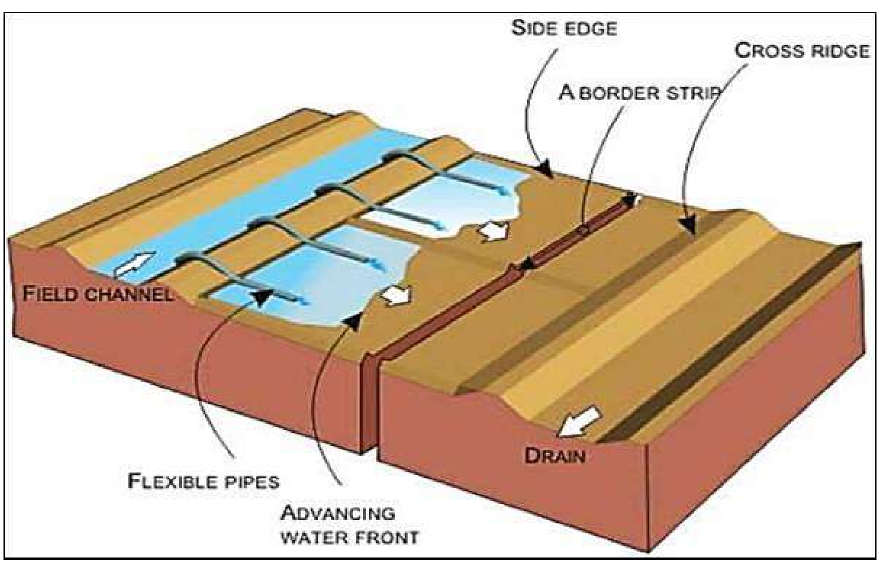


Fig 5: Water entering each border strip independently

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. This method of border is called contour border method of irrigation (Figure 6).

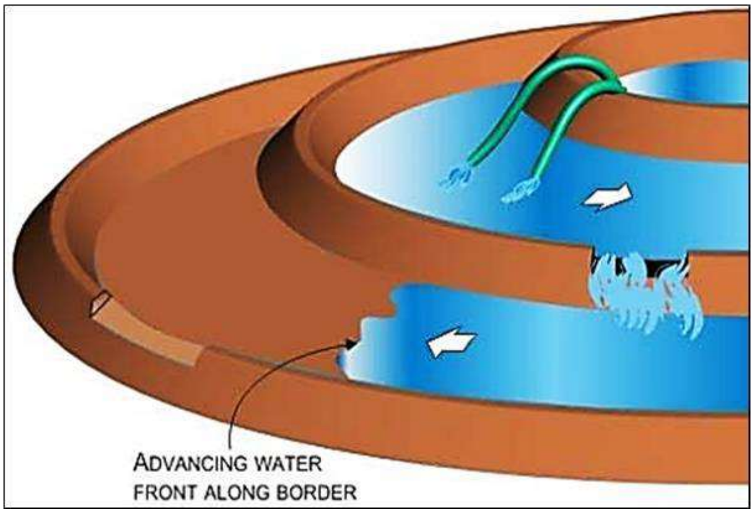


Fig 6: Contour border method of irrigation

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.

Basin irrigation

Basins are flat areas of land surrounded by low bunds. The bunds prevent the water from flowing to the adjacent fields. The basins are filled to desired depth and the water is retained until it infiltrates into the soil. Water may be maintained for considerable periods of time. Basin method of irrigation can be formally divided into two, viz.; the check basin method and the ring basin method. The check basin method is the most common method of irrigation used in India. In this method, the land to be irrigated is divided into small plots or basins surrounded by checks, levees (low bunds); as shown in Figure 7.

