

**WATER RESOURCES UTILIZATION,
CONSERVATION AND MANAGEMENT**

As in many other parts of the world, civilization in India also flourished around rivers and deltas, and rivers remain an enduring symbol of national culture. As has been mentioned earlier, the Indus Valley civilization, one of the earliest civilizations, was the world's largest in extent, had great and well planned cities with public and private baths, sewerage through underground drains built with precisely laid bricks, and an efficient water management system with numerous reservoirs and wells. Agriculture was practised on a wide scale, with extensive networks of canals for irrigation. Irrigation systems, different types of wells, water storage systems and low cost and sustainable water harvesting techniques were developed throughout the region at that time (Nair, 2004). The Rig Veda clearly mentions about the life style, social structure, agriculture and crops grown by the society at that time. Irrigation channels and kuccha and pucca wells are also mentioned in different hymns (R.V. 19.4.2/RX2.9.4) (Bagchi and Bagchi, 1991). Agriculture and livestock rearing occupied a prominent role during Jainism and Buddhism period and channel irrigation was in vogue (Bagchi and Bagchi, 1991). McClellan III and Dorn (2006) state that 'the Mauryan empire was first and foremost a great hydraulic civilization'. This shows the degree of knowledge about efficient utilization of water resources and their conservation for the welfare of the society during that time.

During Mauryan period, raingauges were installed in different parts of the country to have areal information of the rainfall and based on the information supplied, the 'Superintendent of Agriculture' gave directions for sowing the seeds in different parts of the country (Srinivasan, 1975). Almost all ancient civilizations were confined to the areas of reliable water resources, revealing the importance of water for development from very ancient days. During the time of Rig Veda, we get many references to water use by means of rivers, wells, ponds etc. for agriculture, domestic and other purposes. Verse I, 121.8 of Rig Veda reveals the same fact as:

अष्टा महोदिव आदो हरी इह घुम्नासाहमभि योधान उत्सम् ।

हरिं यत्ते मन्दिनं दुक्षन्वृधे गोरभसमद्रिभिर्वाताप्यम् ॥ R.V.I,121.8

Similarly verses (I,23.18 and V, 32.2) state that the agriculture can be progressed by use of water from wells, ponds etc. wisely and efficiently. The verse (VIII,3.10) of Rig Veda says about the construction of artificial canals to irrigate desert areas also, which is possible only by efforts of skilled persons (Ribhus/engineer) as:

येना समुद्रमसृजो महीरयस्तदिन्द्र वृष्णि ते शवः ।
सघः सो अस्य महिमा न सन्नशे यं क्षोणरिनुचक्रदे । R.V.VIII,3.10 ॥

उतनों दित्या इष उत सिन्धुरहर्विदा ।
अप द्वारे व वर्षथः ॥ R.V.VIII,5.21 ॥

Verses (VIII, 49.6; X64.9) speak about the importance of water for irrigation. The water from wells, rivers, rain and from any other sources on the earth should be wisely used as it is a gift of nature for well-being of all.

उद्रीव वज्रिन्नवतो न सिज्वते क्षन्तीन्द्र धीतयः ॥ VIII,49.6 ॥

सरस्वती सरयुः सिन्धुरुर्मिमिर्म हो महीरवसा यन्तु वक्ष्णीः ।
देवीरापो मातरः सूदयित्त्वो घृतवत्पयो मघुमन्नो अर्चत ॥ X.,64.9 ॥

Similar to Rig Veda, Yajur Veda also contains references, directing the man to use rain and river water by means of wells, ponds, dams and distribute it to various places having need of water for agriculture and other purposes as:

नमः स्त्रुत्याय च पथ्याय च नमः काट्याय च नीप्याय च ।
नमः कुल्याय च ररस्याय च नमो नदेयाय च वैशन्ताय च ॥ Y.V.,16.37 ॥

In the Atharva Veda, we have references to drought management through efficient use of available water resources and water conservation. It clearly says that the water of river, well etc., if used efficiently, will reduce the intensity of drought, viz.

आपो यद् वस्तपस्तेन तं प्रति तपत यो स्मान् द्वेष्टि यं वयं द्विष्मः ॥ A.V.II,23.1

Verses VI, 100.2 and VII,11.1 of the Atharva Veda explains that the learned men bring water to desert areas by means of well, pond, canals etc. (VI,100.2). It also stresses that the man should think about the drought, flood and like natural calamities in advance and take preventive measures accordingly as:

यद् वो देवा अपजीका आसिंज्वन धन्वन्युदकम् ।
तेन देव प्रसूतेनदं दूषयता विषम् ॥ A.V.VI,100.2 ॥

Verse XII,1.3 of the Atharva Veda explains that those who use rainwater wisely by means of river, well, canals etc. for the purposes of navigation, recreation, agriculture etc., prosper all the time as:

यस्था समुद्र उत सिन्धुरापो यस्यामत्न कृष्टयः संवभूवुः
यस्यामिदं जिन्वति प्राषदेजत सा नो भूमिः पूर्वं पेयं दधातु ॥ A.V.XII,1.31 ॥

शंत आपो हेमवतीः शमु ते सन्तु वर्ष्याः ।
शं ते सनिष्पक्ष आपः शमु ते सन्तु वर्ष्याः ॥ A.V.19.2.1 ॥

Meaning: “That one should take proper managerial action to use and conserve the water from mountains, wells, rivers and also rainwater for use in drinking, agriculture, industries etc.”

