UNIT 12 WATER RESOURCES

Structure

12.0 Introduction

12.1 Water As a Resource

12.1.1 Properties and Distribution

12.1.2 Resource Use

12.2 Water Conservation

12.3 Water Rights

12.4 Summary

12.5 Exercises

12.6 Suggested Reading

12.1 INTRODUCTION

The earth is sometimes called the watery planet as this is the only member in our solar system which has an abundant supply of water. Water is used as a raw material for various metabolic processes. It is an important ecological factor. It is also a very good solvent medium and has sustained life on earth ever since the biological origins of the living organisms. Water as a resource has been known to humans since the remotest past and has been used by them as an essential life-supporting ingredient. We propose to study resource-use practices pertaining to water. The Unit also proposes to analyse the various traditional methods of water conservation as practiced by human societies.Utilisation patterns adopted by various civilisations of the world which kept on changing with the developments in the technology for better appropriation of water and with the growing demand of water for various developmental activities is also our concern. Finally, we also examine the issue of water rights in the historical perspective along with the theoretical propositions connected with water rights in the Unit.

12.1 WATER AS A RESOURCE

Water is one of the important substances necessary for life. Water covers about 75% of the earth's surface, occurring in lakes, rivers, and oceans. The oceans alone contain 97% of all the water on earth. Much of the remainder is frozen in glaciers and frozen ice. Hardly 1% water constitutes ice-free fresh water in rivers, lakes, ponds, etc. It is this negligible amount of total available water that sustains all forms of terrestrial and aquatic life. There are subterranean reserves of water at very deep levels and also at shallow depths trapped in the soils. This trapped water is very useful for agricultural production and even for direct human use. The use of water as a resource has focused on this small amount. It has also been guided by some of the properties of water which we discuss below.

12.1.1 Properties & Distribution

Water in its' fluid form does not exist on any other planet in our solar system and is thus an exclusive privilege available to the inhabitants of planet earth. Only at a certain distance from the sun do we find the right temperatures that permit water to exist in liquid form. The other unique property connected with water is that it becomes most dense as temperature falls to plus 4° centigrade. If it were at its heaviest at freezing point then our lakes and waterways would freeze from the bottom up, jeopardising fish and other aquatic life. Water has surface tension and great capillarity, that is, the ability to rise in narrow tubes. This makes it possible for water to defy the laws of gravity and remain at the surface of the earth where plants can absorb it through the roots. Water is also one of the world's most important sources of energy. Inexpensive, non-polluting, hydroelectric power is a boon to all. Water dissolves salts of various kinds; it can also emulsify indissoluble substances. Blood and lymph are both water solutions which supply body tissues with nutrients and obligingly remove waste from cells. Plants also get the nutrients they need via water based salt solutions.

These properties also have some disadvantages. The same water also dissolves pollutants, acidifying our lakes and waterways and poisoning living organisms. It also spreads disease in flora and fauna. Though water is considered a renewable resource it is finite and governed by a natural water cycle.

The stable water supply of earth is used again and again in this cycle. About one third of all solar energy is dissipated in driving the water cycle. Sun makes water evaporate from the oceans, lakes and streams. This evaporation forms clouds which fall back on earth in the form of water or snow. Some of this water percolates through the soil until it reaches saturation point. Rest of the water returns to its origin point. This whole process of evaporation, condensation and rains is known as water cycle. This cycle keeps replenishing the water requirements of the world.

The global distribution of water shows that only 35% of the total quantity is fresh water, which is available in various forms. The following chart will explain this:

Form	% of fresh water
Frozen	80
Ground	19.7
Lakes	0.2
Rivers	0.02
Soil	0.04
Atmosphere	0.02
Biological	0.001

Water resources can be classified in two groups: a) surface water resources, b) ground water resources. India has a total of 1122 cubic km of water of

which 690 cubic km is surface water and 432 cubic km is ground water, and it is unequally distributed.

