Water Management in Ancient India

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Introduction

The management of water resources is an important component of human endeavour on this planet. Since time immemorial, several instances exhibit past humans' ingenuity in conserving and managing their water resources. The importance of water resources was best understood in ancient India as instances of reverence for water bodies and rivers could be seen. Rivers like Ganga, Yamuna, and Sarasvati (the trinity of rivers) have been held in high esteem, and pilgrimages are undertaken to drive the fact on the importance of these rivers for the entire human population and also to spread messages of awareness among the public to conserve and preserve them. This practice could have emanated from time immemorial as human knowledge was passed on from generation to generation, along with their knowledge of the climate, surface runoff, drainage patterns and flood activities. Traditional water management systems could be seen at least from the Harappan time onwards, during which urbanism enabled better resources to devise, construct and manage such systems. Examples of large reservoirs at Mohenjo-daro, Dholavira and Lothal (a dockyard, in this case) demonstrate the vast knowledge and ingenuity of the Harappans. In particular, at Mohenjo-daro, the Harappans devised methods to seal the joints with bitumen, enabled large drainage networks to drain off the water and repair them periodically, and constructed a well to feed the "Great Bath." However, the series of water reservoirs and storm-water drainage system at Dholavira surpasses all imagination. The human endeavours, which started during the Harappan period, continued into the historical and medieval period, during which several instances of water management systems could be seen all across India. This

paper attempts to compile all such information and present it chronologically for the readers to understand it better.

Concept of Water and Water Management in the Ancient Indian Literature

The importance of rivers can be understood from the earliest literature in India, i.e., the *Rigveda*. The *Rigvedic* geography revolves around the seven rivers, including Sindhu and Sarasvati. Thus, watered by these rivers, the region is known as *Sapta Saindhavah*. The X.82.5-7 of *Rigveda* mentions the primordial waters and the life originating from it, while II.15.6, I.80.5 and I.32.12 mentions about terrestrial and celestial waters. The verses RV VII.49.1 and 2 mention the celestial waters, or waters coming from heaven, which are also bright, purifying, and flowing to the ocean. In this context, water was also deified as a goddess and invoked to protect the invokers. The knowledge about the geography of the *Rigveda* can be gleaned from the mention of the major rivers and their tributaries. Interestingly, the earlier books of the *Rigveda* (*Mandalas* 6, 3, 7, 4 and 2) mention fewer rivers when compared to the later books (*Mandalas* 1, 5, 8, 9 and 10).

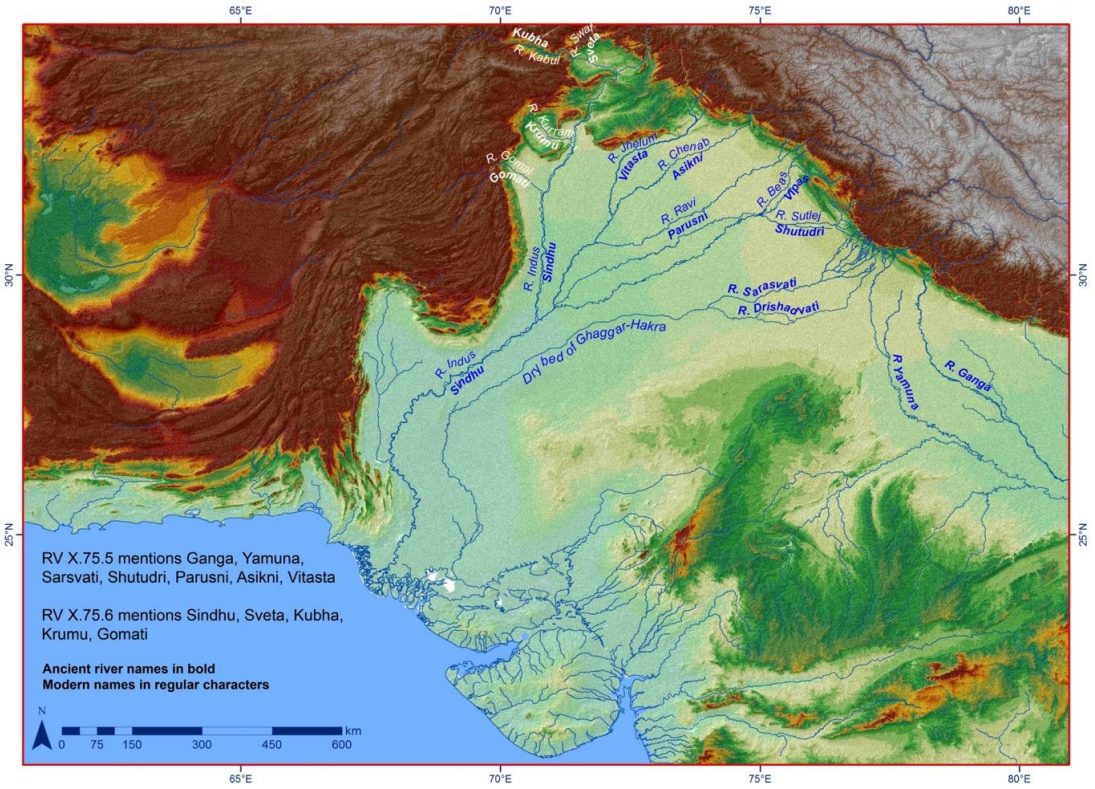

Fig. 1; Geography during the Rigvedic times based on RV X.75.5 and RV X.75.6

The geographical extent of the Rigvedic period, in particular, could be gleaned from RV X.75.5 and 6, which is reproduced below for better understanding:

इमं में गंगे यमुने सरस्वति शुतुद्रि स्तोमै सचता परुष्ण्या ।

असिवक्न्या मरुद्वधे वितस्तयार्जीकीये श्रणुह्या सुषोमया ।।

O Ganga, Yamuna, Sarasvati, Sutudri (Sutlej) and Parusni (Ravi), O Marudvridha with Asikni (Chenab), O Arjikiya with Vitasta (Jhelum) and Susoma (Sohan), please listen to and accept this hymn of mine.

तृष्टामया प्रथमं यातवे सुसर्त्वा रसया श्वत्या त्या ।

त्वं सिन्धो कुभया गामती क्रुमु मेहत्न्वा सरथं याभीरीयसे ।।

O Sindhu (Indus), flowing, you first meet the Tristama (and then) the Susartu, the Rasa, and the

Sveta (Swat), and thereafter the Kubha (Kabul), the Gomati (Gomal), the Krumu (Kurram) with the Mehatnu; and (finally) you move on in the same chariot with them (i.e. carry their waters with you).

Thus, the above verses of the *nadistuti sukta* (hymns in praise of the rivers) of the tenth *mandala* of *Rigveda* clearly mention the eastern and western tributaries of River Sindhu (Indus) along with other major rivers like Ganga, Yamuna and Sarasvati (Fig. 1). River Sarasvati, in particular, was deified and praised as, *"Oh Mother, the greatest of the mothers, rivers, and devi, oh Sarasvati, we are unfit, make us fit"* (RV II 41.16).

अम्बितमे नदितमे देवितमे सरस्वति ।

अप्रशस्ता इव स्मासि प्रशस्तिमम्ब नस्कृधि ।।

The special status given to rivers, particularly River Sarasvati, implies the importance provided to the natural resources; deifying and worshipping them enabled their better preservation. The importance of water is exemplified during the Upanishad period, too, as can be gleaned from the Chhandogya Upanishad. The verse 7.10.1 of Chhandogya Upanishad describes the necessity and importance of water thus, "…*It is the waters which pervade everything, big or small, the earth, the atmosphere, the heaven, the mountains, gods, men, animals, birds, grass, plants, dogs, worms, insects, ants. All these are water indeed".* The literature of the early Historic period is replete with the management of water resources in the context of laying out cities, moats, irrigation networks, and the like. In particular, Kautilya's *Arthasastra* refers to different types of water lifting mechanisms, water divining and irrigation networks. The system of taxation for the irrigation networks is also mentioned in *Arthasastra*. For example, the taxation regime for the farmers existed during that period, and it varied depending on the water source. The personal networks created by the farmers invited lesser taxes

than those created by state mechanisms. Thus, a clear dichotomy of water resources for farming could be delineated, and the evidence for a state-created water resources mechanism for irrigation purposes. Similarly, wherever the water networks in the form of canals could not reach, the creation of tanks and lakes was encouraged. Lesser taxes were levied on those water resources which were comparatively new or recently renovated. This also implies the need to maintain and periodically renovate water resources to retain their water capacity. Along with the taxation, provisions to punish the individuals who indulge in obstruction or diverting a watercourse, failing to create or obstruct the creation of an irrigation tank, damaging embankments, and even causing the drying up of a tank at a lower through the construction of one at a higher level. This is another indication of the creation of water tanks at different levels.

