

Module 3

Irrigation Engineering Principles

Lesson 5

Traditional Water Systems and Minor Irrigation Schemes

Instructional objectives

On completion of this lesson, the student shall learn about:

1. The indigenous systems of water utilisation in India
2. Region-specific traditional water storage systems in India

3.5.0 Introduction

Water is essential for the existence and survival of any life form. Hence human settlements the world over have thrived so long they had enough water for consumption and growing crops that yield food for community. The Indian subcontinent has witnessed many such early settlements that devised their own systems of water harvesting, which could be either from surface water or ground water. In the medieval age areas dominated by feudal system, some of these systems took more scientific form and surprisingly, many of these water extraction storage and conveyance structures are still in use in some parts of the country. In other parts of the country, especially in the hilly and mountainous terrains, the communities have devised certain means of water tapping and transfer systems that have been used for generations to provide water for drinking and agriculture. In fact, even today most of these hilly tracts do not enjoy the benefit of modern irrigation systems and still depend on their age old practices, as may be seen from the table below.

Net area irrigated by sources in Himalayan states (1988-89)
(All figures in thousand hectares)

States	Canals			Tanks (‘000 ha)	Wells (Including Tubewell s)	Other Sources	Total
	Govern -ment	Private	Total				
Arunachal Pradesh	-	-	-	-	-	32	32
Assam	71	291	362	-	-	210	572
Himachal Pradesh	-	-	-	-	11	88	99
Jammu and Kashmir	130	159	289	3	3	15	310
Manipur	-	-	-	-	-	-	-
Meghalaya	-	-	-	-	-	65	65
Mizoram	-	-	-	-	-	50	50
Nagaland	-	-	-	-	-	8	8
Sikkim	-	-	-	-	-	56	56
	-	-	-	-	-	16	16
Total	201	450	651	3	14	540	1,208

Source: “Dying Wisdom”: A publication by Centre for Science and Environment, 1997

As may be observed from the data in the table, the role of traditional irrigation systems, managed by the farmers themselves is important in the remote and hilly areas. In this lesson, we look more closely to these traditional approaches of irrigation prevalent in different regions of our country and discuss ways by which these may be integrated with modern engineering practices.

Irrigation schemes less than 2000 hectare are designed as minor irrigation schemes. Some examples of such schemes have also been discussed in this lesson.

3.5.1 Traditional systems in different regions of India

In India, one may find regions varying in temperature, elevation and rainfall. As a result, the climate is drastically varying from one place to another for example, when that of the northern Himalayan regions is compared with that of the southern coastal regions or the dry western and central regions are compared with the west eastern and north eastern regions. Hence, the methods of traditional systems of water utilization have evolved very differently over the years in different places. The main sources of water have generally been:

- Utilization of stream and river water
- Direct tapping of rain water (rain water harvesting)
- Ground water

Stream/river/surface water

Wherever these sources exist, especially in the hill and mountain regions of India, people developed techniques to divert its water with the help of simple engineering structures, into artificial channels that would take the water directly to the agricultural fields where streams joined to form rivers, even some larger and complex engineering was used to divert the river water, for example the **Grand Anicut** on the river Cauvery.

In the arid and semi arid regions, where water in the streams was more seasonal and not available round the year, the diversion channels were first directed into a storage structure-so that water could be used in the ensuing dry period for human and animal consumption, and for agriculture. However not all storage structures were riverfed or streamfed. Many of them simply collected water running off a catchment area to be stored for later use.

In the flood plains, people developed ingenious techniques to use the menacing flood water, not just to irrigate their fields, but also to fertilize their fields with the silt deposited by flood waters and control diseases like malaria by making use of the fish in the flood waters to eat away the mosquito larvae.

Rain water utilization

There is a great potential of rain water harvesting and this has been used at many places of the country, especially in the drier areas. For example, even in the drier areas of the Thar Desert of Rajasthan, people devised water harvesting structures called the **kundi**. In certain areas of Rajasthan and Gujarat, people even devised and used techniques to tap the scarce rain water falling on roof tops.

Ground water

Traditionally, dug-wells have been constructed, the water from which was lifted using traditional technology like the Persian wheel or simply pulley arrangement for use in agriculture or drinking water purposes. Wells were, and still are, important source of irrigation in the ground water rich region of the Indo-Gangetic plains. In the dry areas of Rajasthan, people built structures like step wells and wells below tanks and other types of water storage structures. These served both as ground water collection points as well as storage structures for rain water harvesting. In some hilly regions, for instance in the hills and mountains of eastern ghats, people have long since used the Middle Eastern technology of **qanats** to build subterranean structures, which are horizontal wells with a mild slope and called **surangams** locally, the top the water seeping down the hill sides for use as drinking water.

In summary, the various types of traditional water harvesting system practiced in India may be presented as given in the table below. It must be remembered that all these methods are ingenious forms of water resources engineering and a modern engineer may not only learn from these age old techniques but also suggest new ways to improve them to make these more efficient.