Similarly, one verse of the Atharva Veda (XX,77.8) directs the king to construct suitable canals across mountains to provide water for his subject for agriculture, industry etc. and to facilitate navigation between two areas as:

आपो यदद्वि पुरुहूत दर्वराविर्भुवत् सरमा पूर्यं ते ।
स ना नेता वाजमा दर्षि भूरि गोमा रुजन्नग्दिरोभिर्गृणान ॥ A.V.XX,77.8 ॥

Water Resources Management

India has a fascinating and significant ancient tradition of conserving land and water and even today, local people follow several such traditional conservation practices. As discussed in the beginning of this chapter, out of the agricultural necessity, the science of water management was given considerable importance during ancient India. During Mauryan era, the Pynes and Ahars (the combined irrigation and water management system) in Magadh region were effective water

engineering tools. Ahars were reservoirs with embankments on three sides, built at the end of drainage lines such as rivulets or artificial works like Pynes. Pynes were diversion channels led off from the river for irrigation purposes and for impounding water in the Ahars. As a representation, the Pyne-Ahar system is shown in Figure 8.1.



Figure 8.1: Ahar Pyne system in Gaya, South Bihar

(Image courtesy: Hindi Water Portal; <https://www.thebetterindia.com/6963/tbi-videos-magadh-jal-jamaat-helps-revive-2000-year-old-flood-water-harvesting-systems-in-gaya-bihar/>)

Agricultural planning was common so as to manage the rainfall excess or deficit. It is very well elaborated in Arthashastra as: “according to the rainfall (more or less) the superintendent of agriculture shall sow the seeds which require either, more or less water”. Kautilya says that “king should construct dams, reservoir etc. filled with water either perennial or drawn from some other source or he may provide with sites, roads, timber and other necessary things to those who construct reservoir of their own accords (Arthashastra, Tras. By Samsastry, Book II, Chapt. 1, page. 46). He further says that the king shall exercise his right ownership (स्वाम्यम) with regard to fishing, ferrying and trading of vegetables in Reservoirs or lakes (सेतुषू)”.

During this period, embankments were constructed surrounding the fields to increase the water holding capacity. Dams were constructed at strategic points with sluice gates to harness river

water with proper regulation facilities. Conduits were also constructed at that time to attain better efficiency in irrigation (Bagchi and Bagchi, 1991). Figure 8.2 shows the Sudarsana lake, Junagadh constructed during the reign of Chandragupta Maurya, by the provincial governor, the Vaisya Pusyagupta; and subsequent improvements involving the addition of conduits during the reign of Asoka, by his provincial governor, the Yavana king Tusaspha (Shaw and Sutcliffe, 2010; Kielhorn 1905-6, p. 41).



Figure 8.2: A view of Sudarsana lake Girnar, Junagadh, Gujarat
(Source: <https://junagadh.gujarat.gov.in/photo-gallery>)

Recently, Sutcliffe and Shaw (2011) explored the Sanchi site (a well-known Buddhist site and a UNESCO World Heritage site) in the Betwa river sub-basin (a tributary of Yamuna in Ganga basin) in Madhya Pradesh. They found a number of dams equipped with spillways. They found that these dams would have been built on the basis of a sound knowledge of the principles of water balance. In addition to the design of the reservoirs, the presence of spillways on at least two of the larger dams, which would pass floods of about 50 years' return period, suggests that flood protection was also taken into account. The Arthashastra of Kautilya also gives us an extensive account of dams and bunds that were built for irrigation during the period of the Mauryan Empire. The water supply systems were well managed within the framework of strict rules and regulations. Specifically, an organized water pricing system, which is an important part of water management, was also developed during this period as evidenced by following lines of

Arthasastra: “those who cultivate irrigating by manual labour (हस्ताप्रवर्तिमाम्) shall pay 1/5 the produce as water rate (उदकाभागम्); by carrying water on shoulders (स्कन्धाप्रावर्तिमाम्) = (water lift worked by bullocks), 1/4th of the produce; by water lifts (स्त्रोतोयंत्राप्रवर्तिमाम्) 1/3rd of the produce; and by raising water from rivers, lakes, tanks and wells (नदिसरासततकाकुपदाहाटम्) 1/3rd or 1/4th of the produce (Arthasastra, Tras. By Samasastry, Book II, Chapt. XXIV page 131)”.

