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Understanding Water Management System in India: Past and Present Discourse

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ABSTRACT

Our ancestor developed a unique idea of worship to water system and this aspect was given prominence in ancient period. They developed the idea of conserving water and also develop the awareness of the importance of water among the common masses. In the Vedas and Upanishads, we have large number of references of God and Goddess control the water. Archaeological evidence shows that the practice of water conservation and management is deep rooted in the science of ancient India. Excavations show that the cities of the Indus Valley Civilization had excellent systems of water conservation, harvesting and drainage system. Water has been an important factor in the development of any civilization. Human settlements and civilization developed around water sources and rivers. Humans started living in areas near where water was available. The main objective of the paper is to analyze the water management system and their continuity I various historical periods in India.

Keywords: Ancient, Water conservation, Literature, Environment

INTRODUCTION

If we look at history, we will find that all major civilizations developed near water sources, such as the Indus Valley civilization on the bank of the River Indus, and the Egyptian civilization on the bank of the Nile River. All these civilizations proved that life and progress are not possible without water. The importance of water is even greater in an agricultural country like India because India's economic and social system is based on water. Therefore, water management has been very important for life in every era. The Tradition of water management in India is ancient; in the Stone Age, humans were completely dependent on natural water sources. At that time, humans did not have any structured water system. As humans started settling permanently and started agriculture, they realized the need for water management.

The Scholars such as R. C. Agarwal, Anupam Mishra, Radha Kamal Mukherjee, B. R. Mani and R. C. Majumdar have noted that water conservation in Indian society was linked to religious and ethical responsibilities. A review of the literature also reveals that Indian water traditions have been studied generally, particularly in regions like Rajasthan, Gujarat, and the southern parts of the country.

The Indus Valley civilization around 2500 B.C. was the first well-planned example of water management in India. Excavations at cities like Mohenjo-Daro and Harappa show how important water must have been for the people of that time and how good their water conservation system must have been (Possehl, 2002). In the Vedic period, rivers like the Ganga, the Yamuna, and the Saraswati were the main sources of water for living. These rivers were not only important for agriculture and livelihood but also became the basis of religious and cultural beliefs. In the Maurya and Gupta periods, water management was considered an important part of the state governance. During this period, large dams, lakes,

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and canals were built. Rulers like Ashok and Chandragupta understood that if the water system is strong, then both agricultural production and public welfare will be protected (Thaper, 2002).

In the medieval period, the nature of water management became more diverse. The large ponds associated with the temples of South India, the baoris of Gujarat and Rajasthan, the canals built by the Mughal emperors, and the ponds built in the villages remained the Centre of community life. During the colonial period, the British built projects such as the Ganga Canal and the Punjab Canal system. This benefited agriculture but weakened traditional community water management. Water was now under the control of the government rather than the local people; this was a big change. In independent India, water management was combined with modern technology, and dams like Bhakra Nangal and Hirakud were constructed, and projects like Narmada Valley were made.

Today, water scarcity is a persistent crisis in India that affects about crores of people every year. According to the 2019 Water Index Report, NITI Aayog, India, is ranked 120th in the list of 122 countries (PIB, 2019). The per capita water availability in India is about 1,100 cubic metres, which is less than the water crisis threshold of 1,700 cubic metres and close to the water scarcity threshold of 1,000 cubic metres per capita (World Bank, 2019). The changing process of water management from the Stone Age to the modern age shows that society and the state conserved and used water according to their needs. In the present times, when the water crisis is increasing day by day, we need to look into history. Integrating traditional methods with modern technology can be beneficial for the future. Traditional water management methods were simple, community-based, and sustainable, strengthened social unity, and were environmentally friendly. In such a situation, it is essential to understand these traditional water management systems within a historical context, and it is necessary to ensure a secure future.

METHODOLOGY

An attempt is made to give an extensive evaluation of existing historical writings that deals with the water management system in India. It is focusing on in-depth study of actual condition pertaining in the literature both historical and archaeological. To authenticate the literary sources, the analysis also made to find the archaeological sources.

