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Society and Environment in Ancient India (Study of Hydrology)

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Abstract: *This paper attempts an analysis of the science and technology evolved in ancient India in relation to water .On the other side it focuses on the dominating role of water in the development of different civilizations as it attached a great importance to their life. The aim of the paper is to highlight the usefulness of those ancient hydraulic techniques of different regions of country at different times in terms of water conservation etc. Thus an effort is made to prove that the hydraulic techniques introduced, not only by the Government but also by the indigenous people which were highly advanced techniques of that period and these specific indigenous water-harvesting and collection methods were developed / evolved in direct response to local geo-physical conditions which has brought prosperity to the state and now the efforts are made by the recent governments and NGOs for the revival of those techniques for the betterment of the people .*

I. Introduction

Every Society however crude or Primitive has certain amount of scientific rationality and endeavor within it. It has been rightly remarked by *Engels* in 1894 "if techniques largely depends on the state of Science, Science depends far more still on the state and the requirements of technique". Thus Science and Technology are interrelated with each other and together they play a dominating role in the development of any society, state or even at a broader level a civilization also. In the same way water has been considered always a driving force of every civilization. An interesting feature about all ancient civilization was that its inhabitants realized the tremendous value of water in human life. Each of this civilization was located on the banks of river or within a convenient distance from the sea. This is to ensure a perennial supply of water for day to day activities. It is this access to water that has long determined the positioning of habitational sites of humans, birds, and animals. It is the development and management of water resources, in which India's traditional knowledge of science and technology have developed and survived from prehistoric to contemporary times. It is this techniques, of the ancient times, that has enabled agriculture, animal husbandry etc even in those areas where their was absence of perennial rivers. It is since ancient times that a wide variety of hydraulic engineering were developed at different geographic locations over different periods which are discussed below.

II. Chronological Development of Hydraulic Engineering in Ancient India

Harrapan civilization:

Their are several evidences which reveals a wonderful knowledge of hydraulic techniques in ancient India which are in present time are considered to be an advanced technique over modern one. If we look chronologically in India, the first major human settlements started in the Indus Valley (3000-1500 B.C.); also called as Harrapan civilization demonstrated a high degree of hydraulic engineering skills. One of the best known examples of this is the **Great Bath** at the site of **Mohanjodaro,** It was a tank, accessed by steps, to which wooden covers were fixed by bitumen, the floor and sides of tank were waterproofed through the addition of gypsum in the building mortar, with a backing of bitumen course for further damp proofing. The sides of the pool were backed by a secondary set of walls, with the intervening space between the two being filled with a bitumen coating and earth, to ensure total waterproofing. Water for filling the 'Great Bath' came from a large well situated in one of the rooms fronting the open courtyard of the building- complex, while a corebelled baked-brick drain in the south- western portion of the bath served to carry away the used water. In **Lothal** (Gujarat) and other places in north and western India small bunds were built by the local people to store rain water for irrigation and drinking. The **Dock-yard** at Lothal is a remarkable lined structure, with evidence of channels for inlet and outlet of water. Towards the southern part of the eastern wall of this dock-yard there is a 7m wide gap. Excavations further to the east, have surmised that this spill-channel connected the Lothal dockyard with the near by Bhogavo river, and thence with the Gulf of Cambay. It has been suggested that boats could enter the lothal dock at high tide using this channel, when the tide waters swelled the channels natural flow and pushed the extra water upstream. In a like manner, the boats could make the return journey back to the river when the tide ebbed. To take care of the problem of the discharge of extra water, a sizeable spill channel was built in the southern wall of dock. The water level could be partially regulated by means of a wooden sluice gate fitted across the spill-channel. A mud-brick platform adjoining its western embankment help in loading and unloading of goods shows that a high level of technique was used to carry out the trade through sea with outer world in ancient times.