In Vrhat Samhita, we get a few references regarding the orientation of ponds so as to store and conserve water efficiently, plantation types for bank protection and proper sluicing to protect reservoir from any possible damage as:

पाली प्रागपारायताम्बु सुचिरं धत्ते न याम्योत्तरा
कल्लोलैखदारमेति मरुता सा प्रायशः प्रेरितैः ।
तां चेदिच्छति सारदारुभिरपां सम्पातमावारयेत
पाषाणदिभरेव वा प्रतिचयं क्षुण्णं द्विपाश्वादिभिः ॥ Vr. S. 54.118 ॥

Meaning: a pond laid east to west retains water for a long time while one from north to south is spoilt invariably by the waves raised by the winds. To render it stable, the walls have to be lined with timber or with stone or the like and the adjoining soil strengthened by stamping and trampling of elephants, horses etc.

ककुभवटाम्रप्लक्षकदम्बैः सनिचुलजम्बूवेतसनीपैः ।
कुरबकतालाशोकमधूकैर्बकुलविमिश्रैश्चावृततीराम ॥ Vr.S.54.119 ॥

Meaning: the banks must be shaded by Kakubha Vata, Amra, Plasa, Kadamba, Nicula, Jambu, Vetasa, Nipa, Kuravaka, Tala, Asoka, Madhuka and Bakula trees.

In next verse (Vr.S.54.120), it directs the construction of spillway as:

द्वारं च नैर्वाहिकमेकदेशे कार्यं शिलासिञ्चतवारिमार्गम् ।
कोशास्थितं निर्विवरं कपाटं कृत्वा ततः पांशुभिरावपेत्तम् ॥ Vr.S.54.120 ॥

Meaning: an outlet for the water has to be made on a side with the passage being laid with stones. A panel without apertures has to be fixed in a frame, which is fastened to the earth with mud and clay.

From this discourse, we can realize that the water management was getting due importance in ancient India and even bank protection, spillway etc. and other minor aspects were given due consideration.

In ancient India much attention was also paid to the proper location of artificial tanks. Various techniques were applied and equally different materials were utilized for the construction of works. It appears that special works for treatise on science of hydrology must have existed in south India. The Porumamilla tank inscription of Bhaskara Bhavadura dated A.D. 1369 throws an abundant light on the elaborate method of construction of tanks and dams in the south India.

Constituents of a good tank are well described in ancient literature. According to the Sastra (Epigraphia Indica, Vol, PP. 108, Quotes from Hemadri, Verses 37-38, Srinivasan T.M., 1970), the following are the 12 essentials of a good tank as: (i) A king endowed with righteousness, rich, happy and desirous of the permanent wealth and fame; (ii) Brahmana learned in hydrology (Pathas-Sastra); (iii) Ground adorned with hard clay; (iv) A river conveying sweet water (and) three Yojanas distance from its source; (v) The hill, parts of which are in contact with tank; (vi) Between (these portions of the hill) a dam (built) of a compact-stone wall, not too long but firm; (vii) Two extremes (Srimga) pointing away from fruit (giving) land (Phala-Sthira) outside; (viii) The bed, extensive and deep; (ix) A quarry containing straight and long stones; (x) The neighbouring fields, rich in fruit and level; (xi) A water course (i.e., the sluice) having strong eddies on account of the portion of the mountain (adri-sthana); and (xii) A gang of men (skilled in the art of its construction). With these 12 essentials, an excellent tank is easily attainable on this earth.

From these points on comparison with the modern, science of water management regarding construction of dams and reservoirs, we will find that the technique in those days was just comparable to the modern sophisticated engineering, as far as general requirements are concerned. Along with these 12 essentials, six faults were also recognized which will reduce the usefulness of the reservoir and water conservation will become difficult. These faults (Dosas) are as follows (Epigraphia Indica, Vol. XIV, PP.108, Quotes from Hemadri, Verse 39, through Srinivasan T.M. (1970) as:

- (i) Water oozing from the dam
- (ii) Saline soil

- (iii) Situation at the boundary of two kingdoms
- (iv) Elevation (Kurma) in middle (of the tank) bed
- (v) Scanty supply of water and extensive stretch of land (to be irrigated), and
- (vi) Scanty ground and excess of water

Epilogue

The above discussion brings out that water use by means of wells, ponds, tanks and canals was prevalent during the ancient times, along with the efforts to supply water in deserts also. Organized water pricing system was prevalent and preventive measures against natural calamities such as floods, drought etc. was common. Construction methods and materials of dam and ponds, essential site and other requirements of good tanks, bank protection spillways etc. were paid sufficient attention. High level of development was achieved in the areas of proper location and orientation of tanks, lining of banks, evapotranspiration control, drought management, etc. Thus, ancient India was at a high plane of development in the field of engineering in irrigation and water conservation. State-of-the-art irrigational facilities were established during the ancient times in India for increasing agricultural produce apart from improved drinking water supplies for the people. Ancient India was highly progressive in the area of water management. Such remarkable development in the absence of scientific instruments of the ancient times invokes astonishment and admiration of the readers.