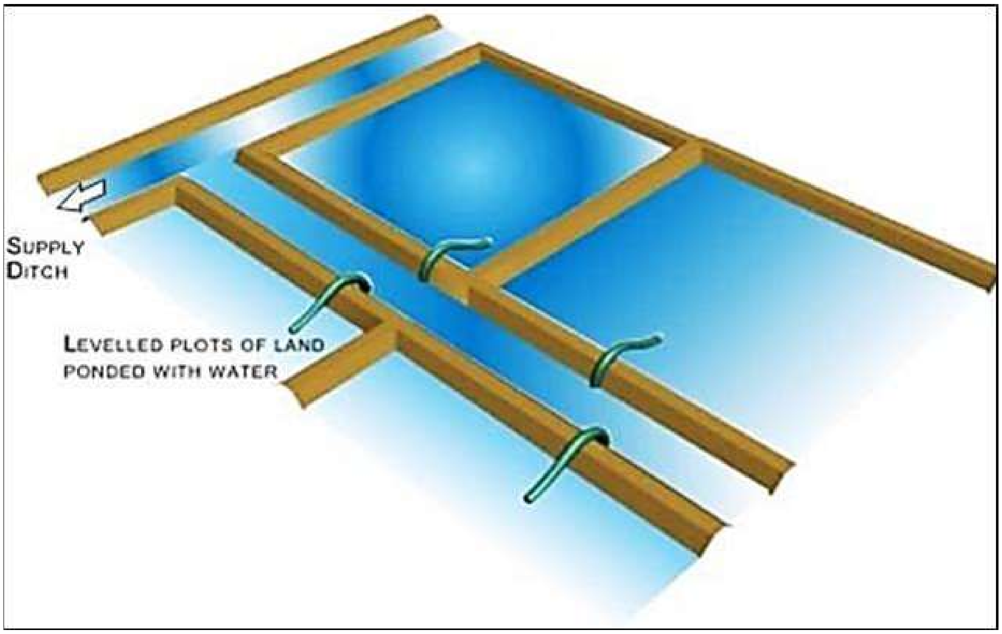


Fig 7: Check basin method of irrigation

Each plot or basin has a nearly level surface. The irrigation water is applied by filling the plots with water up to the desired depth without overtopping the levees and the water retained there is allowed to infiltrate into the soil. The levees may be constructed for temporary use or may be semi-permanent for repeated use as for paddy cultivation. The size of the levees depends on the depths of water to be impounded as on the stability of the soil when wet. Water is conveyed to the cluster of check basins by a system of supply channels and lateral field channels or ditches. The supply channel is aligned on the upper side (at a higher elevation) of the field for every two rows of plot as shown in the figure. The size of basins depends not only on the slope but also on the soil type and the available water flow to the basins. Generally, it is found that the following holds good for basin sizes.

Basin size should be small if the

1) Slope of the land is steep
2) Soil is sandy
3) Stream size to basin is small
4) Required depth of irrigation application is small
5) Field preparation is done by hand or animal traction

Basin size can be large if the

1) Slope of the land is flat
2) Soil is clay
3) Stream size to the basin is large
4) Required depth of the irrigation is large
5) Field preparation is mechanized

Basin irrigation is suitable for many field crops. Paddy rice grows best when its roots are submerged in water and so basin irrigation is the best method for use with the crop. The other form of basin irrigation is the ring basin method which is used for growing trees in orchards. In this method, generally for each tree, a separate basin is made which is usually circular in shape, as shown in Figure 8.