In one instance, Kaultiya declares thus, "…*No one irrigating his field from a reservoir or tank shall cause danger to the ploughed or sown field of another. The water from a lower tank shall not submerge a field fed from a higher tank built earlier. A higher tank shall not prevent the filling up of a lower tank, except when the latter has not been in use for three years...."* This instance indicates that the state machinery is prepared to deal with different situations. This is further corroborated by the references to water management systems that existed in India through the lens of foreign historians and writers. For example, Strabo, the famous Roman writer, mentions, "…*Among [the officials], the first keep the rivers improved and the land re-measured, as in Egypt, and inspect the closed canals from which the water is distributed into the conduits, so that all may have an equal use of it…".*

Kautilya's Arthasastra, while prescribing a model layout of the city and its divisions into different quarters to be occupied by people of various occupations, also mentions the necessity of creating irrigation networks around the city, creation of tanks and lakes, provision to supply water to the moats around the city.

Archaeological Evidence for Water Management / Creation of Dams / Reservoirs

Chalcolithic Period

Explicit evidence from prehistoric times is unavailable due to the fragmentary nature of archaeological material culture. However, close observation of present-day practices often leads to interpreting the past. This happened in the Balochistan region, wherein the locals partly divert the flow of river water to embankments that serve as catchments for the fertile silt and the diverted water. Over time, these embankments develop into a flat, cultivable area enriched with silt and moisture. The locals call these features a *gabarband*.

The term "gabar" is equivalent to a "dam" and can be traced back to the Zoroastrians of the medieval period. The present-day system consists of two major features: (i) to restrict the natural flow of water and release it slowly into the fields, and (ii) a diversionary system, where the dams were placed as weirs to diver the waters into the canals for irrigation. They were designed and built to divert, and not impound, water and allow the alluvium to build up slowly, thereby creating small, fertile and naturally watered fields.

Archaeologists trace the practice of such a system at least to the times of Nal Chalcolithic culture (fourth millennium BCE) in Balochistan. Thousands of such *gabarbands* can be seen in modern-day Pakistan's Balochistan, Sindh Kohistan, and Kirthar ranges.

Harappan Period

Evidence for extensive water management systems could be gleaned from the Harappan period onwards. Sites like Mohenjo-daro, Dholavira and Lothal have produced excellent evidence of such systems. The well-known "Great Bath" from Mohenjo-daro is one example that was well-preserved when excavated. The bath complex was found in association with a "granary" and an "assembly hall" in the "Citadel" area, clearly indicating its importance in the overall

planning and layout. It measures 12 X 7 X 2.4 m, with a flight of steps on the north and south. Evidence of sockets at the edge of the steps indicates it could have supported wooden planks or treads. A ledge wide enough for movement of people is found along the edge of the pool. People could have walked around the pool without entering into the actual pool. The builders cared enough to seal the joints of the brick walls and the floor with gypsum plaster and another layer of bitumen between the gypsum and the brick face. The floor was constructed with a brick-on-edge technique for better strength and stability. The bath complex was entered from the south, with provisions to enter from the north and east. Along the eastern side is a series of rooms, which could have been used for the changing over. One of these rooms also has a well. An elaborate drainage system is connected to this bath complex, terminating near the "granary" complex. A small version of the "Great Bath" could also be seen in the "Lower Town" of Mohenjo-daro (Vidale, 2010) adjacent to a large "palace" complex. This is an indication that versions of bath complexes, smaller in size, were constructed by the inhabitants of Mohenjo-daro.

The Harappan city of Dholavira, located on the Khadir Island in the Great Rann of Kachchh in Gujarat, produces excellent evidence of water management in the form of reservoirs of varying sizes, wells, smaller tanks, water harnessing systems, stormwater drainage systems. The location of such a large city of Harappan times on an island itself is a big surprise, as there are no other examples in this regard. Jagat Pati Joshi of the Archaeological Survey of India discovered Dholavira (mentioned as Kotadi near the modern village of Dholavira) in 1966 (IAR 1967-68: 14-16; Joshi 1990:412) 1990) and was excavated for thirteen field seasons by R.S. Bisht between 1989 and 2005. The Harappan city of Dholavira is located between two seasonal streams, Mansar in the north and Manhar in the south, at a suitable place to take advantage of the gradient and harness the rainwater.

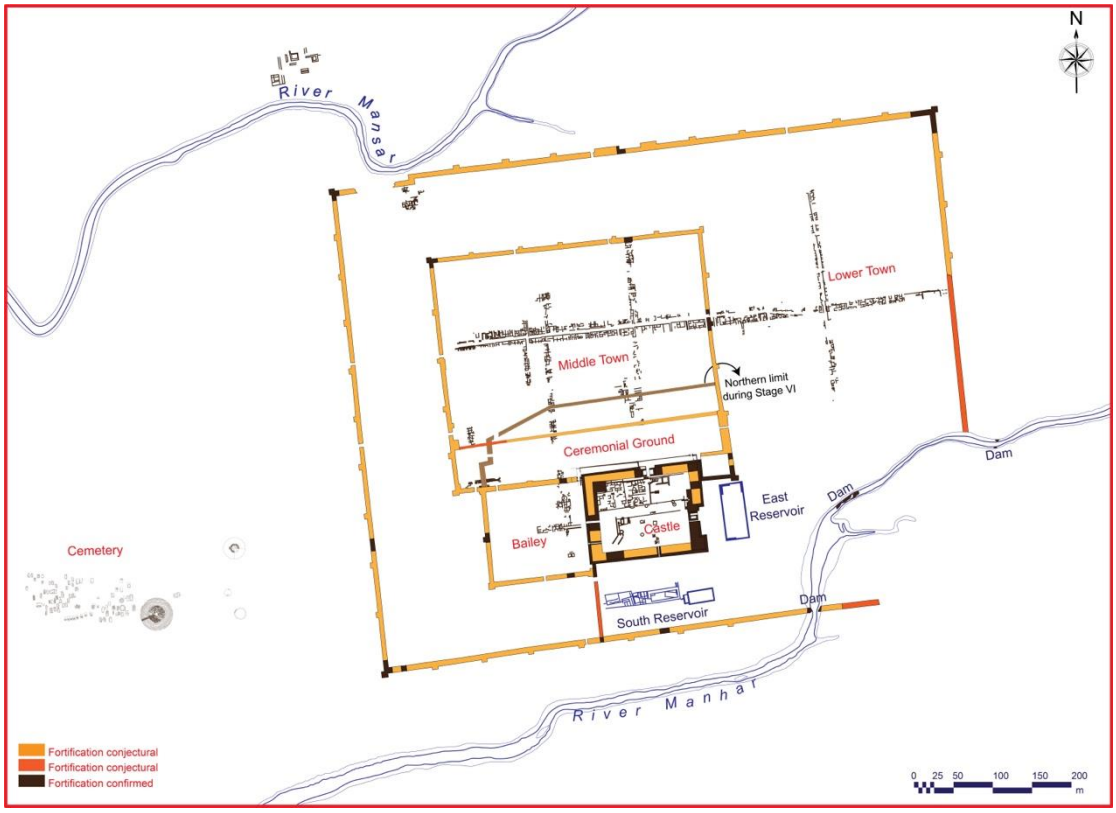

Fig. 2: Site plan of Dholavira showing different parts of the city (after R.S. Bisht 2017)

The excavator names the various habitations of the city (Fig. 2) into the castle, bailey, middle and lower town (Bisht 2017). The excavation brought to light occupation of the site for nearly 1500 years from c. 3000 BCE, with a brief hiatus after the post-urban stage. The Castle consists of elaborate water management mechanisms in stormwater drains emanating from various directions, the most prominent one from the top of the eastern arm of the fortification. The primary purpose of these stormwater drains is to let off the rain during the monsoon (Bisht 2017). These drains are intricately connected and provided with utility holes at regular intervals (Fig. 3). It runs along the central street towards the west, takes a turn near the West Gate, and ultimately drains off through the western arm of the fortification. The significantly elaborate network of drains, meticulous layout and care taken to maintain the system indicate the importance of the settlement inhabitants. No other divisions of the city have such a drainage system. Interestingly, the Castle accumulates an enormous quantity of water even during the

present times during monsoon season. These stormwater drains were defunct during the late Harappan phase, as indicated by a few house drains draining into them.

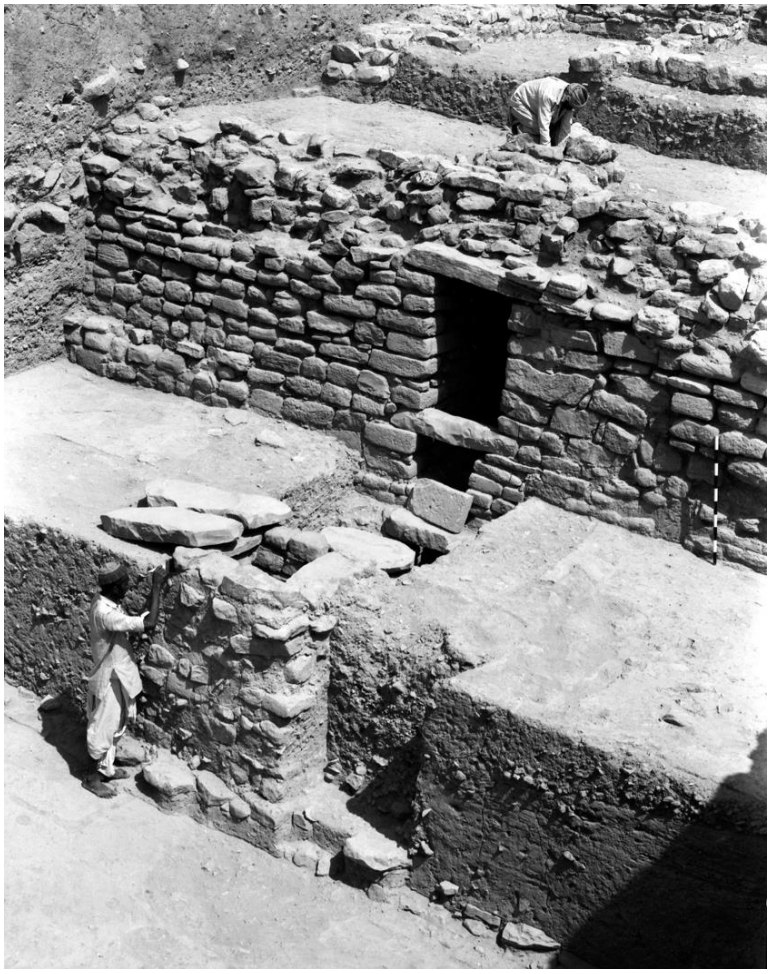

Fig. 3: Details of drain and utility hole in Castle (courtesy: R S Bisht)