In the same way, **Dholavira** is another important site of Indus Valley had complex system for collecting and storing rain water within several reservoirs. It has a prolonged history of droughts, thus water management seems to have been an issue that the harappans were actually aware of. This is reflected in the occurrence of several rock-cut reservoirs. To fill these, their were two local seasonal rivulets the Mandsar(which lies to north west of Dholavira) and the Manhar (lies to south eastern part of the walled area), which help in collecting the rainwater in the catchment areas of the sites and brought to the reservoirs. This was achieved through an ingenious system involving stone bunds of dams that were raised across the streams at suitable points. From these, the monsoon runoff was carried to a series of reservoirs, gouged out in the sloping areas between the inner and outer walls of the Harappan period city, through inlet channels. These water reservoirs were separated from each other by bund-cum-causeways, which also served to facilitate access to different divisions of the city. The Dholavira excavations reveal that at least 16 water reservoirs were created within the city walls. A network of storm water collection drains was also laid out, criss-crossing the citadel area to collect rainwater. These brick and stone built drains were not used for sullage at all, but only to collect and carry rainwater to a receptacle for later use. Their were apertures served as air ducts to help the easy flow of storm water. Household drains were linked to soakpit at Dholavira. In this manner every effort was made to preserve rainwater in an area where there is no perennial source of surface water and ground water is largely brackish.

At other harappan sites like **Kalibangan, Surkotda, Chahnudaro** etc buildings have also yielded evidence of individual wells serving residential units. An archaeological survey suggests that every third house had a well. Besides private wells, there were also public wells. Beside this, individual houses possessed paved bathrooms with drains to carry out waste water from the houses into the local city drainage system. This drainage system entailed well-covered street drains made of Kiln- baked bricks, with covered manholes at intervals for purposes of cleaning and maintenance. Thus the techniques involved in the ancient Indus system of sewerage or drainage were developed and used in cities throughout the civilization were far more advanced than any found in contemporary urban sites of world. This shows that science applied in those times were unique in itself and was highly advanced which led to the rise of complex, urban societies in ancient India.

Vedic Age:

After the Harappan culture came to its abrupt end, the Vedic age started. According to which all life in this planet evolved from **Apah** (water). Their are copious references in Vedic literature about the medicinal properties of water and the importance of conservation and preservation of water. Literary references and archaeological data from about 6th century BC onwards indicate the development of embankments, canals and other hydraulic works, sullage devices like soak-pits(or ring-wells), and protective moats outside the towns which sprang up in the wake of the 'Second Urbanisation' of South Asia.

Different dynasties of North India:

Different dynasties give evidences of the maintenance of water system by the state and even by the village communities, for example **Satavahan** (1st Century B.C.-2nd Century A.D) introduced the brick and ring wells. In the 4th century BC **Nanda dynasty** kings (363-321 BC), built irrigation canals to carry water from river to agricultural tracts. Their successors, the **Mauryan dynasty** rulers (321-185), built many more irrigation works to facilitate agriculture (besides providing wells for public use alongside roads and accompanying travelers rest-houses). Details about irrigation techniques, rainfall regimes, and water harvesting systems of this period, can be found in Kautilyas Arthshastra. It also mentions that the state rendered help for the construction of irrigation works, initiated and managed by the inhabitants of a newly settled village. The Hathigumpha inscriptions of 2nd century BC include descriptions of the major irrigation works of Kalinga (the modern Orissa area). During Gupta period (300-500 AD) large scale development of water resources took place.

Artificial reservoirs or tanks too were built for irrigation purposes- often through damming smaller streams. One may also note here a series of tanks excavated at the site of **Sringaverapura**, near **Allahabad** (of 1st century BC). This remarkable example of hydraulic engineering entailed a tank described as "…*the longest of its kind discovered so far- more than 250m long*". The sringaverapura tank complex obtained water from the nearby river Ganga during the monsoon season. As a result, excess water used to spill over from the Ganga into an adjoining stream (nullah). From this stream, an 11m wide and 5m deep canal carried the water further into the Sringaverapura tanks. The water first entered a settling chamber to enable silt and debris to settle so as to get the clean water which is used for ritual bathing and prayers. And excess water was returned to the tank. A series of wells in the bed of the tank allowed access to groundwater even during the hot summer months.