India is a country of rivers. There are 12 major rivers with the total catchment area of 252.8 million hectare (m.ha.). Tanks and ponds have around 2.9 m. ha. area, reservoirs have around 2.1 m. ha. area, where as smaller rivers and canals occupy 7 m. ha. area. Most of the area under tanks and ponds are located in southern states of Andhara Pradesh, Karnataka, Tamil Nadu, followed by West Bengal, Rajasthan and Uttar Pradesh accounting for almost 62% of the total. In the case of reservoirs, Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh dominate. Orissa ranks first as far as brackish water is concerned and followed by Gujarat, Kerala and West Bengal. The annual precipitation including snowfall which is the main source of the water in country is estimated to be around 4000 cubic km. The resource potential of rainfall for the country is estimated to be around 1869 cubic km. Clearly, the water resources are thus unequally distributed over the country. Further if we consider the average availability it is 2208 cubic meter per capita annually. Average availability in Brahmaputra is as high as 16589 cubic meter while it is as low as 360 cubic meter in Sabarmati basin. Any situation of availability of less than 1000 cubic meter is considered as scarcity situation.

The ground water situation in different parts of the country is as varied as the surface water situation. In the high relief areas of the northern and north-eastern regions occupied by the Himalayan ranges, the various hill ranges of Rajasthan, the central and southern Indian regions, the presence of very steep slope conditions and geologic structures offer extremely high run-off and thus very little scope for rain water to find favourable conditions of storage and circulation as ground water. The large alluvial tract extending over 2000 km, known as Sindhu-Ganga-Brahmaputra plains is the most potential region as far as ground water resources are concerned. Almost the entire central and southern India is occupied by a variety of hard rocks with hard sediments in the inter-tectonic and major river basins. Rugged topography, hard and compact nature of rock formations, the geological structures and metrological conditions have yielded an environment which allows ground water to store itself in the weathered residuum. It is a potential region for ground water development. The coastal and deltaic tracts, particularly of the East Coast, are caused by vast and extensive alluvial sediments and are very productive in terms of water availability but in the vicinity of coasts suffer from salinity.

12.1.2 Resource Use

As water is an essential condition of life on this planet, water resources have been a decisive factor in the growth and sustenance of human civilisation since ancient past. All the early civilisations were distinctively and predominantly riparian. Prime examples of ancient river valley civilisation of the world are Egyptian civilisation in the Nile valley, the Mesopotamian civilisation in the valleys of the rivers Tigris and Euphrates, the Harrapan civilisation in the Indus valley and the Chinese civilisation in the Hwang-

Ho valley. Harness of water from natural resources and its careful use in agriculture and other activities is a hallmark of these civilizations. Archaeological evidence shows that certain engineering measures were also adopted to enhance as well as sustain water resources.

As we step on a period of history for which written records become available we get regularly occurring information on the use of water as a resource and methods employed to use this resource in the most beneficial manner. Reservoirs are made, embankments are raised, wells are dug up, channels created for transporting water to desired destinations and devices invented for utilising the various properties of water. The written records are replete with such information and a sizeable number of structures have survived the ravages of time to surprise us by their ingenuity even today. The evidence is rich and dense and any efforts at listing all of them are likely to use a huge space. We shall attempt a random recall which is also likely to be a rewarding exercise.

We can begin by recalling some of the characteristic features, related with the use of water as a resource, of the first civilization on the Indian sub-continent. The environmental settings were arid or semi-arid. The importance of water as a resource was clearly understood. The habitation sites were selected with a lot of care so that deposit of good alluvium soil for agriculture resulting from seasonal floods was regularly available. Canals were excavated in the river basin to take water to agricultural fields. A canal of this type has been traced near Shortughai drawing water from Kokcha river (Irfan Habib. *The Indus Civilization*, p. 25). The wells were made for use by individual households that seldom changed their location – the earliest evidence of the exploitation of ground water. Drainage was carefully planned so that the waste did not pollute the fresh sources of water. Towns like Dholavira, surrounded by brackish water, paid great attention to water storage. “In its heyday, the entire city might have looked like a lake city or a *jala durga* (waterfort). The area reserved for the tanks was immense, approximately 750 m. in length and the southern and northern margins, while the width varied from 70 to 80 m. In the west, the tank area was about 590 m. In the south-eastern area, for example, the reservoir covered about 5 ha (hectare), the largest within the walled area. The walls acted as effective bunds. Both faces of the wall were plastered with fairly water-repelling sticky clay. Special and vulnerable areas, mostly on the exterior face, were vencesed with hammer-dressed stones.