Another crucial evidence for providing water resources directly to the residents of the Castle is preserved in the form of two small tanks (named *pushkarini*) and a large well (Fig. 4). The well and the two tanks were created during Stage IV and used during Stages V and VI (Bisht 2017). The excavator also indicates evidence of the benefit of the well during Stage VII. Be that as it may, creating these water resources gave the castle residents direct and private access. The Castle's residents also made utilising water from the east and south reservoirs possible. The internal diameter is 4.25 m in the north-south direction and 4 m along the east-west. The well was excavated up to a depth of nearly 13.6 m; however, the water table might have reached

another 10 m deeper.

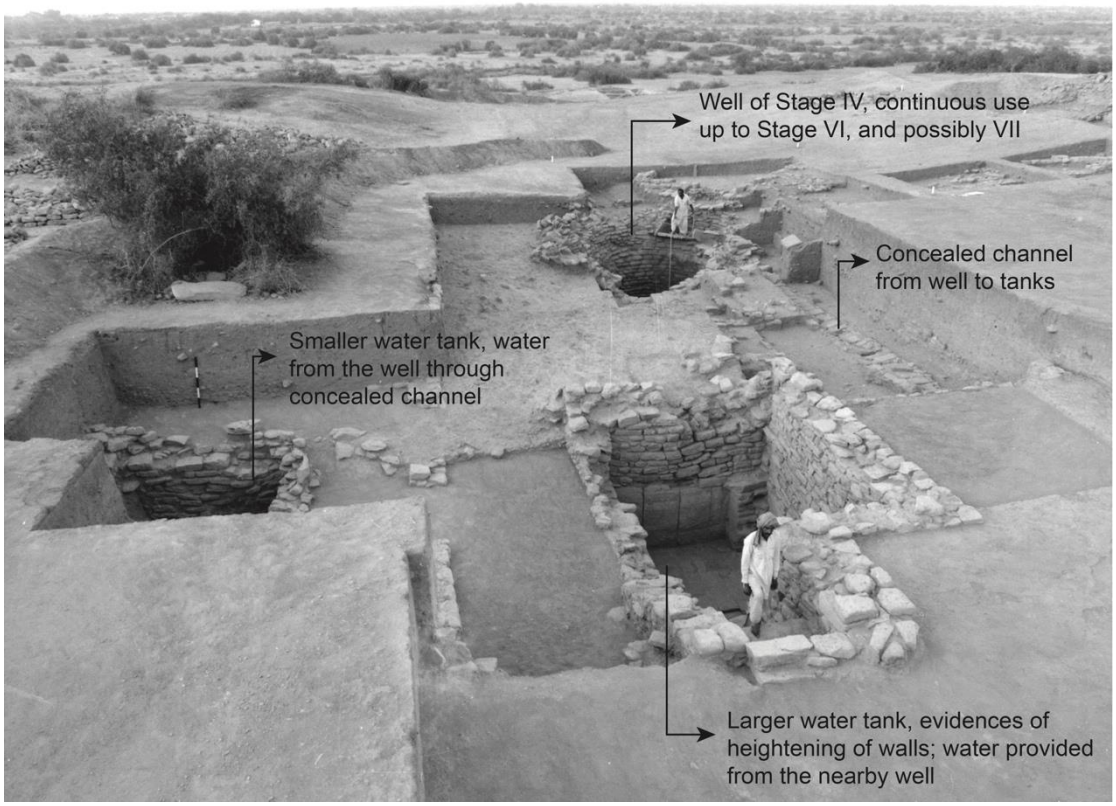

Fig. 4: Large well and two tanks in Castle (after Bisht 2015; modified by the first author for nomination dossier of Dholavira for WH status)

Two tanks fed by the water drawn from the well are located to the north of the well (Fig. 8). The larger of the two lies nine m to the north, and the smaller one 13.20 m to the northeast. A distance of 4.7 m separates them, and both are approached by a flight of steps from the broad central street of the Castle. Water for both tanks was drawn from the deep well, with an arrangement of a trough on its southern side, thereby emanating a drain in a south-north direction. Then, the larger tank was connected first, followed by the smaller one. The larger tank was constructed in two or three phases, and the maximum depth is 3.8 m. Large limestone slabs measuring 1.2-1.3 m in length and 0.6-0.7 m in width are found at the lower level, followed by a random rubble masonry at the upper level. A small *kund* is also noticed at the centre of this tank. It is approached by a flight of steps measuring 2.25 m north-south and 2.50 m east-west. The steps, having a span of 1 m tread of 40 to 50 cm, and riser from 20 to 40 cm, descend from the

broad-way on the north (the 13 m wide broad-way running east-west divides the castle into two unequal halves).

The smaller tank measures 2.2 X 2.3 (NS-EW) with a maximum depth of 4.85 m. In this case, the staircase measures 2.45 m in width and 5.3 m in length. Here, the tread is gentler and measures 0.3 m. The excavator believes that this tank could have been used as a bathing tank due to the position of a cylindrical limestone block placed near the descent of the staircase. These two tanks could have been constructed for the exclusive use of the elites residing inside the Castle. Understanding the water table and effectively digging a deep well that could have been nearly 23 m in depth, lined with stone blocks, is an engineering feat.

A series of water reservoirs on the east and south of the Castle is noticed at Dholavira (Fig. 5), surpassing all known evidence in the Harappan context so far. To fill these reservoirs, the Dholavira Harappans effectively devised several check-dams at different contours of the Mansar and Manhar rivers. In particular, the reservoirs were fed by a dam constructed along the southern arm of the outer fortification of Dholavira, which helped divert the sheet of water towards the east and south reservoirs. The East Reservoir (Fig. 6), the largest freshwater reservoir so far found from any Harappan site, measures 70-73.5 X 27.7-29.3 X 7.2-7.5 (L X B X H). Three flights of steps help in reaching the lowest level. They are provided in the reservoir's northeast, northwest, and southwest corners. The bedrock was carved at those places where a flat surface was not found. Another added attraction is finding a rock-cut stepwell (Fig. 7) at the centre along the eastern wall of the reservoir.

Fig. 5: Location of water bodies and reservoirs, Dholavira

In the southern direction of the Castle, a series of five reservoirs are found in an east-west direction. Collectively, they are known as South Reservoirs (SR-1 to SR-5). Among them, the central one, SR-3, is the most elaborate, embellished, and centrepiece of all five reservoirs. A small inlet leads water to SR-3 from the SR-2, which is a small reservoir meant for desilting purposes. SR-1 is located in the extreme east, closer to the dam across the river Manhar (Fig. 11). This reservoir basically stores the silt-laden water from the river, and the water from the upper level, with less silt, reaches SR-2. Water is allowed to settle here, and the desilted water reaches SR-3.

Fig. 6: East Reservoir

Fig. 7: Rock-cut reservoir inside East Reservoir

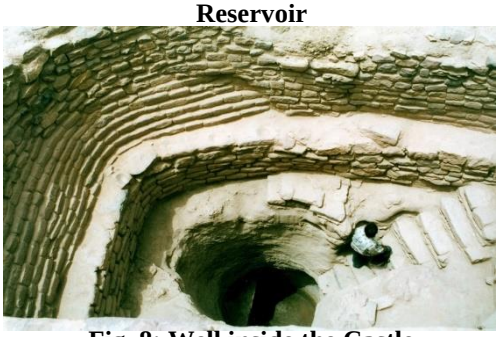

Fig. 8: Well inside the Castle

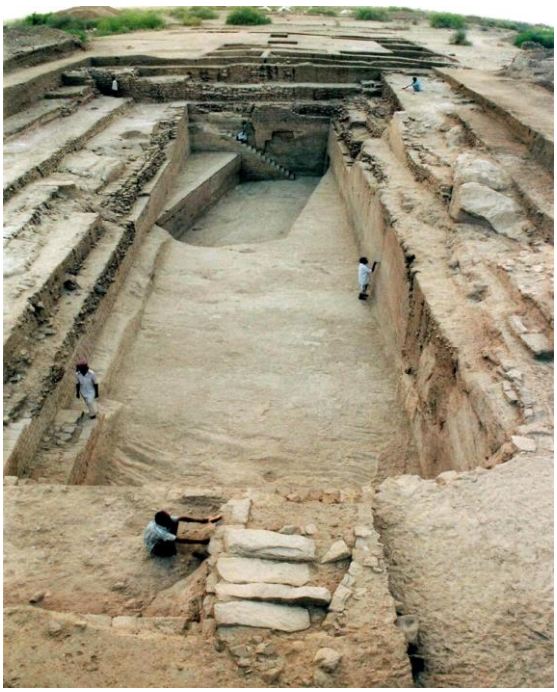

Fig. 9: South Reservoir (SR-3)

