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Water Management Systems from Ancient to Pre-Modern India: A Historical Overview

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Abstract

This paper aims to provide an overview of the Water Resource Management System and irrigational technology from ancient times to pre-modern India, covering both spatial and temporal aspects. Studying water management in India during this period is important for its ecological, technological and politico-religious significance. First, it focuses on understanding how individuals and successive governments (ancient and medieval periods) make choices regarding the use of various water distribution and control systems across different regions and eras. Grasping the technical, functional, and developmental aspects of various water-lifting devices is dealt with before delving into examining different methods of water resource management. Additionally, this paper explores how authority, patronage relationships, social power, and the economy were reinforced through water resource management by rulers, individuals, and communities throughout the ancient and medieval periods.

Keywords: *Water Management, Irrigation, Water Lifting, Well, Canal, Tank*

Introduction:

Due to physiographic and climatic differences and uneven, erratic, and uncertain rainfall in different parts of India, there is a need for human intervention in the water resource management system. India has a long history of water management. Water has cultural and spiritual connotations in addition to its economic worth. Water has been crucial in the rise of ancient civilizations as well as their progress and economic development. Most ancient civilisations emerged in locations where water for agricultural growth was easily accessible, such as near springs, lakes, rivers, etc. The emergence of civilisation in a river valley, dependent on water resources, made *K.A. Witt Fogel* characterise the civilisation as '*hydraulic civilisation*,' and the futility of its application in the Indian context raised a spate of questions by Indian scholars[1]. Additionally, safety concerns and attempts to prevent vulnerability linked to the use of sea-level fertile land led to the establishment of settlements on elevated hills or in more rugged regions. Even underground water levels, natural slopes, natural settings, climate, and limited availability of water, carrying it long distances, largely influenced the techniques of water lifting, methods of irrigation, and water resource management through the ages. The erratic, uneven, and uncertain rainfall causes Indian agriculture to rely significantly on diverse irrigation and water management systems. For agricultural purposes, people used rainwater and river water, i.e., natural

means of irrigation; artificial irrigation emphasises man's efforts to cultivate land through various management of water works such as digging wells, canals, tanks, reservoirs, etc., and techniques to raise water.

Before delving into the water resource management system, an attempt has been made to give brief glimpses of various means/devices used for water lifting in different periods of time, which is a prerequisite for understanding the Water management system as a whole. Water lifting devices in traditional ages (in ancient and medieval times), such as *Shaduf (dhenkli*), *Charas (rope-bucket contraction)*, *Noria (araghatta- pots tied on the rim of a wheel),* and Persian wheels have been used. *A.J. Qaiser* has given a clear description of five types of devices and their function and uses[2]. He categorised these devices based on water supply into intermittent and continuous water supply devices; and, depending on the characteristics of the operative source, divided devices into two types: (a) operated manually or by human power and (b) operated by animal power. All devices, with the exception of one, shared two characteristics because water had to be hoisted from wells: rope and bags or buckets, the latter of which varied in size according to the amount of power employed.

Type A) device: The simplest method was to pull water using a rope and bucket without any mechanical aids. Clearly, the bucket was limited in size, and it would not have been suitable for irrigating larger fields, but for domestic use and maybe for irrigating small fields of crops.

Type B) device: The second method/ approach involved using pulleys combined with a manually operated rope bucket contraption. So, there is the use of '*Pulley'* that helps in lifting comparatively larger water buckets or bags.

Type C) device is an improved variety of the earlier one, where the employment of animal power has been used in place of manual labour in operating this device, which, in turn, conveys the impression of a large output of water sufficient to irrigate larger fields. This device in north India is known as *charasa*. Babar describes its operation in Agra, Chandwar, and Biana [3]and notes that water could not be used for drinking or domestic purposes, as the ropes were contaminated with excrement, urine, and dung before they were lowered back into the well. So, it is generally devised for irrigation purposes only.