Keeping in mind the general slope of the city, several bunds were constructed across the width of the tanks to reduce the pressure of the stored water body on the city walls. The bunds also served as conseways for easier movement. In times of scanty rainfall, they enabled the water to get stored in selected tanks instead of being spread out over a large area and reduced quickly by evaporation and seepage. In the area designated as the citadel, an interesting networks of drains, both small and large, was discovered. Most of the drains intersect each other and ultimately link up with an arterial drain.

The entire drainage system could have been set up to assiduously conserve every drop of rainwater that fell in the city. The water must have been a treasured commodity in an area lacking in perennial source of surface water and where the ground-water, largely brackish and saline, tends to dry up during droughts" (J.P. Joshi, R.S. Bisht, *India and the Indus Civilisation*, New Delhi, 1994, p. 31).

The importance of water for agricultural societies during the Vedic period must have increased. Flow of water in channels for irrigation purpose was practiced. There are references to artificial waterways — *kulya* and *khanitrima apah* — in Rig Veda. These perhaps refer to irrigation channels. The other expressions used for the same device are *Sushira* and *Soormi*. Wells – *avat* – were dug up. Lifting devices to draw water from the wells were also in use, called *ansatrakosh* and *ashmchakra*. These were probably composed of a leather bucket drawn over a pulley for lifting water from the wells (Cf. G.C. Pandey, *Vaidic Sanskriti*, Allahabad, 2001, p. 263; R.C. Majumdar, ed. *The Vedic Age*, Bombay, 1951, p. 403).

Mauryans, as the founder of one of the earliest empires, gave special importance to water resources. On the authority of Kautilya we know that the building of reservoirs by damming streams was an important public work the king was encouraged to construct. Similarly Ashoka refers in his edicts to the construction of wells and watering-places along the major routes. The epigraphic evidence testifies to the construction of a big reservoir of water by damming a stream in the Junagarh district of Gujarat by Pushyagupta, the governor of the region during Chandragupta Maurya's reign. The reservoir was named as Sudarshan. Under Asoka his Greek governor Tushasf maintained the dam and the reservoir. In AD 150 there occurred a breach in the dam which was repaired by Rudradaman. The dam seems to have been maintained till the fifth century AD when the last known repairs were carried out by Parndatt during the reign of Skandagupta, in AD 457-8. (Cf. P.K. Majumdar, *Bharat ke Prachin Abhilekh*, Delhi, undated, pp. 109-115 & 149-158).

Since medieval India was also a largely agricultural society, the resource-use practice with regard to water was basically geared at providing irrigation to the fields. Besides using most of the prevalent methods, a few new techniques were introduced during this period. The prominent among them were *arghatta* and *arhat* (Persian wheel), which improved irrigation significantly.

In the 14th century a very elaborate network of canals was constructed by Firuz Tughlaq. The rivers from which the canals were cut were Yamuna, Sutlej and Ghagghar. An additional water tax was levied on the farmers of the irrigated areas. Due to greater and more secure availability of water, production of cash crops had increased. The same concern for the use of water resources was shown by the Mughals. They also promoted irrigation facilities by providing loans to farmers to install irrigational devices. There was a general concern for better use and regulation of water resources.