Historical Context of the Water Management System:

In prehistoric times, humans probably used rainwater harvesting techniques, but there is no archaeological evidence to substantiate this. The Archaeological evidence of water management is available from the Harappan civilization onwards (Singh, 2020). The Harappan civilization, from 2600 BCE to 1900 BCE, was one of the world's ancient civilizations, extending across what is now the northwest Indian subcontinent and Pakistan. Its city planning, water management, and drainage systems were highly developed and advanced for their time. Harappan cities were built on a grid system. Roads were straight and intersected at right angles. The water management system of this civilization was very well organized and well planned. Private and public water sources were built in almost every major city. Archeological excavations have uncovered over 700 wells at Mohenjo-Daro. These wells were mostly located within private homes or connected to courtyards. The famous Great Bath at Mohenjo-Daro (in today's Pakistan) is a remarkable example of water management from this period. This bath was found in the citadel area of the city of Mohenjo-Daro, located in Sindh province of Pakistan. It measures approximately 12 meters long, 7 meters wide and 2.5 meters deep. It was built of baked bricks. To prevent water stains, the walls were coated with bitumen and gypsum (Marshall, 1931). Sturdy steps led down to it on both sides. To fill the tank, water was drawn from a nearby well and transported to the tank through a paved brick drain. An advanced, fully covered drainage system was used to drain the water after use. Historians and archaeologists believe that this great bath was used not only for bathing but also for religious and group rituals. The amazing structure of the bathhouse proves that the water conservation technique of the people of the Harappan civilization was excellent. The planning and construction of this bathhouse reflect the amazing efficiency of urban planning and water management of that era. The great bath at Mohenjo-Daro provides a remarkable example of the advanced water management and religious social life of the Harappan civilization. This tradition of water structures followed gradually, and it developed in other cities (Fig. 1 and 2).

Fig. 1 : The Great Bath of Mohenjo-Daro

Fig. 2 : Pipal leaf shaped well, Lower Town. Mohenjo-Daro

Moving forward in this sequence, Dholavira city was even more unique in terms of water infrastructure. Located in the Kutch district of what is now the state of Gujarat. The region was dry due to the lack of rain and seasonal rivers, so the inhabitants developed a unique and scientific system of water management. Archaeologists have discovered approximately 16 large reservoirs at Dholavira, built in a stepped pattern of stone and baked bricks. These reservoirs were placed around the city to collect rainwater and water from the nearby rivers Manhar and Mansar. River water was brought to these reservoirs through canals and channels, and to keep the water pure, it was filtered through layers of sand and stone.

The water collected during the rainy season slowly seeped into the ground, keeping the groundwater level high, so that wells did not dry up even in summer. Historians believe Dholavira's water management system is an excellent example of the engineering and city planning of that time. The water management system at Harappa demonstrates the adeptness of this civilization in utilizing natural resources in an organized and scientific manner. It continues to inspire modern water management schemes (Fig. 3 and 4).

Fig. 3 : A large reservoir with a store water drain from the southern end

Fig. 4 : Dockyard at Lothal

Water management took a new form in Lothal. Lothal was an important city of the Harappan civilization, located in the Ahmedabad district of the present-day state of Gujarat. It was a major center of maritime activities from approximately 2400 BCE to 19600 BCE. Lothal's

most remarkable discovery is its dockyard, which is considered the world's oldest artificial dockyard. Archaeologists have discovered a large rectangular reservoir here, measuring approximately 214 meters in length and 36 meters in width. The dockyard here was connected to the nearby Bhogava River by canals so that ships could easily move in and out during high tides. Harappans used advanced water harvesting techniques in coastal areas, controlling flow and facilitating trade (Possehl, 2002).

Thus, from the underground water structures at Dholavira to the coastal water system at Lothal, the influence of the Harappan civilization's water management tradition can be clearly seen (Fig. 5 and 6).