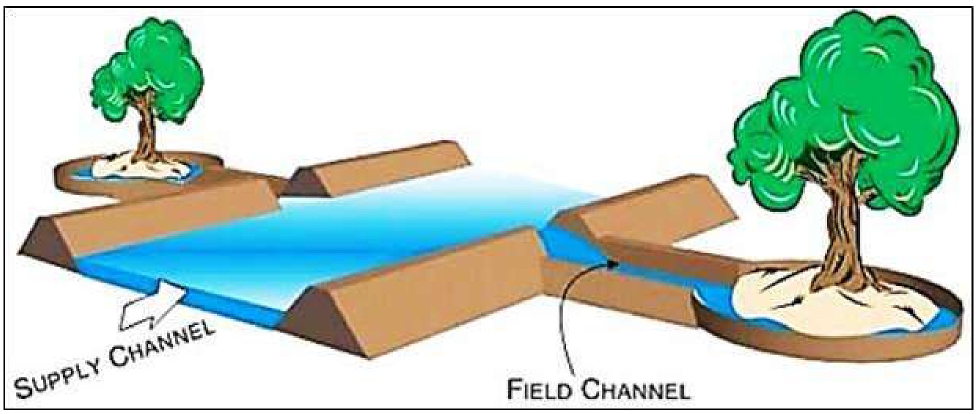
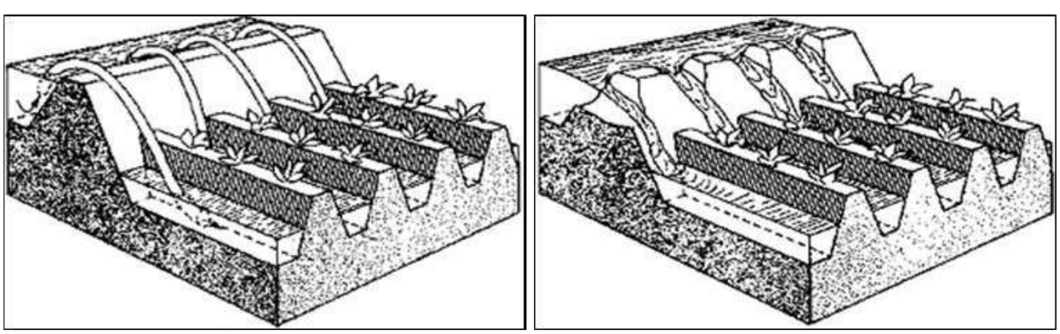
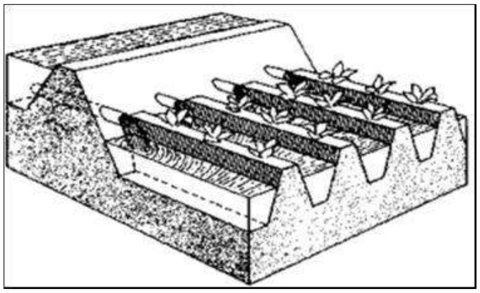


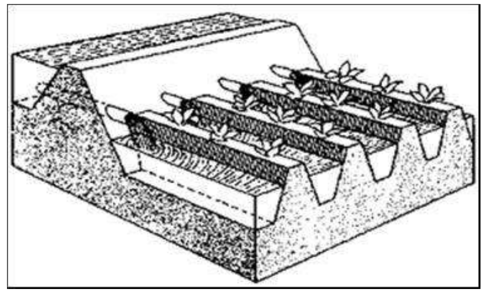
Fig 8: Ring basin method of irrigation

Sometimes, basin sizes are made larger to include two more trees in one basin. Water to the basins is supplied from a supply channel through small field channels conveyed the basins with the supply channel. Trees which can be irrigated successfully using the ring basin method include citrus and banana. Basins can also be constructed on hillside. Here, the ridges of the basins are constructed as in contour border method thus making the only difference between the two is in the application of water.



(a) **(b)**





(c) (d)

Fig 9: Furrow irrigation method of applying water to a field

a) Using flexible pipes to siphon out water from field channel

b) Using the breach method to apply water to the furrows

c) Pipe outlets to deliver water to the furrows

(Image courtesy: Food and Agriculture Organisation, FAO)