In South India, too, great emphasis was laid on a careful use of water resources. The system of tanks, small and large both and the mechanism of their regular upkeep from a very early time is too well known. The streams and rivers were also channellised by raising empanlements and dams. The famous *anaikattu* (anicut) on Kaveri river was built by Chola rulers for the irrigation of the lands in Tanjore. Large dams were also built in this region for creating big reservoirs of water. Ka Katiya rulers are known to have built three big dams in Warangal. Another dam located at Kamthana, near Bidar built by the Kakatiyas, supplied water for irrigating the neighbouring region. The epigraphic evidence and archaeological remains support this picture. This picture changed drastically after the colonial power established control over India. The apathy and neglect shown by the new dispensation towards these age old resource-use practices resulted in the ruin of most of these devices. Francis Buchanan noted this pitiable state during his travel along the eastern coast in eighteenth century. A major consequence of this was a series of famines and consequent loss of life. Thereafter new policy was initiated to redeem the situation, though considerable damage had already been done.

A comprehensive survey of traditional water harvesting systems in India has been undertaken by Centre for Science and Environment and their compilation of the results of survey published under the title *Dying Wisdom* (*State of India's Environment: A Citizen's Report*, Vol. 4, ed. Anil Aggarwal & Sunita Narain, New Delhi, 1997). We strongly suggest to you to use this book to get larger information on the subject.

The optimal management of available water resources today has become a major issue world over. The spatial and temporal variability of rainfall along with high evaporation and runoff is posing a major challenge to the scientific community. Added to these is the increasing demand resulting from an exponential population growth. It has created more and more pressure on dwindling supplies and per-capita access to fresh water is falling. We shall discuss these issues in Block 6.

12.2 WATER CONSERVATION

Water is a renewable resource, but it is also finite. We have no more than what we had in the days of Harappan culture but the demand has multiplied. Water has become at least as important a resource as oil. Water shortage and deteriorating water quality are the two major concerns today. It is thus evident that there is an urgent need to initiate measures for water conservation. We have to join hands in day-to-day battle to protect the lands, rivers, lakes, aquifers and seas against pollution. In this regard past practices of water conservation need to be examined in some detail.

Water conservation has a long history going back to earliest times. The need of conservation at that time was perhaps to save water for the lean period of the year. It was conservation directed at quantity as quality conservation did not seem to be their concern. The evidence for water conservation is available from ancient literature, epigraphy, archaeological remains and local oral traditions. Conservation was a special feature in

habitats that were located a little away from source of water or were naturally deficient in water. Digging well was a regular old practice. It provided avenues to harness the ground water. Wells have been as old as a Harrapan tradition. Almost every dwelling unit of Harrapan culture had a well. Mohenjodaro records over 700 wells. Unlike other running sources like rivers or streams wells provided an option to fetch only the required amount of water – an early evidence on judicious use of water.

Another source of water, that is the running water, but particularly the flood water was very nicely utilised by past cultures. We have the evidence from Srinagaverupura situated near Allahabad on the banks of river Ganga. During the monsoons, the river swells up by about 7-8 meters and spills into the nearby artificial canals. This canal was dug by settlers of the region to carry superfluous floodwater. This diversified water was stored in tanks, to be used during lean periods of the year. The water from the canal first entered a silting chamber where the dirt settled down. Relatively clear water entered the first tank which was made of bricks. Thus next tanks received cleaner water.

The mechanisms of rainwater conservation however differed according to the physiographic features of the respective regions. In Rajasthan it was basically rooftop method whereas in the case of south India it was tank based method. In Rajasthan these mechanisms were known as *Kund/ Kundi*. Individually rooftops were used as catchment area which collected rainwater and stored it in an underground tank. This water was even potable. In other words *Kund/Kundi* were artificial wells conserving rain which would have otherwise run-off. The mechanism was also used in open field for general public where similar *Kund/Kundi* were built and the neighbouring area used as the catchment.

A very indigenous method to secure drinking water was practiced in the Runn of Kutch by Maldharis. They knew that the density of sweet water was less than the saline water. On this theoretical premise they were able to store rainwater afloat on underground saline water. It is known as *Virdu* method of water conservation.

In the North-East Himalayan region people developed methods of carrying natural spring water for drinking purposes. As the region is mountainous, the rainwater runs off very fast. However, the upper range natural springs survive throughout the year. The people there used intricate network of bamboo pipelines to carry water to convenient points where it was stored and subsequently used.