Types of Indian Traditional water harvesting systems

<i>Ecological Regions</i>	<i>System for Irrigation</i>	<i>Systems for Drinking water</i>
1. Hill and Mountain regions	a) Diversion channels leading directly to agricultural fields (eg. <i>Guhls</i> and <i>kuhls</i> of western Himalaya) b) Occasionally, the channels first lead into a storage structure so that water can be used in the subsequent dry period, too (eg. <i>Zings</i> of Ladakh).	a) Natural springs were often harvested. b) Rainwater harvesting from rooftops. c) In the Northeast, spring water is often carried over long distances with the help of bamboo pipes.
2. Arid and Semi-arid regions	a) Rainfed storage structures which provided water for a command area downstream (eg. Tanks)	a) Groundwater harvesting structures like wells and stepwells were built to tap

	<p>b) Stream or riverfed storage structures, sometimes built in a series, with overflow from one becoming runoff for the subsequent one (eg. System tanks of tamilnadu, bandharas of Maharashtra, keres of Karnataka)</p> <p>c) Rainfed storage structures, which allow runoff to stand over and moisten the fertile soil-bed of the storage structure itself, which is later used for growing crops (eg. Khadins of the Jaisalmer district and Johads of the alwar district in Rajasthan).</p>	<p>groundwater aquifers (eg. Bavdis of Rajasthan).</p> <p>b) Groundwater harvesting structures like wells and stepwells were invariably built wherever they were possible, especially below storage structures like tanks to collect clean seepage for use as drinking water (eg. Several such structures can be found in the forts of chittor and Ranthambhore).</p> <p>c) Rainwater harvesting from rooftops (eg. Tankas of Pali).</p> <p>d) Rainwater harvesting using artificially created catchments which drain water into an artificial well – just about any land can be used to create such a water harvesting structure (eg. Kunds of Rajasthan)</p> <p>e) Special rainwater harvesting structures which help to keep sweet rainwater from mixing with saline groundwater and, thus, providing a layer of potable water (eg. <i>Virdas</i> of kutch)</p> <p>f) Horizontal wells similar to the middle east to harvest seepage down hill slopes (eg. <i>Surangams</i> of Kerala).</p>
3. Plains and Flood plains	<p>a) In the flood plains of major rivers, people built inundation channels which allowed floodwaters to be diverted to agricultural lands (eg. Flood irrigation system of west Bengal)</p> <p>b) In specific types of soil and cropping regions, people also store rainwater in the agricultural fields by bunding them (eg. Haveli system of Madhya Pradesh).</p>	<p>a) Dugwells</p>

4. Coastal Areas	a) Regulatory systems to control ingress of saline riverwaters, especially during coastal tides, and thus maintain crop productivity in the coastal plains (eg. Khazana lands of Goa).	a) Dugwells
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The following sections mention briefly the ingenious ways of local people in different parts of India in the field of water tapping, storage and utilization for irrigation as well as drinking purposes.

3.5.2 Western Himalayan region

This is the portion to the north of India spanning from Jammu and Kashmir valleys and going in a south-eastern direction through Himachal Pradesh and ending in Uttaranchal. This region forms the upper catchments of the river Indus and its five tributaries, viz, Ravi, Beas, Sutlej, Jhelum and Chenab in addition to those of the rivers Yamuna and Ganga. Generally, terraced agriculture is commonly practiced on the slopes, and paddy cultivation in the valleys that separate the sub-himalayan ranges from the middle mountains.

Here has been an extensive system of water harvesting in the western Himalayas. Farmers have had a major tradition of building canals aligned roughly with contours to draw water from hill streams or springs. These canals are known as **kuhls**, which vary from 1 to 15 kms. Generally, a kuhl would have a trapezoidal cross section, 0.1 to 0.2 square meters in area, and usually conveys a discharge of around 15 to 100 litres per second. Many kuhls collect rainwater and snow melt running of the slopes above them, and as a result, occasionally it is possible to find a kuhl whose discharge increase along its length. The discharge can vary along with the season. A single kuhl can irrigate an area of 80 to 400 ha through distributaries or by flooding. The irrigated land, being situated on hill slopes, is terraced. The system is common at altitudes from 350 to 3000 m in the outer and middle Himalaya where there is a significant drop in elevation in the path of a kuhl, the fall is utilized to drive a simple machinery, like flour mills. Apart from these water channels, another water harvesting structure-the ponds is fairly common in the Jammu region. However, these ponds now suffer from growing encroachment of rising population at water inlets and from siltation.

It is worth noting that utilization of the waters of the mountain streams is need in many villages to drive grinders for grain crushing. In fact, it is the energy of the water due to elevation difference of the water flowing from one point to another. Recently, some villages have taken the initiative to utilize this traditional system of water-energy tapping to drive small turbine connected to generators. The traditional grinders, working with rather very low efficiencies is also being replaced by modern high-efficiency runners which enable higher quantities of grains to the grinded per unit time compared to the traditional areas.

It may be mentioned that though not a traditional system of water utilizing method, the **hydraulic ram** (or **hydram** for short) is needed at many hilly streams to lift water to fields at higher elevations.

In the Nainital and Dehradun districts, channels called *Guhls* are used extensively. Here streams are dammed by temporary diagonal obstructions made of trees and branches, which are used to direct the water into contour channels along the hillside.