Fig. 5 : Drainage system at Lothal

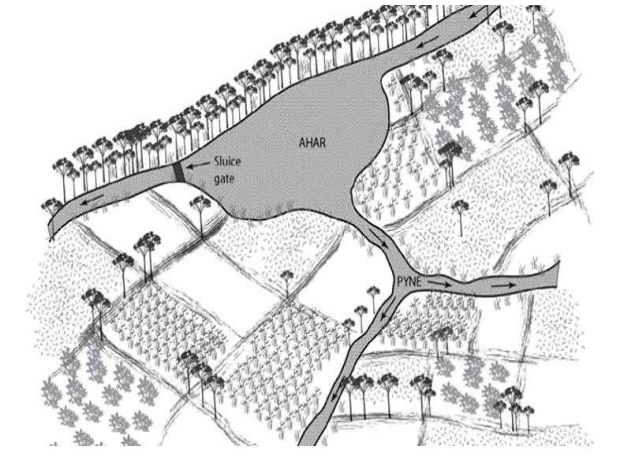

Fig. 6 : Ahar-Pyne structure

After the decline of the Harappan civilization, knowledge of water management transformed from the Harappan technological tradition to the spiritual and rural traditions of the Vedic period. The importance of water in Vedic society manifested itself in religious rituals, the sanctity of rivers, and the necessity of water in yagnas. There is no direct evidence to confirm water management and technologies during the Vedic period. Most of the information we have about the Vedic period comes from religious texts such as the Vedas. The Rigveda and Atharvaveda describe water as life-giving and medicinal. Words like "Kup" (Well) or "Kul" (Channel) are mentioned, but these terms are mostly associated with religious rituals, such as worship and Yagna, rather than large-scale water management and technology (Witzel, 2003). In the (10, 93.12 and 10,101.7) verse of the Rigveda, there is a mention of Ashma chakra, a wheel made of stone, with the help of which water was poured into the vessel with the help of a leather strap (Rigveda, 2004). Based on the available literature and limited evidence, it can be said that Vedic society considered water sacred and essential, but planned water management systems are not visible in the Vedic period. The descriptions related to water in the texts are not technical but religious and ideological. There is no concrete evidence available about water management systems and techniques in the Vedic period.

The Mahajanapada period, from the 6th to the 4th century BCE, was a period after the Vedic period. During this period, Water management was not a natural necessity but also an essential part of state and city planning. The Mahajanapadas, located along rivers like the Ganga, Yamuna, and Sone, developed water infrastructure according to their geographical location. Magadha was the most powerful Mahajanapada of its time. Buddhist literature reveals that Magadha built large ponds such as the AhirayaPokhar. Water management during this period was largely community-based. The Ahar-Pyne system, an excellent example of rainwater harvesting, primarily associated with the Magadha region, is believed to have originated during the Mahajanapada period. It was later organized during the Mauryan period (Majumdar, 2012). Local feudal lords and the Magadha administration maintained these water structures. The people here depended on natural water sources and created permanent structures and community rules whose influence is visible in the Maurya, Gupta, and later dynasties.

The Mauryans gave a framework to the collective water infrastructure inherited from the Vedic and Mahajanapada periods, a form of state policy. During this period, canals, lakes, and ponds were developed in a planned manner. Maurya Empire: This period from 4th BC to 2ndBc was famous in Indian History for city planning and an agriculture-based system. Megasthenes's Indica describes that the city of Patliputra had a complex canal system connected to the Ganges and the Sone Rivers (J.W. Mc Crindle, 2000). Kautilya's Arthashastra describes dams for irrigation during the Mauryan Empire. It also mentions taxes and regulations governing water management systems, including water use, penalties for water-relatedcrimes, and flood and famine management (Rangarajan, 1992). During Ashoka's reign, water was linked to religious rituals and social welfare. The Pushya Gupta, a governor of Chandragupta, commissioned the construction of the Sudharshan Lake, as described in the Girnar inscription in Saurashtra. This artificial dam created water, serving as the main source of construction and irrigation for the surrounding region. After the decline of the Mauryas, the Sunga and Kanva dynasties continued the tradition of water structures (Fig. 7 & 8).

Subsequently, during the Gupta period, the state's role in water management became crucial. During this period, Gupta rulers granted local village chieftains and landowners the authority to maintain water structures. Pushkarnis and ponds were built alongside temples and monasteries. Artificial lakes, stepwells, and canals were constructed during this period.Sudarshan Lake, built during the Maurya period, was later repaired by the Gupta rulers.

Fig. 7 : Sudharshan Lake Region of Kathiawar (Gujarat)

Fig. 8 : Chand Baori at Abhineri

During the Early Medieval period, India lacked a major central power. Consequently, several regional powers began to emerge in India. Everyone developed water management according to their geography. In northern India, the GurjarPratiharas (8th-11th AD) ruled primarily over Rajasthan, Uttar Pradesh, Madhya Pradesh, and Gujarat. This region was dry due to a lack of rainfall. To address the water shortage in Rajasthan and Bundelkhand, rulers commissioned the construction of stepwells and lakes. For example, the Chand Baori at Abhineri is a deep, 13-story, stair-shaped stepwell that served not only as a water source but also as a center of social and religious life. The ponds and lakes at Ajmer and Pushkar are also included in this list.