A very interesting method of water harvesting is practiced by Jarwas in Andaman. Although Andaman Islands have an annual rainfall of 3000 mm it runs-off rapidly due to ragged physiography of the place. The Jarwas use full length split bamboos. An entire length of 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 in pits called Jack wells. These split bamboos are also placed under trees to collect the fall of rains through the leaves. A series of increasingly

bigger Jack wells is built, connected by split bamboos so that overflows from one lead to the other, the bigger one. This stored water is basically used for domestic purposes.

We have already read about Sudarshan lake near Junagarh which was constructed to store water for domestic and irrigational purposes. Similar evidence for tank and canal construction from ancient past from different regions is also available Hanthigumpha inscription of 2nd century BC. describes that a canal was dug in Tosali division near capital city of Kalinga. According to the Kuntagiri plates, the Kadamba king Ravivarmann ordered construction of a tank bund for irrigational purposes. Most of these were developed to channelise water for optimal use which otherwise would have gone to waste. Such an awareness of water conservation emerged due to unequal seasonal distribution of rains. The plateau region-Deccan is full of artificial tanks which stored rainwater for irrigation. These are known by various names like *arakes, volakere, derikere, katte, kunte, kola,* etc. depending upon the difference in structure and nature of use.

Similar structures are called *zing* in Ladakh and *ahar* in south Bihar where water from seasonal streams or rainwater is stored to be used in ensuing period for domestic and agricultural purposes. *Ahars* are rectangular catchments receiving water flowing through hilly rivers. On similar lines we have indigenous methods employed in Bengal. They created broad and shallow canals to carry floodwater of rivers. These canals ran parallel to each other at a reasonable distance. By creating cuts in the canals floodwater was released to fields.

A very useful method of water conservation for irrigation was developed by Paliwal Brahmins in the arid region of Rajasthan. They created rain-fed water storage structures, which allowed runoff to stand over and moisten the soil bed of the storage structure itself. This piece of land was later used for growing crops. These structures were known as *khareen.*

Another unique method of rainwater harvesting is known as *haveli* as practiced in Madhya Pradesh. The area has heavy black clay which can hold a large amount of water but when it dries it becomes hard and develops wide cracks. Bunds are created to tap rainwater and released few days before sowing by an opening into embankment. This release makes soil soft and allows the sowing of wheat and gram to rarely need second helping.

The above description make it amply clear that various methods of water conservation were practiced traditionally depending upon the local needs. These methods utilised every kind of water supply – rains, floods, ground water, etc.

12.3 WATER RIGHTS

The details of resource-use practice given above make it clear that water has been considered a useful essential resource. Therefore rights to it have also been zealously safeguarded. In early times, however, population

was limited and it was often possible for individuals or communities to settle differences in many cases by simply moving on and exploiting a new source. The scale of water available in most situations and consumptive uses, even for irrigation, seldom threatened others with deprivation. Customary rights/uses regulated most transactions.

Gradually greater rights began to be exercised and in many cases the state initiated the practice of levying cesses on the use of water especially on the water drawn from state built reservoirs or such similar devices. No codified procedure though had come into practice. It was, however, from the nineteenth century onwards that water laws for various uses began to be invoked. This trend was further strengthened with the multiple uses and increasing diversions for consumptive/commercial use which were often conflicting in practice. The problem has since then become more acute because of increasing population. The increasing demand over the availability has been creating scarcity and resultant disputes. Over the world a serious and intensive thinking on availability of earth's fresh water resources and possibilities of exploitation has begun

With rapid population growth placing more and more pressure on dwindling supplies, per-capita access to water is falling. Ancient usage pattern is being challenged by new claims. More than 200 countries in the world have to share their common resources of surface and ground water transcending their political boundaries. The competition for the world's water resources is becoming a major contentious political issue of our time. Shortage of water, quality of water, and management of water are the three issues being discussed in contemporary world. Hence, there is a need to define the rights over water and their historical evolution.