3.5.3 Eastern Himalayan Region

The Indian portion of the eastern Himalayan regions consists of the states of Sikkim and Arunachal Pradesh Darjeeling district of West Bengal.

Artificial irrigation is common in the terai region of Darjeeling district. The slope of the land and numerous small streams that exist there, make it easy to utilize the water. The hill springs, called **jhoras**, are the only dependable source of water in most places.

In Sikkim, local people have evolved efficient water harvesting systems together with land management systems. Irrigation is mostly confined to rice fields and cardamom plantations. In rice fields, irrigation is done in bench terraces. In the case of cardamom, irrigation water is allowed to flow without proper distribution channels. Construction of water channels, regulation of water flow, and drawing of drinking water were traditionally done through community participation. The common sources of drinking water are streams and **kholas** (tanks).

There are two important traditional irrigation systems in Arunachal Pradesh-the irrigation of rice terraces with bamboo pipes, and the **Apatani** system of wet rice irrigation. In the former method, water is transported through an intricate system of Bamboo pipes to agriculture fields. But this system is now becoming obsolete and is being replaced by iron pipes and channel irrigation.

The apatanis have evolved a very scientific system of field irrigation. The striking features are partially flooded rice fields, and the intricate design of the 'contour dams' dividing the plots. The valley floor has a gentle gradient, and the terraced holdings are laid out along the general slope. The plots are divided by about half a meter high earthen dams supported by bamboo frames. All holdings have an inlet facing the water head and an outlet at the opposite side. The inlets for the low lying plots act as outlets for the higher level plots. A deeper conduit channel connects the inlet point with the outlet point. When a terrace is to be filled with water, the outlet is blocked. By opening and blocking the connecting ducts, any field can be flooded or drained as required.

3.5.4 Northeastern hill ranges

This region stretches over six states Assam, Nagaland, Manipur, Mizoram, Tripura and Meghalaya. The water resources potential of the region is the largest in the entire country. Consequently, there is an abundant groundwater resource. Maximum scope for groundwater exists in Assam, Tripura and Arunachal Pradesh. The available surface water resources have hardly been tapped because of the rugged nature of the terrain. Hence, cultivation in the region is largely rainfed and *jhum* cultivation (shifting cultivation) has been widely adopted.

In Nagaland, the cultivations of the southern districts mainly practice net terraced rice cultivation. The proportion of Jhum cultivation in these areas is only 20 percent of the total cultivated area whereas, in Tnensong and Mokokchung districts, it is as much as 70 to 80 percent.

Water harvesting practices in Meghalaya take the form of wet rice cultivation in parts of the Jaintia hills, and of bamboo drip irrigation in other regions. This ingenious system of tapping of stream and spring water by using bamboo pipes to irrigate plantations is widely prevalent and so performed that about 18 to 20 litres of water entering the bamboo pipe system per minute gets transported over several hundred metres and finally gets reduced to 20 to 80 drops per minute at the site of the plant. The bamboo drip irrigation system is normally used to irrigate the betel leaf or black pepper crops planted in arecanut (betelnut) orchards or in mixed orchards. Bamboo pipes are used to divert perennial springs on the hilltops to the lower reaches by gravity.

In Manipur, the jhum method of cultivation is still the prevalent mode of cultivation. However, there has been some tradition of water harvesting amongst the Nagas of Manipur.

In Mizoram, the high rainfall (about 2500mm over about eight months a year) has had ill effects on hillslopes as deforestation has resulted in soil erosion and reduction in water retention capacity of the soil. The traditional sources of water were the numerous springs in the hills, known locally as *tuikhur*, but many have been drying up recently. For domestic water consumption, therefore the method of rooftop rainwater harvesting has become a widely prevalent practice in Mizoram. A common method of storing rainwater is to place horizontal rain gutters along the sides of the sloping roof, which is normally made of corrugated iron sheets. Rainwater pours into the pipe connected to the tank.

3.5.5 Teesta, Brahmaputra and Barak valleys

These are the plains of the North Bengal and Assam which drain the adjacent hilly and mountainous terrains.

In the North Bengal, there was an old tradition of harvesting streams in the plains abutting the hills. It has been reported that cultivators cut small irrigated channels,

locally called *jampoi*, from streams which seemed suitable. As such, this method was once the principle source of irrigation in the Jalpaguri district.

In the Brahmaputra and Barak valleys of Assam, too, there had been a long tradition of artificial irrigation, by the means of artificial channels in the sub-mountainous tracts. In certain parts of the state, particularly in Golaghat, Sibsagar, and Jorhat areas, there was also a tradition to dig ponds which were mostly used for drinking water.

3.5.6 Indo-Gangetic plains

This is a zone of high human concentration and is a vast enclosed basin of numerous small and large rivers, separated by alluvial divides. This region comprises of Punjab, Harayana, Chandigarh, Delhi and Northern Uttar Pradesh in the upper Ganga plains. The Middle Ganga plain is the transitional zone between upper and lower ganga plains, located in Eastern Uttar Pradesh. The lower ganga plains extends over Bihar and West Bengal.