Fig. 10: South Reservoir (SR-3)

Fig. 11: South Reservoir (SR-1)

Images courtesy: R.S. Bisht

SR-3 is partly masonry and rock-cut (Fig. 9). The undulations in the bedrock were taken care of by proper chiselling and filled with finely dressed limestone and sandstone from the excavated bedrock itself. The reservoir consists of two levels: the upper one measures 33.4 X 8.9-9.45 X 5.9-6.4 m (L X B X H), while the lower one (Fig. 10) is scooped into the bedrock in

the eastern half of the upper reservoir. The lower reservoir is oriented in a northwest-southeast direction and measures 15.6 X 5.65 X 1.5 m (L X B X H). Flight of steps is also noted in this reservoir, in the northeastern and northwestern corners. The stone blocks used for constructing the steps and filling the voids and undulations are of exceptional quality and finish. Two more reservoirs are located to the west of SR-3, named SR-4 and SR-5. SR-4 is unique, as it has a ramp to lift the water through wheeled vehicles; SR-5 is also partly rock-cut and masonry-built, with a large portion of the bedrock still lying within. The excess water from the reservoir was allowed to drain through a spillway on its western arm, which probably drained into an open-air reservoir on the southwestern part of the city. Excess water from this reservoir was again allowed to fill a large open-air reservoir located to the southwest of the city and outside the fortification. Interestingly, the cemetery remains are located on the northern banks of this lake, including the interesting and unique tumulus burials of Dholavira.

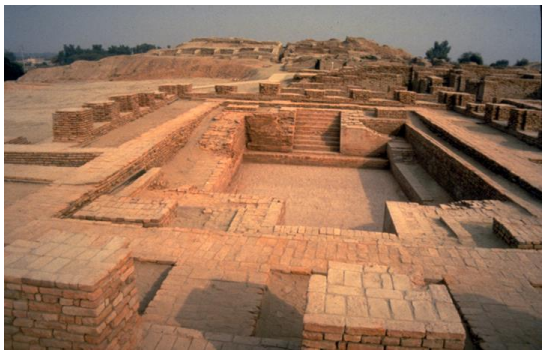

Fig. 12: Great Bath, Mohenjo-daro

Fig. 13: Latrine, Mohenjo-daro

Fig. 14: Bathing platform, Mohenjo-daro

Images courtesy: J.M. Kenoyer

The excellent water management systems of the Harappans are also known from the extensive drains constructed at Dholavira, Mohenjo-daro, Harappa, Lothal, and even at smaller

sites like Bhirrana and Banawali. Wherever stone was available, they used them as the building material, as seen in the case of Dholavira. In case of the non-availability of stone, they used baked bricks for the drains and bathing platforms. The extraordinary construction mechanism ever undertaken by the Harappans at Lothal is the dockyard, which was meant to dock smaller boats in the size range of 10-15 m.

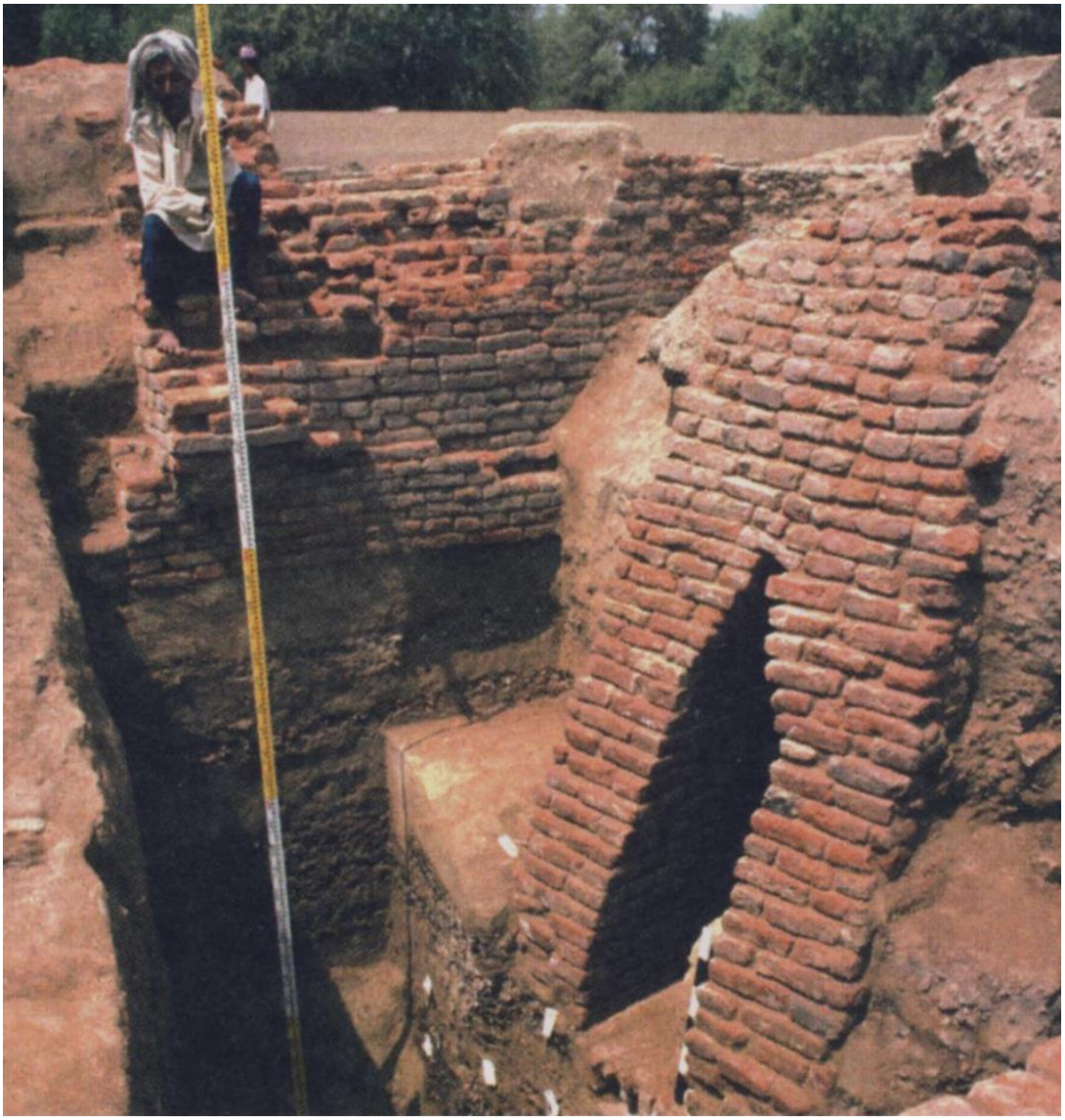

Fig. 15: Corbelled arch of a large drain between the Mounds E and ET, Harappa (courtesy HARP and J.M. Kenoyer

This dockyard was connected to a nearby river, which was also controlled by the rising sea tide from the Gulf of Khambhat. At Mohenjo-daro, evidence of houses having bathing

platforms (Fig. 14) and washrooms (Fig. 13) has been unearthed. In particular, bathing platforms were also found in the first storey, and the water was drained using terracotta pipes. The water from the houses was diverted into medium-sized drains through concealed baked brick drains, which ultimately were fed into the larger drains that carried the water outside the settlement. A large, corbelled arch of such drain was excavated at Harappan below the gateway connecting Mound E and ET (Fig. 15).

Iron Age (Megalithic South India)

During the Iron Age Megalithic South India, it has been recognised that a majority of the burial groups are located adjacent to ancient water bodies, like lakes and reservoirs. Examples in this regard are the large clusters of northern Tamil Nadu, wherein the famous Kunrattur megalithic site is adjacent to the Chembarambakkam reservoir, which now provides drinking water to Chennai. Similar is the case with the Sholinghur Lake, which is close to several types of megaliths. Further, an inscription of Parantaka I (c. 916 CE) of the Chola dynasty is also found on a rocky boulder along the lake. Parantaka Chola mentions the grant he gave to enrich the *Cholavaridhi* tank. A clear continuation of maintenance of the tank. Construction of contour tanks and lakes (locally known as *Aeri* in Tamil and *Cheruvu* in Telugu) based on the surface geomorphology could be traced to at least the Iron Age period (beginning of the first millennium BCE onwards), the tradition of which continued until recent times. The recent urban expansion and rapid construction activities have eliminated most of these water reservoirs, which otherwise were instrumental in tackling the drought situations in Tamil Nadu. Since Tamil Nadu is in the rain shadow region, the ingenious methods of situating several reservoirs based on the topography and observing the slope enabled the ancient inhabitants to tackle the issue of water for drinking and use for agricultural purposes. Thus, it served a dual purpose, and these reservoirs were located so that the overflow of one reservoir was diverted to another at a lower contour, which continued in connecting several such reservoirs until the final overflow reached the sea. Krishnan

and Veeravalli (2006) also demonstrate how the network of irrigation tanks enabled the better management of agricultural practices in South India.