In the border method, the water is applied once during an irrigation cycle and is allowed to flow along the field and as the water infiltrates, till the supply is cutoff. In the basin method, as in a rice field the water is higher at a desired level on the basin. Basin irrigation is suitable for many field crops. Paddy rice grows best when its roots are submerged in water and so basin irrigation is the best method for use with this crop. 3.4.7 Furrow Irrigation Furrows are small channels, which carry water down the land slope between the crop rows. Water infiltrates into the soil as it moves along the slope. The crop is usually grown on ridges between the furrows, as shown in Figure 9. This method is suitable for all row crops and for crops that cannot stand water for long periods, like 12 to 24 hours, as is generally encountered in the border or basin methods of irrigation. Water is applied to the furrows by letting in water from the supply channel, either by pipe siphons or by making temporary breaches in the supply channel embankment. The length of time the water is to flow in the furrows depends on the amount of water required to replenish the root zone and the infiltration rate of the soil and the rate of lateral spread of water in the soil. Furrow irrigation is suitable to most soils except sandy soils that have very high infiltration water and provide poor lateral distribution water between furrows.

As compared to the other methods of surface irrigation, the furrow method is advantageous as:

- Water in the furrows contacts only one half to one-fifth of the land surface, thus reducing puddling and clustering of soils and excessive evaporation of water
- Earlier cultivation is possible

Furrows may be straight laid along the land slope, if the slope of the land is small (about 5 percent) for lands with larger slopes, the furrows can be laid along the contours.

Subsurface irrigation methods

As suggested by the name, the application of water to fields in this type of irrigation system is below the ground surface so that it is supplied directly to the root zone of the plants. The main advantages of these types of irrigation is reduction of evaporation losses and less hindrance to cultivation works which takes place on the surface.

There may be two ways by which irrigation water may be applied below ground and these are termed as:

- Natural sub-surface irrigation method
- Artificial sub-surface irrigation method

These methods are discussed further below

Natural sub-surface irrigation method

Under favorable conditions of topography and soil conditions, the water table may be close enough to the root zone of the field of crops which gets its moisture due to the upward capillary movement of water from the water table. The natural presence of the water table may not be able to supply the requisite water throughout the crop growing season. However, it may be done artificially by constructing deep channels in the field which may be filled with water at all times to ensure the presence of water table at a desired elevation below the root zone depth. Though this method of irrigation is excellent from both water distribution and labour saving points of view, it is favorable mostly for the following.

- The soil in the root zone should be quite permeable
- There should be an impermeable substratum below the water table to prevent deep percolation of water
- There must be abundant supply of quality water that is one which is salt free, otherwise there are chances of upward movement of these salts along with the moisture likely to lead the conditions of salt incrustation on the surface

Artificial subsurface irrigation method

The concept of maintaining a suitable water table just below the root zone is obtained by providing perforated pipes laid in a network pattern below the soil surface at a desired depth. This method of irrigation will function only if the soil in the root zone has high horizontal permeability to permit free lateral movement of water and low vertical permeability to prevent deep percolation of water. For uniform distribution of water percolating into the soil, the pipes are required to be very closely spaced, say at about 0.5m. Further, in order to avoid interference with cultivation the pipes have to be buried not less than about 0.4m below the ground surface. This method of irrigation is not very popular because of the high expenses involved, unsuitable distribution of subsurface moisture in many cases, and possibility of clogging of the perforation of the pipes. 3.4.9 Sprinkler Irrigation System Sprinkler irrigation is a method of applying water which is similar to natural rainfall but spread uniformly over the land surface just when needed and at a rate less than the infiltration rate of the soil so as to avoid surface runoff from irrigation. This is achieved by distributing water through a system of pipes usually by pumping which is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The system of irrigation is suitable for undulating lands, with poor water availability, sandy or shallow soils, or where uniform application of water is desired.