In western India, the Solanki, Chauhan, Parmar, and other local dynasties implemented water management measures. Bavariya ponds and artificial channels for rainwater harvesting were developed to support agriculture. In Rajasthan, stepwells and lakes were built near forts and cities in areas such as Chittor, Ajmer, and Jaipur, such as Gadisar Lake in Jaisalmer (Fig. 9 and 10).

In South India, the Pallava, Chalukya, Rashtrakuta, and Chola dynasties adopted scientific and efficient methods of water management. The Pallavas built small and large ponds and temple tanks in Kanchipuram and the surrounding region. The Chalukyas built stepwells at Badami, and the famous Rani ki baoli was also built in this period.

The Rashtrakutas harvested rainwater through

Fig. 9 : Gadisar Lake, Jaisalmer

Fig. 10 : Eri system of rainwater harvesting

artificial lakes and tanks. The Chola Empire developed advanced water conservation systems like the Eri system and the Grand Anicut, which were good examples for irrigation and social life. Eri is a traditional community-based managed system of large tanks and reservoirs. The Grand Anicut, also known as the Kallanai Dam, was built across the Kaveri River. The dam was constructed by the Chola king Karikala in the 2nd century CE.

Throughout India, the Pala and Sher dynasties built large ponds, diggis and tanks in the Ganga Brahmaputra region. While various regional dynasties such as the Palas, Rashtrakutas, and Rajputs developed the tradition of tanka baolis and nehris according to their geographical conditions in the early medieval period, water management became part of centralized state policy from the 13th century with the establishment of the Delhi Sultanate.

During the Slave Dynasty (1206- 1290), Qutbuddin Aibak and Iltutmish constructed ponds and stepwells to meet the needs of the city and fort. The Hauj-iShamshi, built by Iltutmish, was a massive reservoir that served not only to supply drinking water but also to support religious and social rituals (Fig. 11 & 12).

Fig. 11 : Hauji Shamshi

Fig. 12 : Hauz Khas Reservoir

Subsequently, during the Khilji dynasty (1290- 1320), Alauddin Khilji built several water structures to supply water to his newly established city of Srinagar. He expanded the Shamsi and later developed the Hauz Khas. The Tughlaq dynasty (1320-1414) of the Delhi Sultanate is considered the most important in the history of water management. Ghiyasuddin Tughlaq made initial efforts,

but the most notable work was carried out by Firoz Shah Tughlaq. He developed irrigation systems by digging canals from the Yamuna and other rivers. He also built the Rajba Canal.He also renovated the Hauz Khas. He also built hundreds of stepwells and ponds to provide water not only to the capital but also to rural areas.

He also renovated the Hauz Khas. He also built hundreds of stepwells and ponds to provide water not only to the capital but also to rural areas. At this time, another important power emerged in South India-the Vijayanagara Empire (1336–1646 AD). While Sultanate water management had largely focused on the demands of cities and fortresses, Vijayanagara rulers integrated water management with agriculture, urban development, and religious life. The Vijayanagara Empire (1336-1646 AD) developed the most advanced and integrated water management system in medieval India, crucial to the sustainability of its capital, Hampi, and its extensive agricultural system. Its core was the tank irrigation system, which created large artificial lakes such as the Kamalapuram Tank and the Bukkambudhi Tank. These tanks were combined to form a cascade system, where excess water from one tank was diverted to another. Some tanks had the capacity to store millions of cubic feet of water. Connected canal networks relied on gravity, harnessed natural streams, and attempted to consolidate water. Branch canals from larger canals distributed water to individual estates.

Temple tanks were important from both religious and cultural perspectives. They were used not only for religious rituals but also to supply the city princes. From a technical perspective, anicuts (water channels), *i.e.,* stone dams built across rivers, were of particular importance in Vijayanagara's water management. Water was diverted into canals. Sluice gates and spillway structures controlled the flow and safety of water. Additionally, a robust system of wells and stepwells—stepwells, recharge wells, and solar wells—was installed throughout the city.

Agriculturally, this system enabled multi-cropping. Rice, agricultural produce, cotton, and other crops were grown, along with horticulture and fruit and vegetable cultivation. To mitigate rainfall, water was stored in ponds and systematically distributed during the fishing season. In the capital, Hampi, special canals were built to supply water to the royal palaces and gardens, along with public taps and water temples, and even parallel drainage systems.