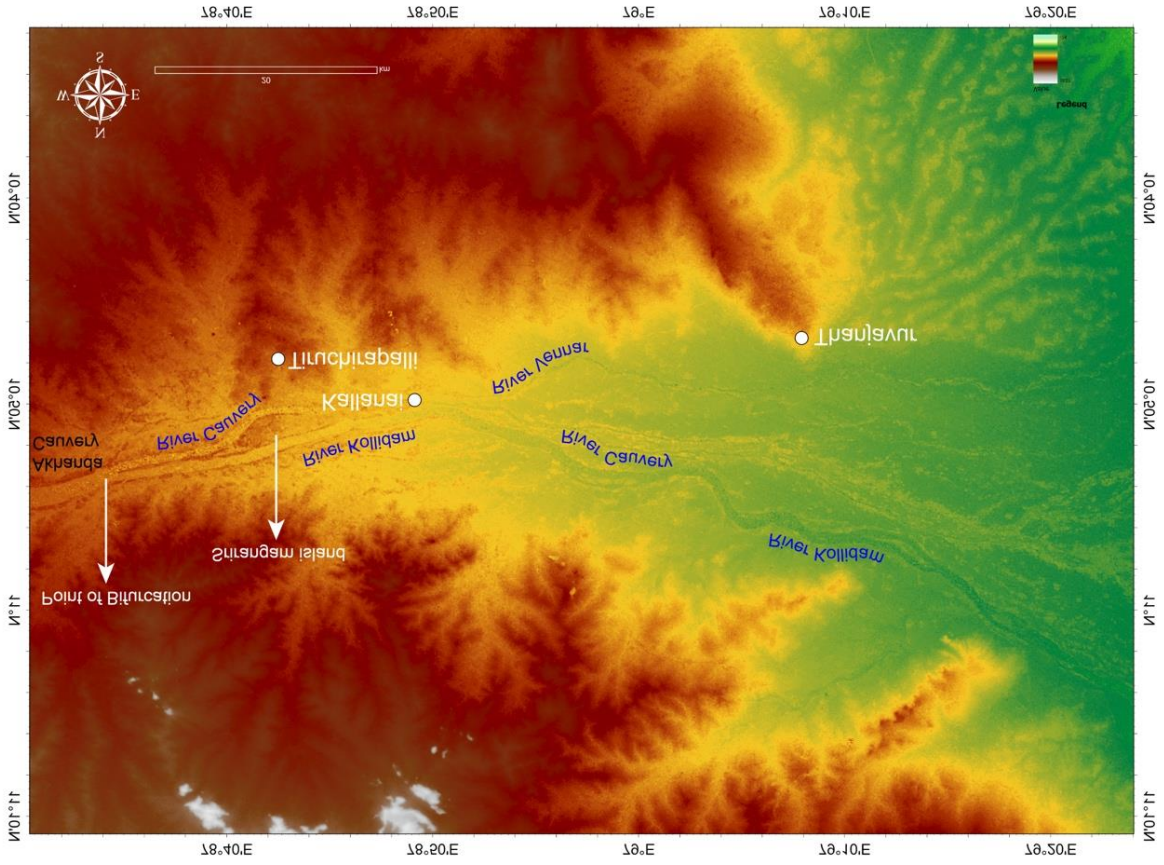

Fig. 16: Location of Kallanai and various streams of river Cauvery

Further, the design of these reservoirs enabled tackling issues of sedimentation and the diversion of excess water to adjacent reservoirs at lower contours, thereby creating a large network. Krishnan and Veeravalli (2006) also demonstrate the effectiveness of the Kallanai Dam (a large earthen dam believed to have been constructed by Karikala Chola in early centuries, to divert the water from the faster and deeper Kollidam River and distribute it to several channels to enable distribution to a much larger area for irrigation (Fig. 16). The system is still functioning, albeit with many modifications and modern constructions.

One of the advantages of maintaining a series of water reservoirs in different contours is to recharge the water table effectively. During drought conditions, wells could be dug on the

dry bed of the reservoirs.

Early Historical Period (~beginnings of the Historical Period)

The vast legacy left over by the Harappans continued in different regions during the early historical period. In particular, the island of Khadir exhibits several examples of the Kshatrapa period, wherein small streams were provided with dams for water storage purposes.

Fig. 17: Ancient dam across a stream of river Jhandiasar, ~3 km north of Dholavira

The remains of an ancient dam (Fig. 17) could be seen near a habitation site known as Saragwala Wasan, located ~3 km to the north of Dholavira. Several ancient dams were also in continuous use, and recently, a few of them were provided with additional layers of walls, completely altering their shape and size. Due to this, the remains of ancient walls are no longer visible due to the sheer size of the modern dams.

Archaeological evidence for the descriptions provided in Kautilya's Arthasastra is often difficult to unravel. It is also difficult to exactly correlate them in the archaeological context. In

particular, several historical sites have been completely obliterated due to urban expansion and irrigation projects.

Fig. 18: Google Earth image of Sisupalgarh, showing the location of water bodies

The city of Patna, located on the ancient remains of what used to be the sprawling city of Pataliputra, the capital of the Mauryan dynasty, is a classic example. Arthasastra prescribes that the city walls should not be built of timber but of stone or baked bricks. However, the excavated remains of palisades and fortification walls of Pataliputra at the Bulandibagh site indicate that they extensively used timber in their architecture. This could also be gleaned from the bas-reliefs carved on the entrance *toranas* of Stupa 1, Sanchi. The description regarding the division of the city into different quarters, the location of the moat, water bodies, etc., tallies with

the archaeological remains of Sisupalgarh, Odisha, to some extent. The excavated remains at Sisupalgarh, along with the Google Earth images, clearly indicate the location of water bodies within the fortified limits and a large reservoir to the north of the city (Fig. 18). These water bodies could have fulfilled the provisions required for the city and those located outside the fortified limits.

Another hallmark effort in creating a vast water network is from Sringaverapura. The place is identified with the famous episode of Rama embarking into the *vanavasa*. The project on the Archaeology of Ramayana and Mahabharata sites was initiated by B.B. Lal in the 1970s, and the excavation at Sringaverapura brought to light this water tank network datable to the Kushana period (~1900 years old). Excavations were carried out at different locations of the site, named SVP 1 to SVP 7, out of which SVP 4 brought to light the water tank complex. The detailed descriptions of the SVP 4 are published by the Archaeological Survey of India (Lal 1993). A series of four tanks were constructed, one of which is circular in shape. The water from the nearby river Ganga entered the first tank meant for desilting purposes. The upper level of relatively cleaner water entered Tank B stepwise, and later, it entered Tank C, circular in shape and with an elaborate arrangement of staircases descending into it. Water from Tank C overflowed into a series of seven-channelled spillways, enabling the excess water to flow into the Ganga.