It was believed for a very long time that water in a natural stream was not the subject of property but a wandering thing without an owner. However, this understanding underwent a significant change in the industrial world and the issue of water rights came into existence. The genesis of water rights is generally traced to the rights of navigation in rivers that often formed the boundary between two states. Rivers that formed natural boundaries or flowed through successive domains or territories and came to be used as a common highway were supposedly open to all for communication and commerce. However some states began to exercise greater control over them thereby denying others, or reducing their, usage of the resources. This necessitated framing of some kind of laws as the dispute over ownership rights of water increased. Conventions pertaining to the Danube between Austria and Turkey in 1619 and the Rhine between Germany and France in 1697 were among the early landmarks in the making of modern International law on navigation. Inland navigation was an item on the agenda of the Congress of Vienna in 1815.

These disputes were basically on consumptive uses. The scenario changed as world saw rapid pace of industrialisation. Political issues of boundary alignment along wayward rivers tended to be settled on the principle of the median line - a line purporting to demarcate the deep water course

of a river. However, braided rivers and those prone to make large erosive invasions of territory on either bank have continued to pose problem of jurisdiction.

Historically there have been following principles defining the water rights:

- *Riparian Doctrine*: The private property right in water only to those whose land abutted the river was a viable theory so long as people living away from the river satisfied their needs from other sources. However, with the change in nature of utilisation/needs it is no more viable.
- *The Prior Appropriation Theory*: According to this theory water in the natural course is the property of the public. It is in fact a suitable version of the riparian theory which puts the earlier appropriation right holders on advantage over all subsequent users.
- *The Territorial Sovereignty Theory*: According to this theory the owner has an absolute user right. This notion of private property when extrapolated for the entire domain of natural resources generates territorial sovereignty principles.
- *The Equitable Apportionment Theory*: Equity is a legal or a judicial notion therefore it provides basis for legal interpretation. It says: treat all claimants as equal right holders and through fair legal means apportion the resources in accordance with their individual needs.
- *The Equitable Utilisation Theory*: It says distribute the resources equitably such that optimum utilization occurs for all concerned when all relevant factors are taken in to account. It is based on the guidelines laid down by (Article 5 of) the Helsinki rules for equitable utilization of water resources.
- *The Community Interest Theory*: In 1851 the English common law made a distinction between *bonus vacans* and *public–juris* that is between no one's property and every one's property. The notion of every one's property is appropriate for water resources , which are to be used by numerous communities all along their flow. As a principle of distribution this theory allows the groups, participatory in the distribution, to be defined as communities in various ways, as culture specific groups or domicile specific groups. Otherwise it is based on the equitable utilisation theory.
- *The Public Trust Theory*: It emphasises that the principles of distributive justice need not be based only on the notion of private property, rather one should consider natural resources a common property and the sovereign or the state as its only trustee. This theory says that the state, which holds the natural water as a trustee, is duty bound to distribute or utilise the water in such a way that it does not violate the natural rights of any individual or group and safeguards the interests of the public and of ecology.

12.4 SUMMARY

In this unit we attempted to highlight the significance of water as a resource for human survival. It also dealt with the question of availability of water in various forms on earth and the amount of water available for human use. It was followed by an examination of the various resource-use practices of the past societies. Further the mechanism developed by these societies for the conservation of water were also discussed. The unit also gave a brief survey of various theories of water rights and its applications.

12.5 EXERCISES

1) Examine the historical practices of use of water as a resource.
2) What mechanisms did pre-modern societies in India adopt for water conservation? Elaborate.
3) Write a note on water rights and their environmental significance.

12.6 SUGGESTED READING

Chhatrapati Singh, *Water Rights and Principles of Water Resources Management*, New Delhi, 2001.

Anil Agarwal and Sunita Narain, ed., *Dying Wisdom: Rise, fall and potential of India's traditional water harvesting systems,* Centre for Science and Environment, New Delhi, 1997.

Madhav Gadgil & Ramchandra Guha. *This Fissured Land, An Ecological History of India,* Delhi, 1992.