Punjab, the land of five rivers, has been rich in cultivation all through its history and traditionally, irrigation was done with the help of canals can be found from the Mughal times when much larger and longer canals started being constructed. For example the Badshahi Nahar was constructed in 1633 A.D by the famous engineer and architect Ali Mardam Khan under the orders of the Mughal emperor Shahjahan. In other places, the Persial wheel was used extensively to lift water from wells. Among other canals, were the Hasli canal originally built by Mughals and later revived by the sikh to feed the sacred tank at Amritsar. In British rule, efforts to renovate the canal were made, but finally it was scrapped and the canal in the upper Bari Doab was constructed. Another medieval canal, the Shah-Nahar, was an inundated cut branching off from the beas. Records show that in the Beas-Sutlej doab (the elevated region between two rivers), irrigation was almost entirely done through wells. A normal well could draw about two thirds of an acre. Irrigation in some areas, like Kapurthala was done by flood waters of rivers. During the British rule, the Sirhind canal was opened which had a large extent of the **distributary** channels to bring water within the boundaries of each village.

In Harayana, too there was development of canals during the Mughal period, though prior to that the most prevalent way of irrigation was through wells. Ali Mardam Khan begun the Rohtak canal in 1643 AD by diverting water to Delhi from the old channel, constructed for irrigation. This was gradually extended as far as Gohana rule. The British remodeled these canals in 1870 by putting up a weir on Yamuna at Tajewala, which is the place where the river leaves the hills and joins the plains. The western Yamuna canal still serves to bring water through the plains of Harayana to Delhi, irrigating many hectares of land on the way. In the areas south of Delhi, irrigation was done by the Agra canal which took off from a weir at Okhla on the Yamuna constructed by the British in 1875 this canal still also is under operation.

Since Delhi was not as populated as it is today till some years back, many parts of the region were used for cultivation. The rulers of Delhi had taken keen interest in providing artificial irrigation water and a number of interesting engineering feats of water storage and conveyance were constructed. Though none of these are probably used today for the purpose they were made and even some of these have dried up, it is interesting to note the high level of engineering skill that was existing since about a thousand years in this region.

The Gangetic plains of Uttar Pradesh were always irrigated by wells because the ground water level was very high, and hence boring of wells was easy and cheap in most districts except in the sandy lowlands along the rivers. In these tracts, the wells, unless made of masonry, broke down during the rains. Tanks were also built, which varied in size, generally covering less than a hectare and not more than 5 to 6 meters deep. Usually, a **kuchcha** (unlined) well would be dug at the centre to reach the ground water table. Other sources of irrigation were natural wheels, swamps and small water courses. During British rule, irrigation canals were built in western Uttar Pradesh like the Ganga canal designed by P B Cautley in 1846, which is still working today. In Bihar, the large number of Himalayan rivers join the Ganga from the north—Ghagra, Gandak and Kosi, among others. Of the traditional water utilization system, the method of **ahar-pyne** was particularly interesting, which probably dated for over two thousand years. The pyne were canals that bring water into **ahars**, which were tanks. The ahar recharged the ground water and thus the nearby wells generally could draw good amount of water most parts of the year. In recent years, there have been attempts to revive this system, especially where modern irrigation system has not spread. The pyne-ahar system also helped to divert some part of the rain water falling within the catchment thus reducing flood potential of the larger rivers at lower positions of the terrain.

In Bengal, one of the traditional systems of irrigation had been the inundation canals, which is almost totally abandoned today. In this method, the high flood waters of the rivers were allowed to inundate the adjacent flood plains, thus bringing with it rich silt over which good amount of crops were grown after the passage of flood. However, from the times of the British rule, especially in the early twentieth century and even after independence almost all rivers were embanked, leaving no room such traditional practice of agriculture. As a result, the rivers have to flow through a much constricted cross-sectional area during floods, with a corresponding rise in flood water levels. The falling floods have also deposited the silt on the constricted riverbed, thus raising it dangerously high at many places. At times, the embankments breach during floods, thus inundate the human settlements that have unauthorizedly encroached upon behind these embankments in the flood plains.

3.5.7 The Desert Areas

This is the Thar desert area to the west of Rajasthan and covering parts of Gujarat, Punjab and Haryana. Being a generally water scarce area, these regions developed judicious methods to conserve water. Though many of these systems have been in use

for centuries, at many places they are still being used. In the towns, however, new methods of water supply have put some of these in disuse but very recently, with growing awareness about scarcity of water, many such systems are being revived.

The wells have been the most important source of water both for irrigation and drinking purposes in the Jodhpur district. The land irrigated by wells was referred to as **chahi**. The Luni is an important river in Jodhpur. During rare floods, river water overflowed and crops of wheat and barley were grown on the saturated soil. Tanks have also been used at many places. The land irrigated by canals emanating from large tanks was known as canals **nahri**. Villagers also collected rainwater in covered pits called **kund** or in simple excavations called **sor**, where the ground was hard. The practice of water conservation was also very strong in this region. In some households in Jaisalmer district, even today people bath on the wooden platform under which a vessel is kept. Water that drains into this vessel is used for animal consumption. Similarly, in parts of Jaisalmer, Pokhran and Phalodi, people bath on a stone block outside the house, from which water drains into an animal watering tank.