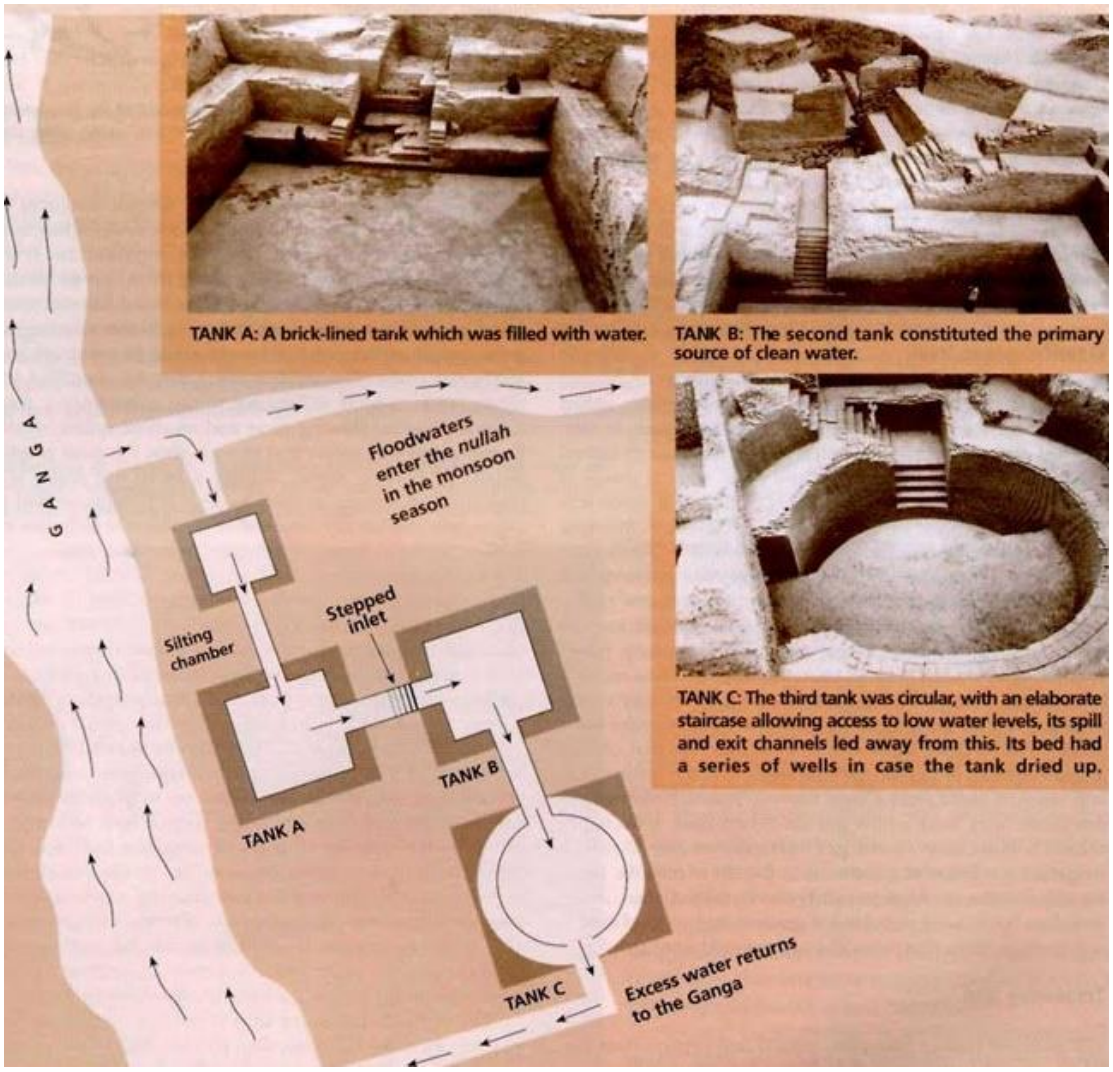

Fig. 19: Arrangement of water tanks and probable functions, Sringaverapura, Uttar Pradesh

Inscriptional evidence for Sudarshana Lake, Junagadh

Archaeological evidence often brings to light long-lost and forgotten historical evidence. A classic example in this regard is the mention of a vast lake known as Sudarshana, first mentioned by the Kshatrapa ruler Rudradaman (~150 CE) in the Girnar rock inscription (Fig 20). The same rock also has the major rock edicts of the Mauryan ruler Asoka and Gupta ruler Skandagupta (456 CE). Rudradaman mentions Lake Sudarshana and explains how it was built and how strong it was due to the construction techniques using stone and clay and the embankments rivalling the spur of the mountain. It was also provided with conduits and drains meant to channel the water for agricultural purposes.

He mentions that that lake was constructed during the period of Chandragupta Maurya by a Vaishya Pushyagupta and later adorned with conduits during the period of Asoka by the Yavana king Tushaspha.

He further mentions that due to torrential rain in 150 CE, rivers like Suvarnasikata, Palasini and other streams of mount Urjayat (Girnar) flooded the Sudarshana and caused a breach of nearly 18.28 m in length and 3.42 m feet in depth, causing the entire lake dry and ugly to look at. During his reign, the dam was repaired by his minister, Suvishakha, son of a Pahlava named Kulaipa. Suvishakha was the governor of Anarta (north Gujarat) and Saurashtra. Thus, a reservoir created nearly 500 years before the reign of Rudraman was still functioning, and the damage caused to the walls was immediately repaired. Again, during the reign of Skandagupta (~456 CE), the lake was again damaged due to the torrential rains, causing floods in the rivers Prausthapada, Palasini, arising from the mountains Raivataka and Urjayat, and bursting the embankments. With great efforts, the breach was constructed with stones for a length of nearly 4.57 m in length, 3.10 m in breadth and 10.85 m in height. The recorded history of nearly 800 years, for the first time in Indian history, of constructing a vast reservoir and later repairing it during different periods speaks volumes about the importance of this reservoir and the efforts made by the ruling dynasties to maintain it.

Fig. 20: Girnar rock on which the inscriptions of Asoka, Rudradaman and Skandagupta are found; the inscription of Rudradaman (~150 CE) is seen

The importance of the River Trinities, the Ganga, Yamuna and Sarasvati

The importance of River Sarasvati is already seen above, in the context of X.75.5 & 6 of Rigveda, described in association with the rivers Ganga and Yamuna. The *Salyaparvan* of the *Mahabharata* describes Balarama's journey while visiting the tirthas on the dried river Sarasvati. Salyaparvan in turn, consists of four sub-parts: *Salyavadha*, *Hradapravesa*, *Tirthayatra* and *Gadayudha*. The journey is said to have started his journey from Prabhasa, near the seaside. At present, Prabhasa is identified with Somnath, and it is difficult to presume that the river Sarasvati drained into the sea at this place. The memory of river, Sarasvati was transmitted to several places, for example, to the river of the same name flowing by Patan and Siddhapur and the S*angam* of Sarasvati with Yamuna and Ganga at Prayaga. Similarly, the once-famous *sangam* of the original river Sarasvati could have been carried to a new place, modern Prabhasa, after it completely dried up. Nevertheless, traditionally, the source of Sarasvati is identified with Plaksha Prasarvana, wherein Balarama proceeded further and performed rituals at the nearby river Yamuna. The *Sarasvataparvan* of Mahabharata is also a good source for identifying the nature of the Sarasvati River and the various pilgrimage centres along its banks.

The desiccation of the river Sarasvati is quite evident towards the end of the Rigveda, amplified further in the later Vedic period and continued well into the Epic period. Traditionally, the river is believed to have disappeared into the desert. However, the *Salyaparvan* indicates that it reappeared again and flowed to the sea. Balarama proceeds upstream after starting his journey at Prabhasa and comes across a place known as Camasodbheda before reaching Udapana. This place is identified in the desert, wherein Sarasvati made her reappearance. Scholars also identify this place with Udasar in Rajasthan (Bhargava 1986). Balarama identified the river's course as being due to vegetation on the moist riverbed. After leaving Udapana, Balarama reached Vinasana, which is identified as the frontier of the traditional *Aryavarta*. This could be the actual location where the river Sarasvati disappeared in the sands of the desert. After Vinasana,

Balarama passed on several other tirthas, such as Sankhatirtha (famous for the presence of an extraordinary tree), Dvaitavana, Prithudaka, Sthanutirtha (modern Thanesar) and Nagadhanvan. There is a mention of a place known as Arunasangama near Prithudaka, identified as the *sangam* of the river Sarasvati and its tributary stream, Aruna. It is also identified with Kapalamochana.

In the Kurukshetra region and during the course of his journey, Balarama reached Naimisakunja, which is identified as the confluence of Sarasvati and Drishadvati (in modern Rajasthan). The *Sarasvataparvan* also identifies this location as swampy. After Naimisakunja, Baralama reached Saptasarasvata, the location of which was considered very sacred due to the seven Sarasvatis present here (Szaler 2017) Prithudaka is identified with modern Pehowa in Haryana (Bhargava 1986), which is held sacred even today for the performance of *sraddha*-rites and a small temple of Sarasvati.

Balarama reaches Agnitirtha after leaving Sthanutirtha, wherein the gods found the disappeared Agni due to the curse of Bhrigu. Then, he passed on to several *tirthas* named Kauberatirtha, Ramatirtha, Yamunatirtha, Sarasvatatirtha, and Vriddhakanyatirtha in the Kurukshetra region. After passing through the Kurukshetra region, Balarama finally reaches the spring Plaksha Prasravana. This episode clearly indicates the continuing tradition of holding the river Sarasvati in high esteem during the Epic period. The different descriptions of the river disappearing and reappearing clearly indicate its physical state. The river was held sacred, at least from the times of the Rigveda. After its disappearance, the memory was transferred in different forms and ways, as mentioned above, including identifying it at Prayaga.

The sacredness of the rivers and deifying them as goddesses is deeply imbibed in ancient literature, which is also linked with the endeavour of humankind to seek salvation from the ever-repeating life cycles and attain *moksha*. The rivers and sacred water bodies, including springs, acted as *tirthas* in this human endeavour. Sarasvati, too, was identified as a sacred river, and

several locations on its banks were identified as *tirthas* wherein rituals could be performed. Later, the shift to the rivers Yamuna and Ganga occurs due to the disappearance of the Sarasvati River. Yamuna and Ganga were also held in high esteem, and they were worshipped too. They were also depicted on the entrance door jambs, at least from the Gupta period onwards, as evidenced by the Udayagiri caves near Vidisha, Madhya Pradesh. The purpose of depicting the river goddesses at the entrance is to signify purification before entering the *garbhagriha*, the sanctum sanctorum of the holiest. Initially, the river goddesses were depicted on either side of the top portion of the door jamb, as in the case of Cave 4, Udayagiri Caves (Fig. 21). Later, in the structural temples of the Gupta period, they are depicted at the lower portion of the door jamb. As a general rule, this feature continued in the temples in different regions. In one instance, in Cave 16 (Kailasa), Ellora, the three river goddesses, is shown in a single shrine (Fig. 22), even though only Ganga and Yamuna are at the entrance. This is again a personification of three rivers, their presence signifying that the worshipper had reached Prayaga, getting himself purified before entering the main shrine.