Besides canals and tanks, **artificial ponds and lakes** were created too during ancient times by stopping the outlets of streams and rivers. One of the earliest artificial lakes known from ancient India is the '**Sudarsan Lake**' (3rd century BC) in Gujarats Girnar area. This was first excavated by an officer, Pusyagpta during the reign of Emperor Chandragupta Maurya. Supplementary channels were later added by 'Yavanraja Tushaspha

during the reign of emperor Ashoka. Nearly four centuries later the lake was repaired by the Saka King, Mahakshatrapa Rudradaman of Ujjain (recorded in Junagarh or Girnar inscription of 150 AD). The lake continued to exist over the ensuing period, as is attested by an inscription of AD 455, dating to the reign of Emperor Skanda Gupta of **Gupta Empire**. This records that when the embankment dam at Girnar broke, it was rebuilt in 455 AD by the local city Governor, Chakrapalit, son of Skanda Gupta's provincial governor, Parnadatta. Much later, the great embankment, over 100 feet thick at its base, holding back the waters of the lake at Girnar finally gave way sometime in the 9th century AD. It was never again repaired. From such water bodies, water was lifted by counterpoised 'sweeps', or other devices, and fed into smaller channels. These in turn, carried the water into fields. Such methods have been used in Indian agriculture up to contemporary times.
Another largest known artificial lake of India was created in the middle of the 11th century by King Bhoj Parmar, the ruler of Dhar (**Malwa**), at Bhojpur, near Bhopal, by constructing a vast embankment across two hills. The lake apparently received water from as many as 365 streams and springs, its traces indicate that the lake originally covered no less than 250 square miles. Numerous other examples of artificially fabricated lakes are known it has been estimated that, over time, there have existed nearly 1.3 million human-made lakes and ponds across India. Among such lakes, those known is from the State of Rajasthan is the **Ana Sagar Lake**(Ajmer), the **Ghadsisar reservoir-lake** built at Jaisalmer in 1367 AD by Bhati ruler, Rawal Ghadsi; and various lakes at Udaipur city. Another artificial lake is the **Raj Samand Lake**, built at the command of Maharana Raj Singh of Mewar (1676 AD). It is created by damming the waters of a small rivulet, and augmented by excavation of a large tract in which rain-water could be collected. The Rajput dynasty (1000-1200 A.D.) promoted irrigation works in northern India. In eastern India Pal and Sen Kings (760-1100A.D.) built a number of large tanks and lakes in their kingdoms.

One of the finest examples of **Kashmir** which reflects India's rich, technologically excellent and varied hydraulic tradition which is mentioned in Kalhan's 12th century text, the 'Rajatarangini' of Kashmir, describes a well-conceived and maintained irrigation system through various canals, irrigation channels, embankments, aqueducts, circular dykes, barrages, wells and waterwheels, it also details numerous hydraulic works executed during the reign of various different rulers of Kashmir. These include a vast embankment, known as the '**Guddasetu**', built by king Damodara II and the construction of series of **Arghat** or waterwheels, by the 8th century AD king Lalitaditya Muktapida of the Karkota dynasty. These waterwheels were constructed in order to lift the waters of the river Vitasta (Jhelum), and channelize their distribution to villages near Chakradhara (now called Tsakdhar). One of the most notable names of an irrigation engineer that is recorded in the 'Rajatarangini' is that of **Suyya**. He is credited with 'draining the water of the Vitasta river and controlling it by constructing a stone dam, and clearing its bed'. Suyya also 'displaced the confluence of the rivers Sindhu and Vitasta', and constructed stone embankments for seven yojans along the Vitasta in order to dam the vast **Mahapadma lake** (now famous as the **Wular lake**). In fact, Suyya is credited with having made, "…the streams of Indus and Jhelum flow according to his will, like a snake-charmer his snakes". The system of irrigation established by Suyya was designed in such a way that everyone was supplied with a fair share of water.