Type D) device is generally known by various names- *Dhenkli, Tula, Latha/Layh,* regarded as semi-mechanical, since it operates on the principle of the first-class lever. A lengthy rope is secured to the fork of a vertical beam or the trunk of a tree to place it in a swinging stance. The bucket is fastened to a rope, the opposite end of which is attached to one end of the swinging pole suspended above the well. The opposite end of the pole holds a 'counterweight', which is slightly heavier than the bucket when filled with water. Therefore, the fulcrum forms at the centre of the pole with the weight and counterweight (efforts) positioned at its opposite ends. This helps in easily raising water from wells with little use of manual power. A 16th-century manuscript of Mrigavat, illustrated between 1527-1570 A.D, located at Bharat Kala Bhavan at Banaras Hindu University, depicts this device and a 17th-century traveller, Fryer, also gives a vivid description of *dhenkli*[4].

Type E) is the last and fifth device known as *Saqiya* (Persian Wheel), which is radically different from *Noria* (*Aragathha*) not only in its conception but also in its components. Irfan Habib pointed out the differences between *Aragatha* (*Noria*) and *Saqiya* or Persian Wheel[5]. The *Noria* was a Wheel with clay pots affixed along its edge. Thus, this concept generally

entailed raising water from rivers, reservoirs, or streams where it would eventually reach its banks. Therefore, at this point, using it over wells was completely could not be conceived. To raise water from depth or from wells, a chain of pot-garland (mala of pots) fastened to the edge of the wheel operated through manpower. This device, called *Noria* (pots tied to its rim), later followed by mala of pots over its rim, was of indigenous origin. By the 6th century, the pot-garland (mala of pots) began to be hung over the well wheel, as is attested by epigraphic evidence of that century, reinforced by firm references in Bana's Harshacharita in the next[6]. But the arrival of the Persian Wheel and its main gearing mechanism was from the Mediterranean, and Iraq must have crossed the Indian land by at least the beginning of the 15th century to have diffused so widely by Babur's time[7]. The *Saqiya* consists of three wheels (two vertical wheels) and one horizontal wheel operated on a gearing mechanism, operated by animal power. The two vertical wheels were attached to the same axle in which one vertical wheel (which we call well-wheel) had attached to its rim chains of pots, and another vertical wheel had cogs attached to the axle's other end and had set in a manner with the horizontal wheel (which has been placed on an upright axle) having vertical pegs at regular intervals that when operated by animal power, enabled the enmeshed of cogs vertical wheel with pegs of the horizontal wheel, so the horizontal motions of the horizontal wheels enable vertical wheel moving that, in turn, enables moving of well-wheel. In this manner continuous water-supplying process could be achieved to a great degree that enabled the irrigation of larger fields.

It is believed that the first irrigation system started with the king Menes (the first king of Egypt) of the first ruling family (Pharaoh) in the middle of the fourth century BC. Menes introduced the ceremony of Dyke-cutting from the river[8]. Tracing historical evidence on water resource management, conservation, and techniques used for water lifting in the early Indian context started with the first settled agricultural community in Kachi Plain (Baluchistan), in Mehrgarh, which provides reference to an artificial Dam. In the context of the Indus Valley civilisation, there are references to wells, especially Masonry wells at Allahdino, which were made generally on upper land that facilitates the irrigation of lower land easily. For raising water, there may have been the use of a bucket tied with a long rope without *Pulley* as larger wells have staining and scored by rope friction manually[9]. The Drainage system, water-flushed toilets in the Indus Valley civilisation, underscored their wastewater management knowledge. *Shaduf*s (dhenkli) were also being used. At the Mohenjo-Daro seal, such devices are depicted. Numerous pieces of evidence of water harvesting through *Khadin* and tanks, and an exceptionally large rope, have also been found at Dholavira[10]. The presence of 16 large reservoirs (some of them interconnected) and a rectangular stepwell (10 m deep and 29.3 m wide,73. 4 m long, which was larger than Mohenjo-Daro's Great Bath) at Dholavira exemplifies the water management systems. The massive protective wall encircling the Dholavira suggests they may have been aware of ocean catastrophes such as tsunamis or storms.[11] The Urban Indus Valley Civilization created the earliest wells of their type in South Asia, and farmers of Harappa used *Gabarbands*(dams) and canals. Inlets and outlets at Lothal's dockyard indicate the hydraulic expertise that existed in Protohistoric India[12]. In the protohistoric Indian context, people dug unlined or Kuchcha wells, or installed brick-lined or terracotta ring wells in order to draw water[13]. At the OCP level at Lal Qila, R.C. Gaur found a Kachcha or unlined well (4 m deep). At Atranjikhera in the Iron Age (PGW levels), bricks were known, but Gaur found a few deep, circular pits outside the habitation area that could have been Kuchcha