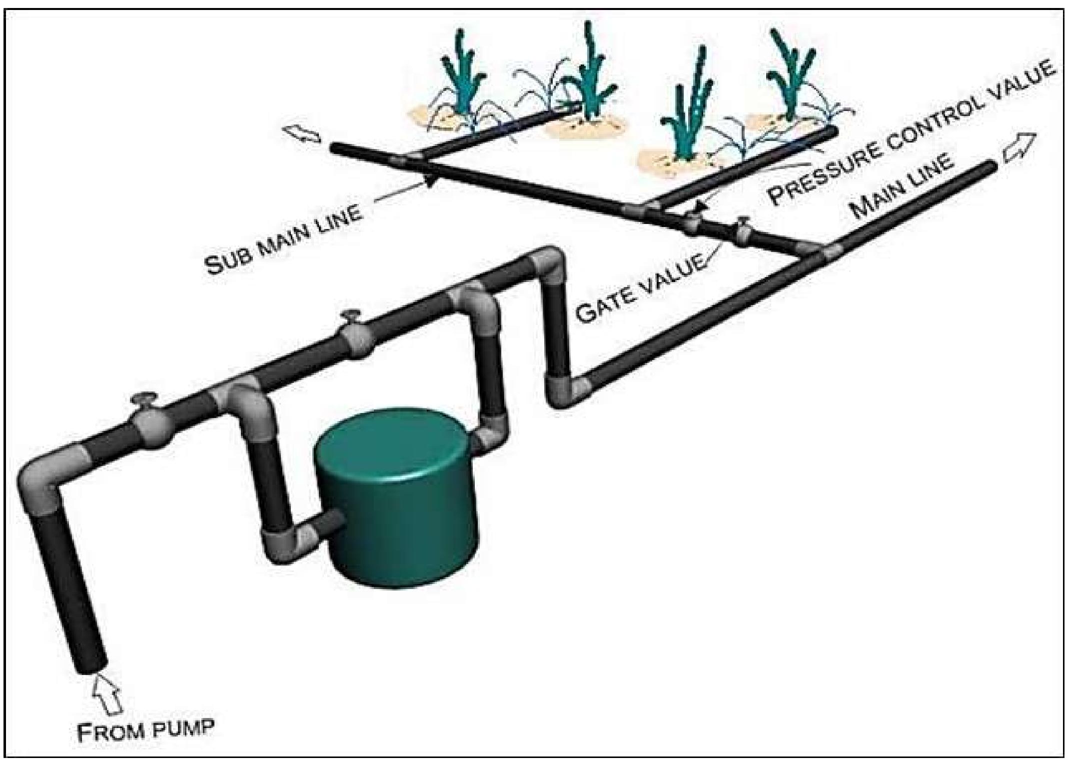


Fig 10: Sprinkler Irrigation system

No land leveling is required as with the surface irrigation methods. Sprinklers are, however, not suitable for soils which easily form a crust. The water that is pumped through the pump pipe sprinkler system must be free of suspended sediments. As otherwise there would be chances of blockage of the sprinkler nozzles.

A typical sprinkler irrigation system consists of the following components:

- Pump unit
- Mainline and sometimes sub mainlines
- Laterals
- Sprinklers

Figure 10 shows a typical layout of a sprinkler irrigation system. The pump unit is usually a centrifugal pump which takes water from a source and provides adequate pressure for delivery into the pipe system. The mainline and sub mainlines are pipes which deliver water from the pump to the laterals. In some cases, these pipelines are permanent and are laid on the soil surface or buried below ground. In other cases, they are temporary, and can be moved from field to field. The main pipe materials include asbestos cement, plastic or aluminum alloy. The laterals deliver water from the mainlines or sub mainlines to the sprinklers.