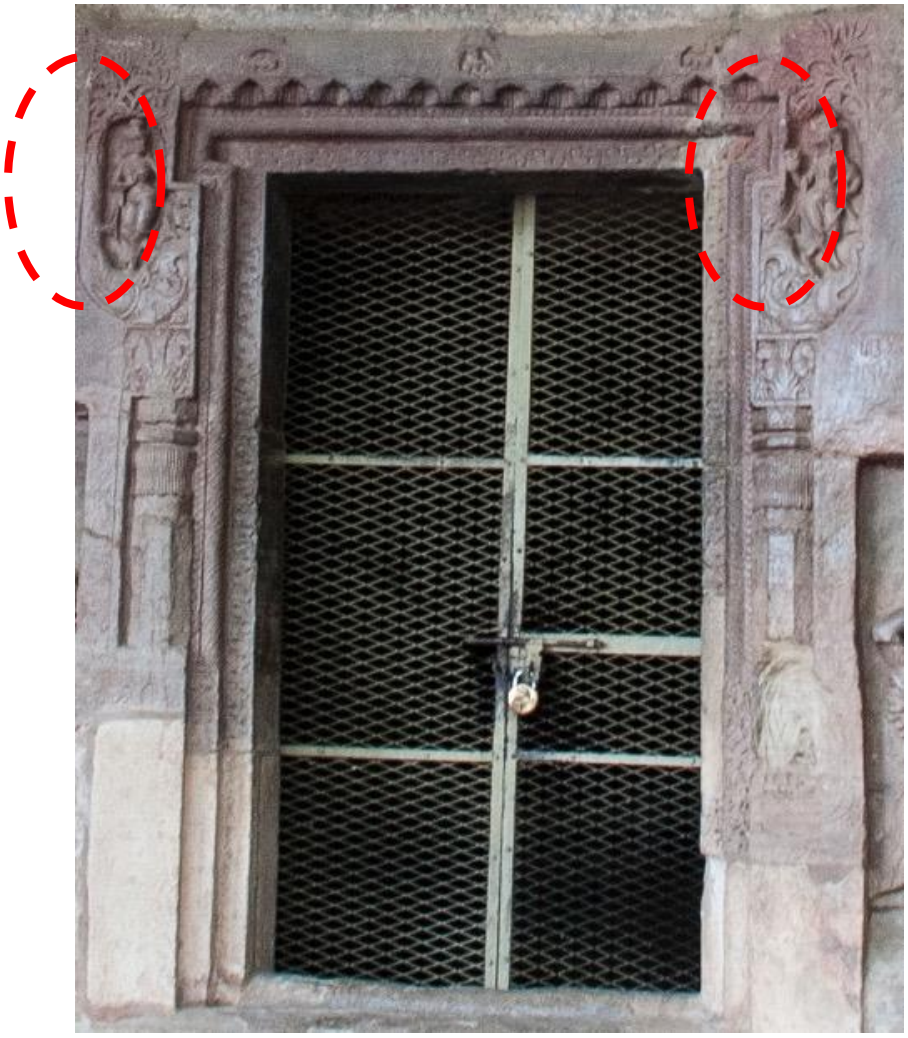

Fig. 21: Depiction of Ganga and Yamuna on either side of the top part of the door jamb, Cave 4, Udayagiri Cave, Madhya Pradesh

Fig. 22: Sarasvati (left), Ganga (centre), Yamuna (right), Cave 16 (Kailasa), Ellora

Fig. 23: Ganga (left) and Yamuna (right), Ahichchhatra, Uttar Pradesh

Terracotta images of Ganga and Yamuna, depicted on makara and kurma, are also found in Ahichchhatra near Aonla (U.P.), a Gupta-period temple (Fig. 23). The personification of river goddesses, depicting them at the entrance, has a dual purpose. The first purpose is explained above to purify the devotees before they enter the temple. The second purpose is to inculcate a habit in the minds of devotees on the importance of their lifeline, i.e. the rivers, respect them, treat them with veneration and not pollute them. This is an important lesson that can be learnt from the traditional knowledge of our ancestors, which is to treat the rivers as sacred and important.

Significance of Water Networks for Ancient Cities and Religious Establishments

The importance of water and its various manifestations in ancient dwellings is well known. The various literary evidence further strengthens its significance. However, archaeological evidence supports and provides clues on the nature of construction methods and

scale. One such evidence is from Halebidu, one of the capitals of the Hoysala dynasty in Karnataka. A series of interconnected waterways were constructed from the river Yagachi to carry fresh water and fill a lake at Halebidu (Rajendran and Aravazhi 2011). The width of the canal is 18 m wide, and it runs for nearly 18 km. This canal also feeds a series of lakes located on the route, thus creating a large network of waterbodies. Further, evidence also indicates the construction of at least four water reservoirs near Halebidu by Virayadanda Nayaka, a minister of Vira Bhallala of the Hoysala dynasty.

Water management with the available resources happened in a major manner with Sanchi as a central location, and several adjoining areas were tapped by constructing small and large reservoirs. The Buddhist monastic establishment at Sanchi could have played a major role in harnessing the water resources. With Sanchi as the central location, several Buddhist establishments are located on the nearby hills at Satdhara, Sonari, Mulelkhurd, and Andher, which were in turn supported by the nearby agricultural tracts, supported by harnessing the water resources (Shaw 2007). The case studies conducted at Sanchi by Shaw (2007) indicate the larger role the Buddhist monastic establishments played. The monastic establishments could have played an integrated role in catering to the need for food resources for the Sanchi monastery and nearby monasteries. Evidence for the construction of large reservoirs could be seen near Sanchi, Nagauri and Karondih and Dargawan. The dam near Sanchi Hill was the largest, with stone walls of 1.35 km connecting the Sanchi and Nagauri hills, which can be traced even now. The stone walls have a height of 2.8 m, and the reservoir area is 3 sq. km., dating at least to the second century BCE.

Several smaller reservoirs are located near the ancient Buddhist monastic establishments at Ferozpur, Gulgaon, Dhakna, and Naroda. The check dams and smaller reservoirs were located very close to the Buddhist establishments in order to manage them properly. Shaw and Sutcliffe (2003) identify them as “early historic complexes” consisting of (a) Buddhist stupa or monastic

complex on a hill, (b) village settlements on the lower slopes, and (c) dams, reservoirs, and artificial lakes close to the settlements and facilitating agricultural activities. With the aid of these reservoirs, the total irrigated area in and around Sanchi is estimated at 23 sq. km. The construction methodology consisted of utilising the nearby available sandstone stone boulders and chiselled rocks, complete with sluice gate mechanisms. They were primarily meant to facilitate irrigation, mostly rice cultivation. The similarity in construction techniques of several of these check dams and reservoirs indicates an organised community activity to aid such resources for the larger benefit of the monastic establishment. The archaeobotanical records also indicate that the water resources could have supported a double cropping system, rice during summer and wheat during winter.

The Buddhist establishment at Sanchi, which was already well-established due to the royal patronage starting from the time of Mauryan king Asoka, soon developed into an independent setup and garnered a larger area. Enough funds were available for the Buddhist establishment due to the aid from royals, traders, merchants, and common people. A centralised community activity for garnering water resources for the betterment of the community was active up to 9^{th} – 10^{th} c. CE.

Another excellent example of harnessing whatever available water resources near the ancient Buddhist establishments is from the rock-cut caves of Western Maharashtra. Right from the earliest Buddhist caves at Pitalkhora, Bhaja, Bedsa, Nasik, Kanheri and Karle to the later period ones at Ellora and Ajanta, water cisterns and reservoirs (Fig. 24) could be seen carved out from the bedrock near the individual caves for various water necessities. Water was diverted into these cisterns and water resources by chiselling grooves on the wall surfaces. These are filled during the monsoon season and continue to hold water during the following periods. One such excellent water source is located near Cave 1, Elephanta Caves, which even provides water to the nearby village.

Fig. 24: Nature of water cisterns in caves of Western Maharashtra

Apart from individual cisterns and water tanks, evidence for constructing check dams across the smaller streams is also found from Pitalkhora and Kanheri. At Pitalkhora, the construction consisted of carving larger holes in the bedrock across the stream to place larger wooden logs. A series of smaller holes supported these dug on either side for placing wooden logs of lesser diameter, and the space in between was filled with earth and rocks. Thus, a small dam was constructed across the stream at Pitalkhora, which also enabled the water supply to last throughout the year. Another piece of evidence is from Kanheri Caves (ancient Krishnagiri),

where a dam was constructed using stone blocks and bricks across a small stream (Fig. 25).

Fig. 25: Nature of a dam across a stream, Kanheri Caves near Mumbai

Evidence during Medieval India

The ancient traditions of creating water reservoirs continued into the medieval period. As seen above, the rulers repaired and strengthened several such reservoirs. We also see several new endeavours to create water bodies in the form of rectangular and square tanks. These tanks were created to hold water for multiple purposes and recharge the water tables. Mechanisms were created to locate these water tanks at such places to collect and store the rainwater and recharge the groundwater so that wells could be dug nearby to reach them. Such an arrangement is known as *khadin* in Jodhpur, wherein during the 15th century CE, several such check dams were constructed near the foothills for recharging as well as for digging wells. Another classic endeavour to create functional and religious water bodies could be seen in the state of Gujarat. It is famous for its several step wells (~*vavs* or *baolis*). The history of digging a stepwell dates back to the Harappan times, as seen above at Dholavira. Based on the construction style, they can be

divided into the North and West Indian styles. The North Indian style is simpler, with a rectangular arrangement, well at the rear and approached by the simple flight of steps with landings at regular intervals. There are provisions for arches and corridors along the flight of steps for relaxing.