wells[14]. In the *Rigveda*, there is a reference to *Shurmisushila* (long channel), which carries water to the field, and the Atharvaveda has a reference to praying when a cut is made to draw river water into channels. In the Vedic times, lakes (*hradah*), canals (*kulya*) and wells were used for irrigation. Verses X 93.12; X 101.7 of the *Rigveda* noted a water-lifting device called as *Asmachakra*; it was likely a stone wheel (a stone-pulley or a disc of stone), and the water was lifted with the help of wheel in a pail using a leather strap. There was also the use of *Ghatiyantra* or *Udghatana* (a drum-shaped wheel round which went a pair of ropes with *Ghata*, i.e., earthen pots tied to them at equal distances[15]. Control over water, or to say river, might have been one of the key ways to show the political superiority and might of one group over the others. In the context of the Vedic age, the battle of ten kings on the banks of Ravi (*Purushni*) was not simply a war of win or defeat, but to control the river's water for agricultural purposes.

Various ancient Indian texts like the *Puranas*, the *Mahabharata*, the *Ramayana*, the *Dharmasutras*, Kautilya's *Arthashastra*, Kalhana's *Rajatarangi*, etc., have references to various methods of water management. *Chullavagganikaya* (350 BCE), with various agricultural references, has references to *Udakabhinetabham* (irrigation). *Brihatkala Bhasya* (700-350 BCE) has references to various sources and methods of water supply in the regional context. It refers to rainfall as a major source of water supply in *Latadesha* (i.e., Gujarat, Western India). It also refers that fields were irrigated from ponds in *Dravidadesha* and wells in *Uttarpatha* (Northern India), and in some areas, river water also have been used. Various types of ancient sources replete with the conjunction of guiding rules, underscored ecology, social, spiritual and moral factors related to the water resource management in the pre-modern Hindu-Muslim governance in India. During the Maurya period, the *Arthashastra* (3rd BC) provided a description of how water was managed under the Mauryan Empire. It indicates that the primary methods of irrigation included the river (*Nadi*), Lake (*Sara*), Tank (*Tadaka*), Well (*Kupa*), Spring (*Usta*), and Reservoir (*Adhara*)[16]. Water pricing in irrigation, in accordance with the sourcing of water, in the Mauryan empire was a driving factor in the cause of water management and conservation, as well as contributing to the state economy. K.A. Wittfogel singled out the Mauryan Empire as having maintained a grandiose hydraulic economy based on hydraulic agriculture, with large-scale state-directed irrigation farming that led to hydraulic despotism. However, except for Chandra Gupta Maurya's Sudashan Lake, there was on large scale irrigation project that might support state business in irrigation. V. K. Jain stated about the area of Sudarshan Lake and the size of the dam that was built on it that implied not a very large area of irrigated land and also highlighted the construction and repair of the dam over Sudarshan Lake by regional governors and officials during the periods of Rudradaman (150 AD) and Skanda Gupta (460 AD), suggesting that local official governors were principally in charge of irrigation rather than the central government, which provides asssistance when required[17]. During the post-Maurya era, both tanks and wells remained in use for irrigation purposes. The Mauryan Empire employed the Ahar-Pyne system for participatory irrigation management and rainwater collection. The pyne are man-made (artificial) channels to use the river water running over mountainous areas, and Ahars are catchment area with tree sided embankment to retain rainwater and water from the Pynes.[18] Ushavadutta, son-in-law of King Nahapana, is credited with building many tanks and reservoirs, and during that period, the increase in the number of wells increased, but no traces of any canals dug out in the Kushana period were found. Traces of two canals at