Dynasties of South India:

Other parts of India, similarly, developed traditional mechanisms for collecting and accessing water over the ages. The southern part of India, under the **Chola, Pandya, Pallava, Chera, Vakataka, Kakatiya,** etc. dynasties, developed a vast network of tanks and canals, famed the world over, that served to irrigate crops and enhance agrarian production. Irrigation tanks were built by developing large natural depressions. Pallava dynasty expanded the irrigation system in 7^{th} century AD. The famous **Cauvery anicut** was built during this period. Large scale construction of Tanks for tapping rain water was also done in Tamil Nadu. The Chola dynasty (985- 1205 AD) witnessed the introduction of quite advanced irrigation system, which brought prosperity in Deccan region. This included not only anicuts across rivers and streams but also chain-tanks i.e. a number of tanks with connecting channels. This new system was more reliable in terms of water availability and provided better flexibility in water distribution. Anantraj Sagar tank was built with a 1.37 km long earthen dam across the Maldevi River. The well-known Korangal dam was built under King Krishnadevraya. One of the oldest water harvesting system is found about 130 km from Pune, a long a place known as **Naneghat,** Situated in the Western Ghats. A large number of tanks were cut in the rocks to provide drinking water to tradesmen who used to travel along this ancient trade route. Each fort in the area had its own water harvesting and storage systems in the form of rock cut cisterns, ponds, tanks and wells that can be seen in use even today.

Though the large number of reservoirs and tanks built in different times by the Kings, village communities and individuals were mainly for irrigation, these also provided water for the cattle and domestic use either directly or indirectly through charging of wells. In fact, wells were invariably built close to the tanks, lakes, canals etc. In the arid and semi-arid areas of northwest India, rain water was collected in underground storage tanks called Tanka, Kunds or Kundis. For example in ancient times houses in the western part of Rajasthan were constructed in such a way that each had a roof top water harvesting system. Though scanty, rain water from these roof tops was directed into underground tanks – this system can be seen in use even today in all the forts, palaces and dwelling houses of the region.Underground pipes and tunnels were built to maintain the flow of water and besides transporting it to distant places , they were used for conserving and storage of water .They are still functional at places like Burhanpur(Madhya Pradesh), Golcunda (here it is known as Capillary system-Andhra Pradesh), Bijapur(Karnataka), Aurangabad (Maharashtra).

Contribution of indigenous people in water collection methods:

One must underline here that it was not just kings, queens, or rich merchants who concerned themselves with the development of water resources. Communities and collectives too did the same. Thus it led to the development of various other indigenous water harvesting/collecting techniques and lifting and conveyance devices evolved in response to regional geographical realities and ecological considerations. Much of this land is located in the arid or semi-arid belts where rain falls irregularly and much of the precious water is soon lost as surface runoff. Recent droughts have highlighted the risks to human beings and livestock, which occur when rains falter or fail. While irrigation may be the most obvious response to drought, it has proved costly and can only benefit a fortunate few. There is now increasing interest in a low cost alternative - generally referred to as "water harvesting". Water harvesting is the collection of runoff for productive purposes. Instead of runoff being left to cause erosion, it is harvested and utilized. In the semi-arid drought-prone areas where it is already practiced, water harvesting is a directly productive form of soil and water conservation. Both yields and reliability of production can be significantly improved with this method. Water harvesting technology is especially relevant to the semi-arid and arid areas where the problems of environmental degradation, drought and population pressures are most evident. While all systems which collect discharges from watercourses are grouped under the term: The method of rain water harvesting it is especially beneficial in the areas, which faces the scarcity of water. People usually make complaints about the lack of water. During the monsoons lots of water goes waste into the gutters. And this is when Rain water Harvesting proves to be the most effective way to conserve water. We can collect the rain water into the tanks and prevent it from flowing into drains and being wasted. It is practiced on the large scale in the metropolitan cities. Rain water harvesting comprises of storage of water and water recharging through the technical process. For example, in the desert areas of the Thar region of what now constitutes the State of Rajasthan, and in its neighboring State of Gujarat, where water is a scarce and much valued commodity, tanks, kunds, step-wells or baolis, wells, ponds etc., were built. This led to systems like johadhs, anicuts, check-dams, khadins, tankas, adlaz, jhalara, modhera, vapi, medhbandhi (earthen structure on fields to prevent water from flowing out), the virdas of the Kutch region, etc., being developed and maintained. Water-lifting devices like draw-wells, 'rahat' and 'dhekli' systems were developed too. Between them, these systems met the drinking water, irrigation, agricultural and other water-related needs of the people of the area even in years of lesser than usual rainfall.