The cities in Rajasthan were built around areas that had some sort of water source. All the forts had tanks and wells. Rooftop rainwater harvesting was common across towns and villages. Rainwater that falls on the sloping roofs of houses is taken through a pipe into an underground tank built in the main house or courtyard. The first spell of rain would not be collected as this would clean the roof and the pipes. Subsequent rainwater would be collected in underground tanks, which would be as large as a big room. It is reported that though this method is gradually giving way to modern methods like piped municipal water supply, many houses in Phalodi, still about 2000 still maintain their tanks.

It is, however, unfortunate that many traditional water harvesting structures have been put to disuse, for example, that of Baiji-ka-talab of Jodhpur which was huge reservoir collecting rain water for use in drier months. Many **bavdis**, or step wells, of these may be revived as the rising population would generate much pressure on the existing water supply system of the town in the near future. Of course, there one other reservoir like the Ranisar Lake situated inside the Mehrangarh fort, which is still use today. The spilled over water of this lake is again collected in another, called the Padansar lake. The water from these lakes not only provides direct supply, but also recharges the ground which keeps the wells and bavdis down the hill full of water throughout the year.

In Gujarat, the desert extends over a large area. Here too, very similar methods of water harvesting, like tanks wells and stepwells have been in use, perhaps from time as old as the 8th century AD. Interestingly, for the nomadic Madhari tribesmen of Gujarat, **virdas** are the principal means of water harvesting. Virdas are shallow wells dug in low depressions and collect enough rain water to ensure the availability of freshwater throughout the year.

3.5.8 Central Highlands

This region comprises of the semi arid uplands of eastern Rajasthan, the Aravali range and the uplands of Banas-chambal basins. In Rajasthan, the Jhansi-Mirzapur uplands of Uttar Pradesh; the eastern hilly regions of Dangs and Panchnabal in Gujarat; northern Madhya Pradesh uplands; the Sagar, Bhopal and the Ratlam plateaus of central Madhya Pradesh; and the Narmada region, include the flanks of the Vindhya and Satpura ranges of southern Madhya Pradesh.

In these areas generally, there is little cultivation on the hillsides. The cultivated area is generally confined to the valleys and the low ground between the hills, where the soil is alluvial. In many of these regions, wells were the chief irrigation source. Tanks were also constructed in and around many forts that are scattered in the region. In some parts of Madhya Pradesh, especially in the upper part of Narmada valley, a unique cultivation system based on water harvesting and runoff farming exists, which is known locally as the ***haveli*** system. Rain water is held in embankment fields, enclosed on four sides until sowing time. Water is let out as soon as the land is dry and the fields are sown. After this, no watering is needed for the crops. The haveli system is location specific, like other ingenious runoff farming practices of the country. The soil, where it is practiced, is heavy black clay, which holds large amount of water. The soil is unfit for kharif crops like paddy or cotton but it is excellent for wheat. An important reason for the development of the haveli system was the need to control weeds.

It may be worth noting that there is a grand example of mughal water engineering works for water supply to the city of Berhampur, by the side of Tapi river. The system, which is still active today, consists of ***bhandaras*** or storage tanks which collect ground water from the underground springs flowing down from the Satpura hills towards the Tapi. The groundwater is intercepted at four places northwest of Berhampur. Water is carried through subterranean conduits with a number of connected wells to a collection chamber, called ***jail karanj***, and from there to the town.

Though not in function any more, there are three ancient water tanks on the hills of Sanchi, a city renowned for its Buddhist past, which are constructed at about the third century BC.

3.5.9 Eastern highlands

This area extends from Chhatisgarh, Jharkhand, eastern Orissa up to Chhota Nagpur plateau. There is evidence of rich tradition of water harvesting systems of this region. In most of these areas, the undulating terrain has been utilized by constructing small bunds either locally by erstwhile Zamindars, British administrative officials or by the respective state governments, usually under minor irrigation schemes, which is mentioned later in this chapter.

3.5.10 Deccan Plateau

The Deccan plateau consists of the whole of the south Indian table land. The plateau occupies large parts of Maharashtra and Karnataka and the eastern half of Andhra Pradesh.

In Maharashtra, the well irrigation was fairly extensively used and was the principal form of irrigation in the central deccan region. Numerous dams, known locally as **bandharas**, as a permanent or temporary nature built either of earthen or masonry, were built across rivers and streams in western deccan. These structures would either raise the water level to enable water to form large reservoirs. Where a bandhara was built across a small stream, the water supply would usually last for a few months. When the water level dropped below the level of a channel, a wooden shovel or scoop was used to lift the water. The system of bandhara making is still prevalent in many places and people use modern day ingenious methods like used cement gunny bags filled with soil piled up to form a dam like structure across small rivers. In some places, the system was extended to what is known as **phad** system, which is the division of the command area into smaller zones called phads. In fact the bandhara based water diversion through canal is very similar to any modern day irrigation system. The cropping pattern in the phads follows local wisdom. In a year of plentiful water, the community may decide to grow sugarcane in most of the phads, whereas in drier years, sugarcane may be cultivated in few phads, with driver crops being planted on others and even leaving a few phads fallow, if needed.