Kumrahar and at Besnagar, which, according to R.S. Sharma, canals were belonged to the Mauryan origin[19]. Based on the Arthashastra's reference to the private holding of wells, tanks, and community collaboration in irrigation organisation, etc., V.K. Jain argued about the Mauryan and post-Mauryan, which is similar to K.A.Wittfogel's hydro-agriculture society, economy, that was based on minor irrigational works such as wells, tanks, reservoirs, etc.

Peninsular India was also very fertile in irrigation projects. South India's history of intensive irrigation and flood control begins with the early Cholas under the leadership of Karikal the Great (c.150 A.D.), who built a 160 km embankment known as the Grand Anicut (Kallanai) along the Kaveri River. This feat of engineering can be compared to Hadrian's Wall. The excavation of the Cholaganga tank by Rajendra Chola symbolises the excavator's military and political might.[20]

Another great South Indian king, enthusiastic about irrigation, was King Kharvela of Kalinga. His Hathigumpha inscription records that he renovated the canal originally built by the Nandas. The Satavahana ruler of the early centuries A.D. is credited with introducing ring wells— dug wells for irrigation. Their successor in Eastern Deccan, Ishvakush, constructed large waterworks comparable to European aqueducts, made possible not only because the state financed them but also due to the existence of a guild of hydraulic engineers (*Odyantriksa*s). With the introduction of feudal elements into Indian polity, this trend continued in lower and southern South India under rulers of the Vakatakas, Pandyas, Hoysalas, Kakatiyas, and Gajapatis, but not in the northern regions under the Vakatakas, Chalukyas, Rashtrakutas, and Yadavas. Furthermore, the physical remains of some of the ruined and operational tanks, such as Raja Tataka, Gangaikonda, Dorasamudra, and Ramappa Lake, still speak to the concern shown by indigenous predecessors of the Muslim rulers of Medieval India for hydraulic agriculture.

In the early Medieval Indian landscape, there was evidence of water management with variability and multiplicity of storage systems and irrigation of the land. Various sources, such as Aprajitapracha (12th C.), Brihatkalpashutrabhasya (an early medieval text), Nitisara, etc., have given information about types of wells (*kupa*), tanks (*tadags*), and step-wells (*vapi*), rivers, and canals, which were the usual means of irrigation[21]. Shreds of evidence make it a well-established fact that appropriate acknowledgement was granted to irrigation, whether natural or artificial. The former system directed water from the rivers and monsoon in the Northern and North Eastern parts of India, while the latter made use of stored water in tanks, pools, and wells, a practice prevalent in Central, North Western, and Southern India. Eastern India is also blessed with great rivers such as the Ganga, Brahmaputra and their tributaries. Hydraulic resources and works have been documented in the Varendri region, which aligns with the Rajshahi, Bhagra, and Dinajpur areas in present-day Bangladesh, the core territory of the Pala Dynasty. Ramapala, the last prominent ruler of the dynasty, is being credited with building a large lake featuring tall palm trees and rows of hillocks along its edge to create the appearance of a veritable sea. These manmade water bodies were grander, more remarkable than usual ponds (*Pushkarini*), tanks (*Tadaga*), representing an amplification of hydraulic resources[22]. Except waterwork of Rampala, hydraulic projects at supra local level by authorities in this area were scant, and subsequently, Senas constructed large tanks throughout Bengal[23]. Evidence shows that in the flat eastern Gangetic plains, agriculture primarily depended on