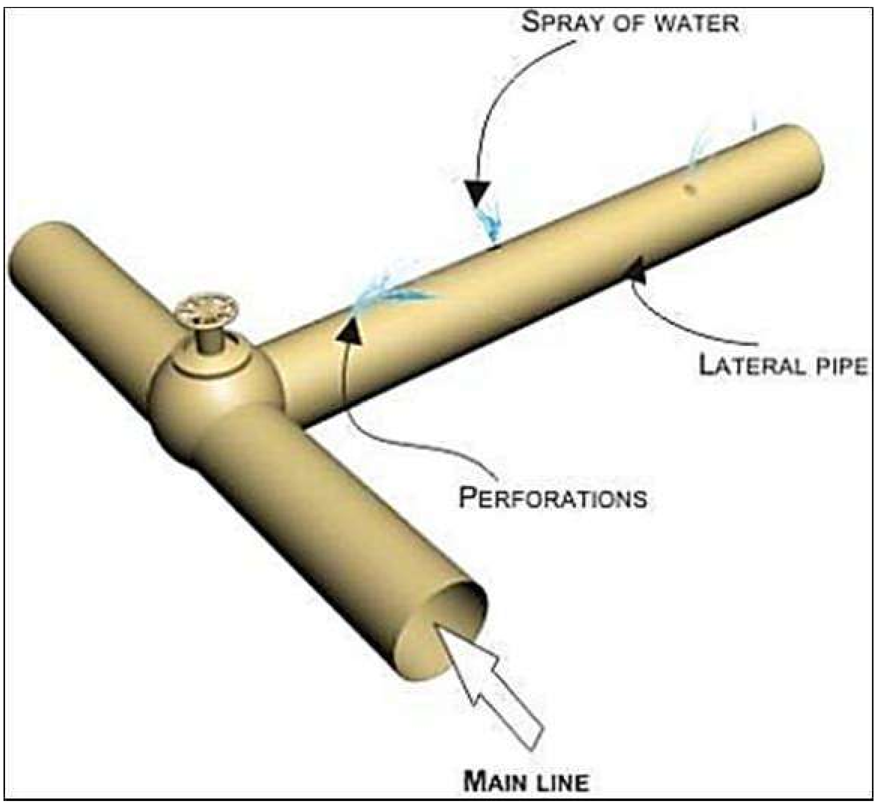


Fig 11: Perforated pipe type sprinkler system

They can be permanent but more often they are portable and made of aluminium alloy or plastic so that they can be moved easily the most common types of sprinklers that are used are:

Perforated pipe system: This consists of holes perforated in the lateral irrigation pipes in specially designed pattern to distribute water fairly uniformly (Figure 11). The sprays emanating from the perforations are directed in both sided of the pipe and can cover a strip of land 6 m to 15m wide. Rotating head system: Here small sized nozzles are placed on riser pipes fixed at uniform intervals along the length of the lateral pipe (Figure 12). The lateral pipes are usually laid on the ground surface. The nozzle of the sprinkler rotates due to a small mechanical arrangement which utilizes the thrust of the issuing water.