Traditional water harvesting for irrigation in Karnataka used a number of systems: water was supplied directly from river channels; from tanks supplied by river channels; from a series of tanks situated in valleys of rivers and streams, and, by wells and springs locally called **talpariges**. At the beginning of the twentieth century, channel irrigation was initiated by the British administration but restricted largely to the south of the erstwhile Mysore state. Irrigation was also obtained in the Mysore state from river-fed tanks using the waters of the Cauvery, Hemavati, Yegachi, Lakshman Tirtha, Kabini, Swarnavati, Nagu and Shimsha. In north Karnataka, the Tungabhadra ancients (dykes across rivers, or bunds) and channels partially irrigated the Bellary, Dharwar, and Bijapur districts of the former Bombay presidency. Tank irrigation was also extremely important in Karnataka and it was found predominantly in Bijapur, Shimoga, Kadar, Bellary, Hassan, Tumkur, Kolar and Bangalore districts. Even though they were not the primary irrigation source in the mysore state, tanks were common in many regions. Many of them are still active but others have become defunct or the water quality has become degraded, or for the famous tank Hussainsagar in Hyderabad, which was built in the sixteenth century by the Nizam rulers of the princely state. In fact, two other tanks were built later for supplying water to the city of Hyderabad-Himayat Nagar and Osman Nagar. However, over the recent past these tanks have not filled up during rains probably because of extensive water tapping in the contributing catchment.

The tradition of tanks, some of which have been built as far back as the fourteenth century, remained the largest source of irrigation in Andhra Pradesh until mid-1960s.

The number of tanks in operation over a span of thirty years, as shown in the following table, may give an idea of the relative declination of the dependence on tanks. However, wells for irrigation have increased lately. This might be a reason for lowering of ground water table in many regions, with a resulting cutoff in recharge to tanks from ground water and consequent drying up of some of the surface tanks. There are about 50,000 tanks in Andhra Pradesh.

Decline of tank Irrigation in Andhra Pradesh

Districts	1955-56				1986-89			
	Number of Tanks			Area1 (ha)	Number of Tanks			Area3 (ha)
	Irrigating less than 40 ha	Irrigating more than 40 ha	Total		Irrigating less than 40 ha	Irrigating more than 40 ha	Total	
Drought Prone Districts								
Prakasam	-	-	-	-	584	200	784	38000
Kurnool	426	92	518	24472	301	88	389	15000
Anantapur	1497	740	2237	37254	931	274	1205	19714
Cuddapah	1029	155	1184	29806	1219	163	1382	15333
Chittoor	5290	1336	6626	72024	7152	465	7617	57000
Mahbubnagar	3847	437	4284	68149	5736	499	6235	28667
Nalgonda	3625	329	3954	45078	5061	447	5508	31333
Rangareddy	-	-	-	-	1706	168	1874	8333
Total for drought-prone districts	15714	3089	18803	276783	22690	2304	24994	213380
Non-drought-prone districts	33997	5728	39715	800211	46230	5439	51669	776286
Total Andhra Pradesh	49711	8817	58518	1076994	68920	7743	76663	989666

Source: "Dying Wisdom": A publication by Centre for Science and Environment, 1997

Area under tanks and wells, and rainfall in drought-prone areas of Andhra Pradesh

District	Area under Tanks		Area under wells		Rainfall	
	1959-62 (ha)	1986-89 (ha)	1959-62 (ha)	1986-89 (ha)	1959-62 (mm)	1986-89 (mm)
Prakasam	NA	38000	NA	60000	802	841
Kurnool	28453	15000	7833	35667	587	760
Anantapur	33757	19714	31439	81333	565	633
Cuddapah	27697	15333	36108	80000	435	732
Chittoor	80980	57000	37799	112333	458	896
Rangareddy	NA	8333	NA	46333	713	988
Mahbubnagar	66355	28667	20747	78000	921	753
Nalgonda	57545	31333	27089	81667	859	759
Total	294789	213380	160925	575333	-	-

Source: "Dying Wisdom": A publication by Centre for Science and Environment, 1997

3.5.11 Western Ghats

This constitutes a narrow long range of hills running from north to south along the western coast of India and spreads over parts of the states of Gujarat, Maharashtra, Goa, Karnataka and Kerala. Though there has been very little documented evidence about the traditional water harvesting practices of the people living in these hill ranges, it is gathered that ponds and tanks for water storage and diversion channels from streams has been practiced for many years for paddy cultivation and orchards.

Wells are common in the coastal belt aquifers of Kerala, while medium to large diameter open dug wells and bore wells are common in the midlands. In the highlands, springs, borewells, dugwells, and medium-sized surface tanks are common water harvesting structures. However, the Kasaragad district of northern Malabar has a special harvesting structure called **surangam**, which is actually adapted from the **qanats** that existed in Mesopotamia and Babylon at around 700BC. It has been found out by the Centre for Water Resources Development and Management in Kochikode that there has been a rise in the number of surangams in the recent years. A survey has also indicated that about sixty percent of the surangams have perennial water supply, though the summer discharge varied from 2 to 60 litres per minute. Surangams are found to be used for both domestic water supplies as well as for irrigation purposes.