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Vijayanagara's water policy was based not only on principles but also on the principles of sustainable development (sustainable practices). This included rainwater harvesting, groundwater recharge, and catchment management. Active participation of local people was also a hallmark of this system. This system met the demands of population growth, multi-ethnicity, and agricultural production. Even today, this system is considered an inspiring model for traditional knowledge and modern water management.Vijayanagara's water policy was based not only on principles but also on the principles of sustainable development (sustainable practices). This included rainwater harvesting, groundwater recharge, and catchment management.

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Fig. 13 : Hampi Water Management System stepwell

Fig. 14 : Anup Talao, Fathepur Sikri (Agra)

After the fall of Vijayanagara, the centre of water management in India shifted from the south to the urban centres of the Mughal emperors in northern and central India. While Vijayanagara had its community and agriculture-centric techniques, during the Mughal period, these were combined with urban planning and horticulture. Babur, the founder of the Mughal Empire, studied India's climate and geography upon his arrival. He described the Indian heat and the need for water in his book, the Baburnama. Aesthetics. He built ponds and canals along with Charbagh-style gardens in Agra and Fatehabad. During the time of Humayun, there was political stability, but wells and small ponds associated with the Baghs of Delhi and Agra developed.

Akbar incorporated water management into state policies. He built large ponds, stepwells, and reservoirs at Fatehpur Sikri. The Anup Talaowere an important part of the water distribution system. Akbar also promoted canal projects connected to the Ganges and Yamuna rivers (Fig. 15 and 16).

Jahangir paid special attention to horticulture and

Fig. 15 : Hauz-i-Shirin, Fatehpur sikri

Fig. 16 : Shalimar Bagh, Srinagar

water infrastructure. He created a network of gardens, including the famous gardens of Shalimar Bagh and Nishad Bagh in Kashmir. Step fountains were built to bring water from the gardens. Shah Jahan's reign is considered the golden age of management and urban planning. He built canal systems such as the Nahar-e-Bihishtand improved the existing system of canals originating from the Yamuna River, which supplied water to the gardens, palaces, and mosques of Delhi and Agra. Under Aurangzeb, water management became more practical, focusing on agricultural and military needs. He developed Malik Ambar's canal system at Aurangabad during his campaigns in southern India.Mughal successors after Aurangzeb maintained the old lakes, baoris, and canals. Until the time of Bahadur Shah Zafar, Delhi's water supply depended primarily on the canals and baoris built by Shah Jahan.

Following the decline of the Mughal Empire, British rule was established in India. They reorganized water management to meet the needs of industrial development. The British focused primarily on large-scale irrigation projects, such as canals and Dam systems, and on urban-district supply.In North India, the British built large dams and canals on rivers like the Ganga and Yamuna, the main examples of which are the Sutlej Bikaner Canal and the Ganga and Yamuna Canal system.The Sutlej Bikaner Canal was built primarily for agricultural irrigation in the desert region, while the Ganga Yamuna Canal system was built to provide water for crops in Uttar Pradesh and Bihar.

In South India, the British studied the Vijayanagara and other older tank and arena systems and combined them with modern technology to build new tanks, lakes, and reservoirs. Urban water supply focused on pumping stations, pipeline networks, and clean water supplies. Cities like Kolkata, Mumbai, Chennai, and Delhi were built with large reservoirs.

After independence, irrigation projects such as the Bhakra Dam, the Nangal Dam, the Hirakud Dam, the Tata Project, river projects, and water conservation policies were developed in India. Technology and community initiatives for rainwater harvesting and urban water supply continue in modern India (Fig. 17 & 18).

Fig. 17 : Hirakud Dam

Fig. 18 : Bahkra Nnagal Dam

Conclusion:

The water crisis and environmental imbalance we are facing today necessitate awareness of water management as a crucial step, and society needs to come together collectively to address this. Ultimately, this research concludes that the traditional knowledge, techniques, and methods used for water management in ancient India should be adopted to ensure sustainable water management for future generations. Similarly, to address the future water crisis, today's generation must be made aware of traditional water sources, structures, and conservation methods. We should develop a sense of community responsibility, empathy, and understanding towards this issue, and this knowledge should be instilled in children through primary education, shaping their behavior accordingly

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