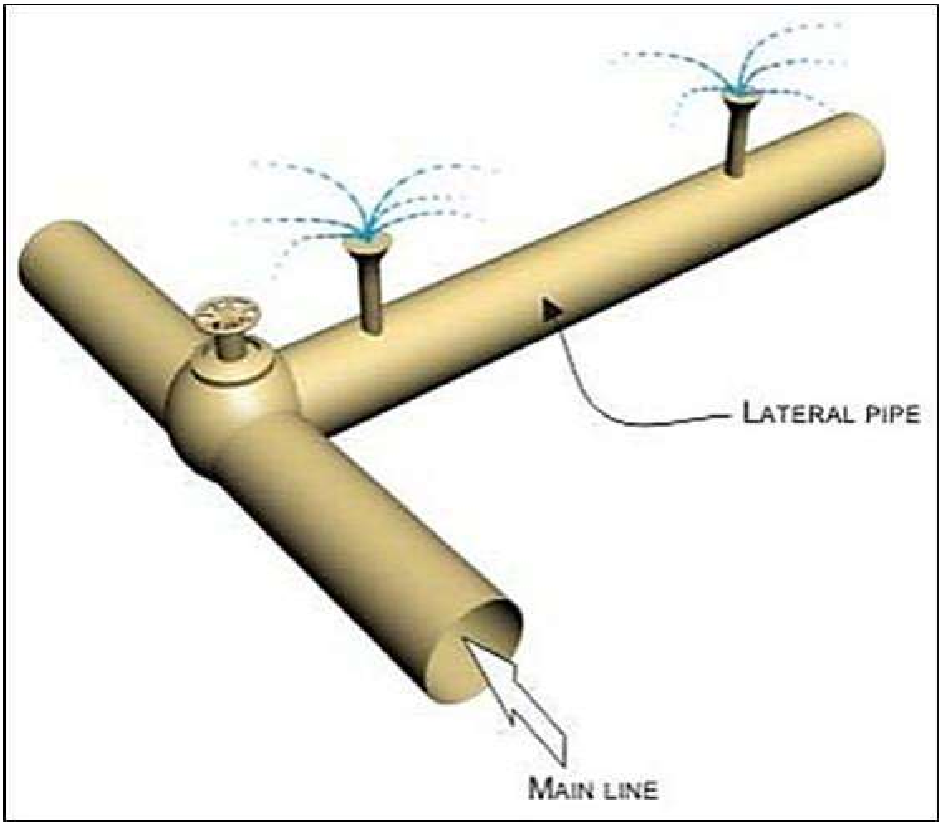


Fig 12: Rotating headed system of Sprinkler

As such, sprinkler irrigation is suited for most rows, field as tree crops and water can be sprayed over or under the crop canopy. However, large sprinklers are not recommended for irrigation of delicate crops such as lettuce because the large water drops produced by the sprinklers may damage the crop. Sprinkler irrigation has high efficiency. It however, varies according to climatic conditions; 60% in warm climate; 70% in moderate climate and 80% in humid or cool climate. Sprinkler irrigation was not widely used in India before the 1980. Although no statistics are available on the total area under sprinkler irrigation, more than 200000 sprinkler sets were sold between 1985 and 1996(with 65000 for 1995-96) according to the National Committee on the use of plastics in agriculture. The average growth rate of sprinkler irrigated area in India is about 25 percent. The cost of installation of sprinkler irrigation depends on a number of factors such as type of crop, the distance from water source.

3.4.10 Drip Irrigation System Drip Irrigation system is sometimes called trickle irrigation and involves dripping water onto the soil at very low rates (2-20 litres per hour) from a system of small diameter plastic pipes filled with outlets called emitters or drippers. Water is applied close to the plants so that only part of the soil in which the roots grow is wetted, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. With drip irrigation water, applications are more frequent than with other methods and this provides a very favourable high moisture level in the soil in which plants can flourish. Figure 13 shows a typical layout of the drip irrigation system.