3.5.12 Western coastal plains

This region stretches southwards from the hot and near-arid Kathiawar peninsula of Gujarat to the humid Malabar Coast of Kerala.

The Kathiawar peninsula and the Gujarat plains lie midway between the barren Thar desert and the humid Konkan region. Here, water is found close to the surface and numerous wells, called **vavs** or **bavdis** are used as sources of water for drinking. In some low-lying districts to the north and northwest of the peninsula, the ground water is saline, and as a result almost every village has a pond or reservoir. In Surat, Bharuch and Ahmedabad districts and the erstwhile Baroda state, wells, lakes and tanks are important sources of water, both for irrigation and domestic use. In Ahmedabad, a number of lakes and reservoirs were built to store water and the Kankariya Lake was built in 1451 AD.

The Konkan region of Maharashtra is a narrow belt of land which lies to the west of Sahyadri range, and is characterized by high humidity and heavy rainfall. Fertile alluvial soils in the lowland regions are used to cultivate rice. These soils are free of salt and the fields are often embanked (**bandhini**) and flooded during the monsoon. Wells, lakes and reservoirs also were important source for irrigation and drinking. The larger rivers are saline ingressed due to their proximity to the sea and the waters are only periodically sweet. Though there are no large canals, often water from small streams are diverted through narrow water courses (**pats**) to irrigate rice fields. Field embankments (**shilotris**) were an interesting feature of tillage in Colaba and Thana districts. These embankments were made to keep out the tidal waters.

The Khazana lands of Goa plays a crucial role in the states' coastal ecology and cover more than 18,000 ha. The term Khazana is said to be derived from the portugese casino, which means a big rice field, and are the low lying agricultural fields irrigated with water from rivers, which is controlled through sluice gates' two major rivers, the Zuari and the Mandovi, form the food bowl of Goa. Paddy is grown in the Khazana fields during monsoon when rain water reduces the salt in the water to its lowest level, bunds or embankments made of locally available materials like mud, straw, bamboo, twigs and branches from mangrove, laterite stones etc. These bunds protect the fields from being flooded with undesirable brackish water.

In the coastal regions of Karnataka, cultivators have used springs and streams skillfully by diverting numerous channels and constructing temporary dams. In some places, like utara Kamada, the lowland coastal belt is narrower and the Sahyadris rise to the east. Its lowland and upland valleys have basins crowded with spice and betel garden. The water to these gardens are brought from springs which abound at the head of every valley, and generally collected in small ponds or reservoir and from there channeled to the gardens. Water is also brought by channels from small rivulets which abound the area. In the dry season, dams of earth, stones and tree branches are made across streams and the land in the vicinity watered. The dam is removed at the close of the dry season or left to be swept away later by floods.

Irrigation in Kerala in the past was restricted to the southern regions of the erstwhile Travancore state and to irrigate rice and garden crops. It has been observed that it is an age-old custom in the coastal regions of Kerala to dam small streams and divert water by gravity flow for irrigation of low-lying lands around. The cultivators themselves used

to temporary bunds put up during seasons of cultivation which were washed off in subsequent floods.

3.5.13 Eastern Ghats

This is the rugged, hilly terrain running almost parallel to the eastern coast of India, covering parts of the states of Orissa, Andhra Pradesh, and TamilNadu. In Orissa region of the Eastern Ghats, traditionally, people depended on tanks for irrigation and terracing for cultivation. In Andhra Pradesh region, channel irrigation was traditionally common though tanks were also dug.

The high mountains of the Nilgiri in TamilNadu rise at the southern-most end of the eastern ghats and mark the meeting point of the eastern and western ghats. The continuous slope from the mountains to the sea was made use of by ancient rulers of Madurai to establish a system of irrigation. Whenever the surface dipped a little on either side of the Vaigai River, a strong curved embankment was raised with its concave side facing a river and a channel branching off near the top of the embankment. During floods, water would run through the channel to low lying lands and fill the tanks. Though no artificial irrigation has been practiced in the Nilgiri district, in the Madurai and Coimbatore districts, channel tank, and well-irrigation is widespread.

3.5.14 Eastern Coastal Plains

This is a wide and long stretch of land that lies between the Eastern Ghats and the Bay of Bengal and also covers parts of Orissa, Andhra Pradesh and Tamilnadu.

The coastal plains of Orissa, comprises of three district geographic divisions-the salt tract; the arable tract, which is the main rice producing zone of the state, and the submountainous tract, where the delta meets the mountainous tract. Generally, the mainstay of irrigation sources in the hilly areas had been the tanks. Some tanks were excavated and fed by natural streams, others were made by constructing embankments across drains. In the plains, the chief source of irrigation was flood water which was let out into cultivated areas through embankment sluices. Earthen dams were also constructed across minor drainage channels to raise the level of water to irrigate adjacent fields.