rainfall, and river water has been used. However, there was some additional surface irrigation, supplied through small private low-lift devices known as overflow irrigation. In the pre-colonial period, zamindars constructed river embankments in the Gangetic delta to protect against floods during the monsoon, often deliberately breaking these embankments after the monsoon to manage floodwaters irrigation. In medieval Bengal, the arrangement of artificial irrigation, like the digging of canals, tanks, and wells, was made by people as well as by the state, leading to overall growth in agricultural production[24]. In his *Tabaqat-i-Nasiri*, the thirteenth century historian Minhaj Siraj noted that Ghiyasuddin Iwaz Khalji constructed an embankment that facilitated movement for people during the inundation[25]. At the same time, when Ibn Battuta travelled to Bengal, he mentioned the use of water wheels[26]. The inscriptions of Sultan Rukunuddin Barbak Shah, Sultan Alauddin Husain Shah, and Sultan Nasiruddin Nusrat Shah inform about the construction of water channels, wells, tanks, and *siqaya* (shed for supplying drinking water)[27]. Even for war purposes, armies in Bengal, under the supervision of Mirza Nathan, had to work on controlling water courses[28]. Probably both communities and rulers played the principal role in managing and maintaining water resources, as Sebastian Manrique (visited countries of the East in 1628-1643 A.D) mentioned the construction of water reservoirs in the village area with collective efforts[29].

It is believed that the land of Kashmir, also known for its water resource management, started with one of the earliest settlers- the Nagas. The main source of water here was springs. Spring, *chesmah* (*enagai*) and a small spring (*negin*) are the key sources of water here. Notably, the Vitasta (Jhelum) of Kashmir begins from a spring close to Verinag and provides water to the majority of the valley. The Nilamatapurana establishes the religious importance of the river as a physical embodiment of Goddess Uma and portrays her as the divine form of the Vitasta[30]. One of the earliest known kings of Kashmir, Suvarna of the pre-Ashokan age, extended a canal named 'Suvarnamani.' A prominent king of Kashmir, King Lalitaditya (8th century), is endorsed for having brought in a novel device called the water wheel (maybe - *dhenkli*) to lift water to higher plateaus[31]. King Damodara constructed stone-lined dykes to protect against floods, as attested by Kalhana. King Baladitya's minister built an embankment. King Lalitaditya, who organised the distribution of the Vitasta waters at Cakradhara (modern Tsakadar) to various villages. These water management activities enhanced the valley's productivity to a certain degree. But the irrigation work started by the monarch was neglected by his incompetent successors. However, King Avantivarman's irrigation minister Suyya in the 9th century attempted to manage the waters of the Vitasta by dragging large rocks from the river, which lowered its level, which in turn facilitated the supply of water to villages permanently. He dammed the lake with its depth and boundaries to make it a natural great reservoir to receive the surplus water of recurring floods[32]. Sultan Zainul Abedin of the 15th century was the only Muslim ruler of Kashmir who made a tremendous effort for water resource management. He is credited with constructing various canals, which were the Karla Canal, Kakapur Canal, the Chakdar Canal, the Avantipur Canal, the Shahkul Canal (of Safapur), the Lachham Kul or Zainaganga,Shah Kul on the Martanda Canal, the Lall Kul or Pohri Canal, and the Mar Canal[33]. A canal, '*Jui-i-Shahi*', built by emperor Jahangir to water his garden, Nur Bagh, from Lar (Sind), and Shahjahan laid out another canal named '*Shahnahr*'. Jahangir built a canal to water the Shalimar Bagh brought out from

the river Haroon, which Asaf Khan further carried out for his garden Nishat Bagh, but Shahjahan later stopped it to Nishat Bagh[34].

B. D. Chattopadhyaya, by relying on ample inscriptional evidence on irrigation through artificial means in early medieval Rajasthan, emphasised on the relationship between the territorial expansion of agriculture and artificial irrigation and opined that organising artificial irrigation could lead to a certain increase in productivity. Wells and Tanks are key in artificial irrigation in early medieval Rajasthan. Rajasthan did not provide any reference to big irrigation projects, such as canal excavation by the rulers of that land[35]. Wells such as *dhimada/dhivada (ordinary/small well), Vapi/Baoli (step well), and Araghata* have been used in the Rajasthan region[36]. Individual ownership, as well as rulers' support and intervention in irrigation enterprises, were evident in early medieval Rajasthan. This irrigational enterprise, where they existed, seems to have played an important role in the rural economy and within the existing institutional framework of patronage[37]. Irrigational efforts are important in socioeconomic and political progression and change, as 'irrigational efforts could and did, to a certain extent, generate economic and social power, albeit at microscopic political-spatial levels', as argued by B. D. Chattopadhyaya[38]. Variability in the Water Management System in Rajasthan's desert area has been practised[39]. People in these desert areas used various types of wells, talabs, tanks, and *khadeen* systems (an artificial depression created manually, dammed on three sides to collect water for irrigation).