In a similar manner, in northeastern areas of the Sub-Continent, and the foothills and lower slopes of the Himalayas, different local communities devised indigenous methods of collecting and channeling rainwater to meet their agricultural and drinking water requirements. Here, and elsewhere, practices like contour-bunding and local-level lift-irrigation schemes have used available water-resources in ways suitable to the local terrain and economy. Most of these devices and systems remained in use, with modifications, over the ensuing centuries. These include the khadin-based cultivation, tankas, nadis etc of Rajasthan, bandharas and tals of Maharashtra, the bundhis common to Madhya Pradesh and Uttar Pradesh, and Bihar's ahars and pynes. These also include the kuhls known in Himachal Pradesh and the kuhals of Jammu & Kashmir, the ponds used in the Kandi belt of Jammu, the eris of Tamil Nadu, surangams of Kerala, and the kattas of Karnataka, which are still in use today. As many of these were the result of local community action, their management and maintenance often vested locally.

Other uses of water:

Water was used not just for agricultural, irrigation, occupation and industry-related and domestic needs but it also held importance in ritualistic practices, structures like tanks, reservoirs, wells, step-wells, southern India's temple tanks (kalyani tank) etc. were invariable accompaniments to religious complexes, temples and sacred groves etc. Besides this, the royalty and aristocracy combined water bodies with their palaces and gardens. Thus, there developed a vast range of water-related architectural features – both religious and secular, with regional and sub-regional styles. For example the step-wells of Rajasthan and Gujarat, which tapped deep aquifers, evolved in time into elaborate structures, which helped in drawing water by a rope from balconies and corridors, to lower levels, and subterranean chambers, to keep it cool. These step-wells not only fulfilled the water needs, but also served the concerned populace as gathering places. Beside this it also facilitates with elaborate systems of transporting water within palaces and forts, and of fountains and water-channels that ran through chambers and gardens was devised. Within the palaces of rulers water was carried in copper pipes for cooling terrace pavilions, channels flowing through royal chambers, fountains and water-gardens, and under-water collection tanks were the norm. Thus, here too, various water-storage methods were devised, as were a range of water-lifting mechanisms. All forts, built in different terrains and climatic conditions, had elaborate arrangements for drinking water. Those built on hilltops or in rocky terrain depended mainly on rain water harvested from surrounding hills. The Amber Fort near Jaipur built about three centuries ago is a classic example of such a system. It has an automatic arrangement for desilting and aeration of harvested rain water before its entry into the large storage tank. The Jodhpur fort in western Rajasthan had water harvesting arrangements to tap both rain water and groundwater. The Panhala Fort of Maharaj Shivaji built on a hillock near Kolhapur in Maharashtra had Baolis and wells to tap underground springs originating in nearby higher hill slopes. The fort at Chittor on top of a hill has a large reservoir formed from the harvested waters of springs. At the Buddhist site of Sanchi (Madhya Pradesh) dating back to the 3rd Century B.C., there are three ancient tanks to store rain water from the hill slopes. Most of the old temples in south India built centuries ago have large tanks in their premises. These tanks are either fed by harvested rain water or by tapping underground springs. In Tamil Nadu alone there are 39 temple tanks with areas varying from 0.25 to 3 hectares. These are all fed by rain water. Though these were used mainly for bathing and religious purposes, these also recharged the drinking water wells. As land pressure rises, more and more marginal areas in the world are being used for agriculture formed the basis for all round development and prosperity.

III. Conclusion

From the above discussion we come to know that our ancients were fully aware of the importance of water in our life. Evidences, are found in every part of India, concerning highly advanced hydraulic engineering, which are even highly preferred by the modern technicians. Development of water resources and its conservation was not only the responsibility of Kings and Queens but it was also considered to be the duty of the local community to develop and maintain such water resources. This meant that these practices were perceived by the common man as his sacred duty and by the communities as part of good local self-governance and social responsibility. Thus this water-wisdom at all levels of society ensured adequate availability of water for all, which in turn brought prosperity and richness to the state. All those techniques prevalent in ancient India are now preferred by modern technicians. And now the attempts are made to revive those ancient trends in modern period also. No doubt hydrology was highly advanced in ancient India.

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