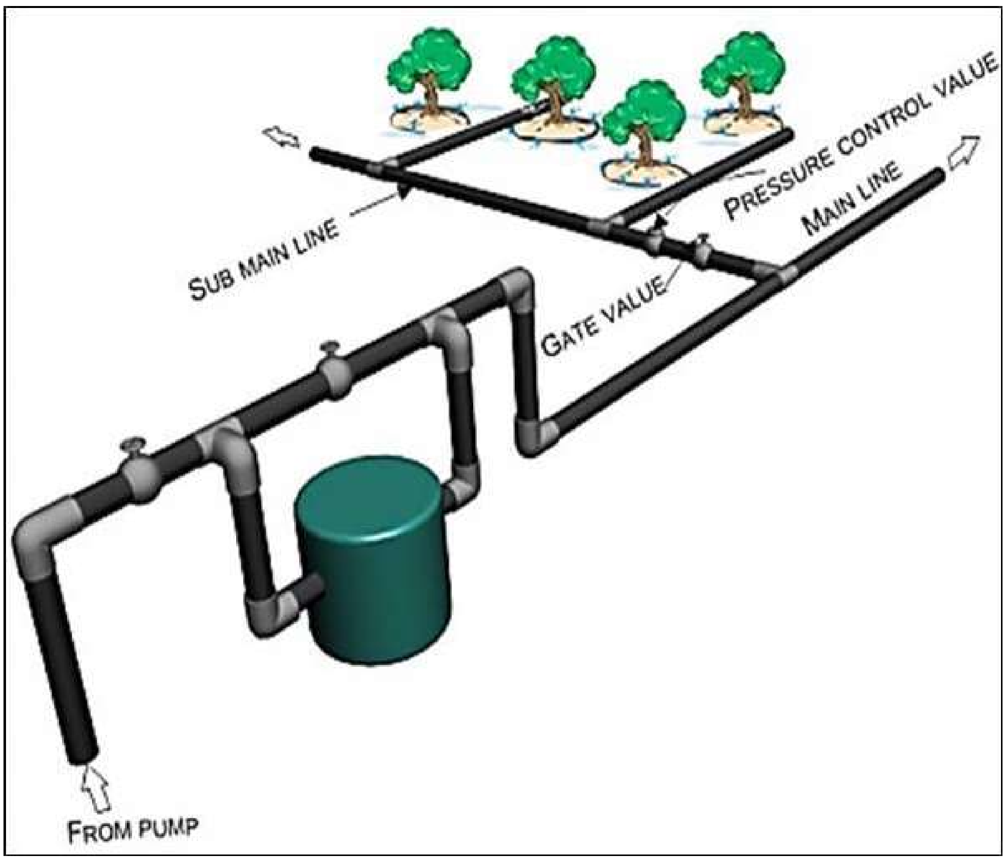


Fig 12: The typical layout of the drip irrigation system

A typical drip irrigation system consists of the following components:

- Pump unit
- Control Head
- Main and sub main lines
- Laterals
- Emitters and drippers

The drip irrigation system is particularly suited to areas where water quality is marginal, land is steeply sloping or undulating and of poor quality, where water or labour are expensive, or where high value crops require frequent water applications. It is more economical for orchard crops than for other crops and vegetables since in the orchards plants as well as rows are widely spaced. Drip irrigation limits the water supplied for consumptive use of plants. By maintaining a minimum soil moisture in the root zone, thereby maximizing the water saving. A unique feature of drip irrigation is its excellent adaptability to saline water. Since the frequency of irrigation is quite high, the plant base always remains wet which keeps the salt concentration in the plant zone below the critical. Irrigation efficiency of a drip irrigation system is more than 90 percent. Drip irrigation usage in India is expanding rapidly. There is even some Government subsidy to encourage its use. From about 1000 hectare in 1985, the area under drip irrigation increased to 70860 hectare in 1991, with the maximum developments taking place in the following states:

- Maharashtra (32924 hectare)
- Andhra Pradesh (11585 hectare)
- Karnataka (11412 hectare)

The drip irrigated crops are mainly used to irrigate orchards of which the following crops are important ones (according to a 1991 survey):

- Grapes (12000 hectare)
- Bananas (6500 hectare)
- Pomegranates (5440 hectare)
- Mangoes Drip irrigation was also used to irrigate sugarcane (3900 hectare) and coconut (2600 hectare)

Conclusion

Among the requirement of agricultural development, irrigation is indispensable for agricultural production. Irrigation is an ancient approach to promoting agricultural development. It is so because in the present day modernized agricultural pattern, the increasing use of modern agricultural inputs and marking the use of various chemicals for soil conservation more effective, require more water for irrigation. The less use of agricultural inputs results only in a low level of production. Thus, we see that irrigation affects the level of agricultural production. Recent advances in agricultural technology have further enhanced the importance of irrigation as it is pre-requisite for the adoption of these technologies. Finally in this study conclude that in area of irrigation facilities increased their cropping intensity and irrigation intensity is higher. It shows that higher cropping intensity in Punjab State is 190 and lower cropping intensity in Manipur state is 100 in India

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