Surabhi Srivastava surmised information regarding irrigation methods in North Central India during the early medieval era, mainly in light of the epigraphs of the imperial Pratiharas, the Paramaras, the Chandellas, and the Kalachuris- four important Rajput dynasties which ruled this region during the early medieval period. Reference to the *water channel (Vaha*) for irrigation purposes is evident in the Vallabhattaswamin temple inscription (dated 876 A.D) and also in the Lal Pahad Rock inscription of Narasimha (kalachuri of Tripura)[40]. Ajaygadh stone inscription (V.S 1227) of the time of Paramadideva of the Chandella dynasty was written to commemorate the construction of Step Well (*Baoli*), and the Rakhetra stone inscription (900/100 A.D.) from Gwalior refers to the construction of water reservoirs by Vinayakapal, the Pratihara ruler and Paramara ruler Bhoj also built a tala at Bhopal to overcome the problem of water scarcity of the region, and kalachuris records also speak of the construction of artificial lakes (Sarovar) by royal members as well as private individuals[41]. Topography, climate, the pattern of rainfall, etc., had a bearing on irrigational works, as we see in the case of the Chandellas (ruled in the Bundelkhand region) among the four dynasties that extensively undertook irrigation works for the aforementioned reason.

The region of Gujarat, known for its aridity and low rainfall pattern, considerably implies the impotent water resource management system. Wells provided the chief form of irrigation in western India. Besides irrigation, reservoirs and talabs are crucial for natural catchment and filling of the underground water level, as these permit water to seep into the ground and replenish the nearby soil. The Step Wells (*Vapi*) were constructed in Gujarat on a wider scale during the Chalukya period, and these wells were solely used for irrigation purposes in that region[42]. Mularaja (10th c.), instructed his officials to excavate tanks and wells, build *vapis*. The tank at Anahilapataka was named after Durlabharaja (11th c.). King Karna commissioned the excavation of two tanks named after him (Karnasagara),

and the construction of a *vapi* at Davad. Royal authority was also working as a pushing factor to the water management system, as gleaned from the fact that King Siddharaja granted a plot of land for the upkeep of a step-well constructed by the son of a minister (Amatya) in northern Gujarat.[43] The Solanki Dynasty, which ruled in north Gujarat, and the Chauhans, who ruled the kingdom of Champaner in eastern Gujarat in the 14th and 15th centuries, created a vast network of reservoirs in these areas, fascinating irrigation needs[44]. However, during the Mughal period, the construction and maintenance of reservoirs, which tended to serve the water needs of the cities they encompassed, not being designed for irrigation, appears to have been encouraged by rulers, without any systematic planning of the short-seen earlier. There was the use of '*Kos*'- a large leather bag, for lifting water. This bag had two types: a '*Sundhyun'*, which had a trunk at the end so contrived that when it was attached wellhead, the water poured in to fill the trough, and the second one, '*Ramaiyo*' means a larger bag without a trunk, made up from a whole bullock hide. This was lifted by bullocks, dragging a rope connected to the bag over the beam placed above the well. The '*Noriya'* is operated manually and is also used for water lifting[45]. In that region, wells were constructed either by individuals or through the finance of merchant capital; there emerged cooperative basis village level organizations and community-level organizations for building maintenance of these waterworks[46].