The coastal plains of Andhra Pradesh comprise a belt of varying width which extends from Visakhapatnam in the north to Nellore in the south. The two main river systems of this region are the Krishna and Godavari. Numerous small streams and rivers flow down the hills which have traditionally been used to irrigate crops either through cuts in embankments or by tanks fed by these streams. In the Visakhapatnam district, the Eastern Ghats give rise to numerous streams that flow directly into the sea or to the Godavari. It has been recorded that traditionally weed and brushwood dams were built

across the streams and flood waters were diverted directly into fields or indirectly through storage tanks. The main rivers that were used for irrigation in these plains were the Varaha, Sarada, Nagavali and the Suvarnamukhi. There were a number of ancient dams, called the **anicuts**, on these rivers. In the Krishna and Godavari deltas, irrigation largely depends on channels drawn from the rivers. Hence, on the whole, irrigation in the coastal plains of Andhra Pradesh was dependent on tanks and anicuts, many of which are still in use today.

The region between the Nilgiri hills and the coast of Tamilnadu covers a large tract of land that suffers from rather scanty rainfall. Hence, artificial irrigation has been practiced for centuries. The various sources of irrigation in the erstwhile Madras presidency were rivers, reservoirs, tanks and wells. Anicuts (diversion weirs) on rivers like Tambraparni, Noyyal, Tungabhadra, Amaravati, Vaigai and Pennar were constructed by local rulers, much before the British rule, to irrigate the adjacent areas through systems of irrigation channels. It is indeed marvelous that many of these systems are still in use today. For example, the grand anicut on the river Cauvery was built by the Chola king, Kariyapalan, in the second century AD, and is still in use in slightly remodeled form. Apart from anicuts, there has also been a strong tradition of irrigation through tanks, called eris. The eris have played several important roles in maintaining ecological harmony as flood coastal systems, preventing soil erosion and wastage of runoff during periods of heavy rainfall, and recharging the ground water in the surrounding areas. It may be noted that the tanks of south India are mostly found in the red soil regions. Though they supply many villages with drinking water, their primary purpose is irrigation, especially of paddy fields. It has been estimated that in Tamilnadu, there are about 30,000 tanks or **eris** which account for an estimated 50,000 Km long embankments and about 300,000 masonry structures. The eris usually have embankments on three sides and one side is left open for water to flow in. The water stored in the eris is released through sluices. Eris have two sluices-the **mettu madagu**, which is on a higher elevation, is usually opened to release water, and the **palla madagu**, which is at a lower level, is opened once the water stops flowing out of the mettu madagu. Tanks also have an outlet (**kalanga**) at the full tank level.

3.5.15 The Islands

There are two sets of islands in India the Andaman and Nicobar Islands in the Bay of Bengal, and the Lakshadweep islands in the Arabian Sea.

The Shompen and Jarawa tribals of Andaman make extensive use of split bamboos in their water harvesting systems. A full length bamboo is cut longitudinally, and placed along a gentle slope with the lower end leading into a shallow pit. These serve as conduits for rainwater which is painstakingly collected, drop by drop, in pits called **jackwells**. Among the ones, buckets made of logs and sometimes of giant bamboo, are often found suspended from the roofs of the huts along with nets and baskets to trap rain water.

In Car Nicobar the tribals, mainly Nicobarese and Jarawas, use circular dugwells ranging from 2 to 20 metre in diameter, since the water table is just about 2 to 3 meters from ground.

In the Lakshdweep islands, the residents usually have wells for meeting their drinking water requirements. Many of these wells are stepwells and almost every house hold has a dugwell for domestic purposes. In Kavaratti, there are about 800 dugwells while in Amini there are more than 650. Presently, however, rainwater harvesting (from roofs) structures are being constructed all over the islands.

3.5.16 Minor Irrigation

Minor irrigation schemes have probably evolved as a systematic development only after the country's independence and with the initiation of the Five-Year Plan. These include all ground water and surface water irrigation projects having culturable command area of up to 2000 Ha. Naturally, the groundwater schemes require pumping up of water from tube wells, whereas surface water schemes may include those which involve flow due to gravity as well as lift by pumping from surface water flow irrigation projects include storage and diversion works and are the only means of irrigation in several areas, like the undulating terrains of Central India and the ghats or the hilly tracts of north and north east India. Such projects offer considerable opportunity for rural employment and also help in hard rock areas. When available surface water cannot be used for irrigation through construction of flow irrigation schemes due to topographical limitations, surface water lift irrigation schemes provide the solution.

As such, ground water development is a major activity of the minor irrigation programme. It is mainly a cultivators' own programme implemented primarily through institutional sources. Adequate energy for pumping ground water is essential for near normal production of crops when there is severe drought. Hence, energy management is also essential.

Under surface flow minor irrigation schemes, water tanks are created by constructing bunds across depressions in undulating terrains. There should be a properly designed spillway for overflowing excess rain water during monsoons and sluice gates for releasing controlled quantities of water to canals. It is obvious that the amount of water expected in the reservoir would be proportional to the catchment area draining into the reservoir and the rainfall in the catchment.

For lift irrigation schemes, pumps have to be installed on the river or canal banks with the suction pipe long enough to be immersed into the flowing water body and should also ensure sufficient draft. At times, floating barges moored to the banks, may have to be installed to accommodate the pumps. Here, the suction pipe would be less but the lift pipe would be longer.