The Muslim rulers of medieval India did not exhibit less hydraulic concern than their indigenous predecessors, but, in fact, should have had the same indifference to it[47]. There are several references to various waterworks and irrigation systems in the medieval period. In his article, I.H. Siddiqi clearly points with gravity to several references to waterworks and irrigation during the Delhi Sultanate[48]. With references to Persian and Arabic sources, Siddiqui points to several waterworks started with dyke (made by the Khilji conquerors of Bengal), a reservoir created by Iltutmish and Alauddin Khilji, which were used for a variety of purposes, including irrigation[49]. He also points to a great deal of improvement in the irrigation system obtained in the Delhi Sultanate during the Tughlaq period. Sultan Ghiyasuddin Tughlaq was credited first for digging canals to promote agriculture[50]. Muhammad Bin Tughlaq provided loans to farmers for the purpose of excavating wells to increase agricultural land. There are references to masonry and brickless (kuchcha) wells and water upblocked by throwing dams (*bands*) upon streams, which provided another source of irrigation, and some of these were built by the local people, and some were built by the state[51]. The technique of water resource management through the construction of dams was well known as early as the 14th century and is seen from the extant remains of eight dams of the 14th century, namely-*Band-i-Wazirabad, Band-i-Fath Khan, Band-i-Shukra khan, Band-i-Salurah, Band-i- Sihpanah* and *Satpula*[52]. Muhammad Bin Tughlaq is known to have constructed a Satpula Wier, built in 1327, to regulate the flow of water, for purposes of irrigation, impounded in the lake immediately to the south of Jahanpanah[53]. Firoz Shah Tughlaq (Akbar of the Delhi Sultanate), created five great canals for irrigation purposes and water management. The most extensive network of canals recognised in India before the 19th century includes names like *Rajab-wah* and *Ulugh Khani* from the Yamuna River and *Firoz Shahi* from the Sutlej River[54]. At that time, excavation and upkeep of public canals (*Anhar-i-Amma*) was the responsibility of the local residents and landholders, whereas the state intervened in big waterworks whenever needed[55]. I. H Siddiqui gives information about rulers, ministers, nobles, officials, and individuals who have taken an interest in the construction of water works in various

regions in the Delhi Sultanate. References were also made in a parallel manner about various regional kingdoms that emerged after the collapse of the Delhi Sultanate, such as the Kingdom of Gujarat, Malwa, and Sharqi in Jaunpur; similarly, the Lodi and Sur Kings and their nobles took great interest in the construction of water works. For raising water from wells, various methods have been used. An improvement in the system was the use of the Persian wheel for lifting water in the fourteenth Century, as argued by I. H. Siddiqui[56]. An improvement in the apparatus of the Persian wheel was made during the reign of Akbar, which enabled it to lift water to great heights from the ground level[57]. Among the Mughal Emperors, Shahjahan was known to build *'nahr-i-faiz'* or '*nahr-i-bahish'* (also known as '*Shahnahr'*-royal canal) from the river Yamuna and another canal *shahnahr* from the river Ravi, also known as the Hasli canal, which was built on the guidance of the renowned engineer Ali Mardan Khan, aided by Mulla Alaul Mulk Tuni, a specialist in hydrology[58].

Conclusion:

It is clear that both the rulers and individuals, or Community engagement, were crucial in the sphere of water resources management. The growth of a complex sedentary society in ancient times was further related to the availability of irrigational facilities[59]. Water resource management in the ancient and medieval times gave new avenues to rulers, individuals, and communities to understand the ecology of the particular land or region of that contemporary period. These people used different types of tanks, wells, and other various types of irrigational technology in accordance with the environment, topography, level of water, etc. Overall, the water management system helped to extend agricultural settlement, which in turn increased agricultural productivity. This agricultural productivity, in one way or another, helps to form a positive effect on the overall economic base of dynasties, communities, and large regions. Water Resource Management extended in ancient and medieval times by rulers may have helped to traverse the 'sacred authority of the ruling dynasty' to the mind of commoners; while water resource management by individuals and communities in rural areas gave them a space within the existing institutional framework of patronage, and earn social power in their regions.

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