The West Indian ones are known as *vav* and are excellent examples of architectural and artistic accomplishment. The West Indian varieties consist of two parts: vertical circular or octagonal shafts at the rear and an elaborate stepped approach way with landings, galleries, pavilions and kiosks at regular intervals. The galleries and pavilions provided soothing, relieving areas during the summer season. The Mata Bhavani *vav* in Ahmedabad dates back to the eleventh century CE and is one of the earliest. Several step-wells can be noticed in several places, including the famous Adalaj and Queen's step wells at Ahmedabad and Patan.

This endeavour reached enormous proportions during the medieval era, culminating at Rani-ki-Vav (The Queen's Stepwell). It is a masterpiece with seven levels. It was constructed by Queen Udayamati in memory of her husband, Chalukya King Bhima I (d. 1064 CE), during the 11th century CE. The step well was completed by his successor, Karna. The step well was completely silted and covered with debris, which the Archaeological Survey of India cleared during the 1960-1980s. The full proportion of the step well could be understood only after complete desilting during the 1980s. The step well is located close to another masterpiece water management system, Sahasralinga Talav, on the banks of river Sarasvati. Originally, it might have contained one thousand lingas, consecrated in a *talav* or on its bank, which are missing now, except a series of interconnected waterways, desilting chambers, sluices and a few shrines.

Fig. 26: Circular desilting tank, Sahasralinga talav, Pathan

The water from the Sarasvati River entered a circular stepped water tank with projections on the steps, which was probably meant to slow down the swirling water from the river (Fig. 26). After passing through this circular tank, the water probably swirled for a while, during which the momentum was reduced, and then entered a long water channel again with steps and projects on them to reduce the velocity of the water. The water from this long channel exited through three sluices, on top of which there are three shrines for Ganga, Yamuna and Sarasvati (Fig. 27). The flow of water from these sluices could be controlled, as indicated by carvings on its interior, probably to hold wooden gates. After exiting from these sluices, the water again flowed through a series of water channels lined with stone steps, and ultimately, it reached a shrine. The exact configuration of the reservoir is yet to be understood, and as per the present evidence, it seems incomplete. Nevertheless, it is an elaborate water management system meant to divert water flow from the river Sarsavati and store it in a large reservoir. It was also designed to be a tirtha due to the shrines for river goddesses and Siva.

Fig. 27: Water channel with three spouts, topped by the shrines of Ganga, Yamuna and Sarasvati, Sahasralinga Talav, Pathan

The Rani-ki-Vav is hardly 300 m southeast of this *talav*. Due to the nearby Sarasvati River flooding, it was silted, and during the visits of James Burgess and Henry Cousens in the 1980s, it was visible as a huge pit with broken pillars. James Burgess publishes one part of the entrance torana of the stepwell. Only the basal portion of one-half is visible at the site at present. It measures 65 X 20 X 28 m (L X B X D). It is oriented east-west, with the well at the western corner. The well shaft is circular in shape with a depth of 30 m and a diameter of 10 m (Fig. 28). There are descending steps which lead to pavilions at different levels. The intervening spaces between the pavilions have profusely decorated wall portions with niches resembling individual shrines. Numerous themes were followed in the depiction of the sculptures. Some of the famous themes are the Dasavatara forms of Vishnu, 24 forms of Vishnu, various deities and their forms like Umamahesvara, Mahisasuramardini, Brahma, Lakulisa, Kubra, Ganesha, Surya, Indra, Lakshmi, Parvati, Chamuni, and Sarasvati.

Fig. 28: Well shaft of Rani-ki-Vav, Pathan

Evidence for 120 apsaras at different levels and on either side of the niches is found. Most of them are intact, while a few were not found in the original location. These apsaras depict different poses and forms, indicating the contemporary lifestyle. A few of the famous ones are apsara looking into a mirror, warding off a monkey, applying some paint on her lips, chewing a twig, etc. Many sculptures depict women in their daily lives, like combing hair, writing letters, holding the beard of a dwarf, etc. Several geometrical patterns are also depicted on the wall

portions. Interestingly, these patterns have found their way into the local textile tradition of Paithani.

The entire stepwell had been designed as a functional well and a recharging pit, and it represented a Vaishnava shrine, wherein the entire gamut of *parivara devatas* are depicted. At each level, a sculpture of Seshasayi Vishnu (Vishnu reclining on the Seshasayi) is depicted in the well shaft.

Fig. 29: Kunda at Sun Temple, Modhera

Medieval India is replete with several examples of stepwells and tanks, often associated with shrines and temples. Very good examples of functional stepwells are Dada Harir Vav, Ahmedabad and Rudabai stepwell at Adalaj. Often, temple tanks are decorated and adorned with ornamental steps and multiple shrines. The best examples of this type are the Ornamented stepped tank at Sun Temple, Modhera (Fig. 29) and Manasarovar Lake (Munsar) at Viramgaon. The latter is an excellent example of water management, as it diverts water from the nearby stream and fills a huge tank with a perimeter of 210 m, flanked by nearly 360 miniature shrines.

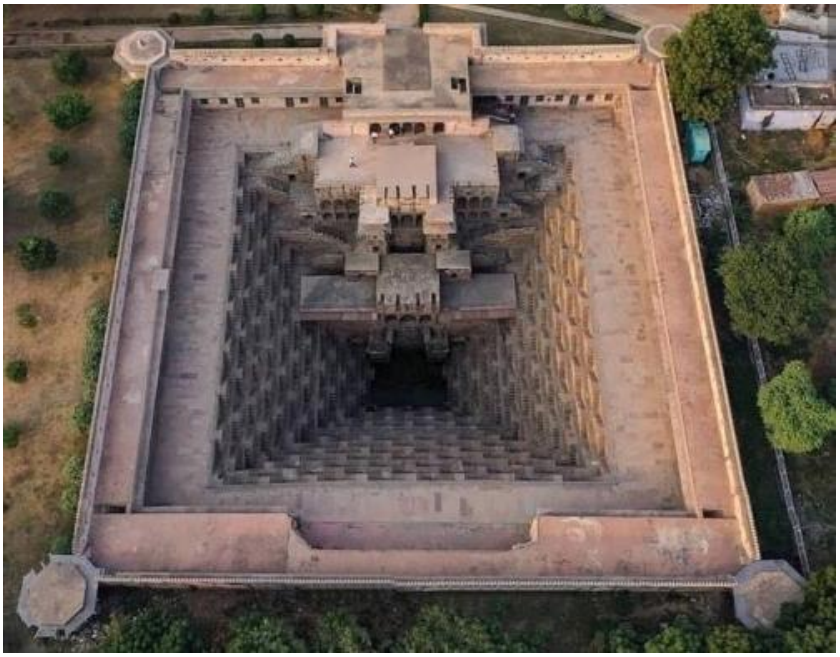

Fig. 30: Chand Baori, Abhaneri, Rajasthan

On the east are two regional-style temples built during the Solanki period and datable to c. 1090 CE. Munsar Lake of Viramgaon could have provided the town with much-needed water and recharged the groundwater table. Chand Baori (c. 9th c. CE) from Rajasthan is a famous square-shaped well built on thirteen levels and consisting of 3,500 double-flight steps (Fig. 30). The double flight of steps allowed to reach greater depths without the normal approachable landings. In order to reach deep wells or tanks, in normal construction, one requires abnormally long landings so that the climb is easier. The double flight of steps removes these requirements, and steps emanate perpendicular to the normal steps, and one can reach the lower levels without lengthier landings. This was achieved in quite a number of tanks and reservoirs in India, for example, at the Rani-ki-Vav, Sun Temple at Modhera, Chand Baori in Rajasthan, and Pushkarini at Hampi (Fig. 31), to name a few.

Fig. 31: Pushkarini, Palace Complex, Hampi, Karnataka

In this regard, the presence of numerous temples in South India, particularly Karnataka, Andhra Pradesh, Tamil Nadu and Kerala, with stepped tanks served a dual purpose. They not only served as the tirtha, as there was no river nearby, to serve the purpose of devotees bathing and purifying themselves before entering the temple but also recharged the groundwater table. In particular, Tamil Nadu is located in the rain shadow region, and thus receives erratic rainfall. As explained above, such arrangements as contour reservoirs and temple tanks provided the much-needed groundwater recharging source. Aqueducts are another important component which enabled continuous water supply to settlements in ancient times. One such example at Halebidu is explained above. Similar aqueducts are also noticed at Hampi, the capital of the Vijayanagar dynasty. These aqueducts not only supplied water to the city from distant sources but were also constructed to distribute water to different parts of the palace area (Fig. 32). One such example is the Bukka aqueduct (Fig. 33), located on the Huligi-Gangavati road on the northern bank of the Tungabhadra River, 3 km southeast of Sanapur Lake. It is believed to have been built around 1345 CE and is probably one of the largest aqueducts in Hampi.

Fig. 32: Aqueducts at Hampi, Karnataka

Fig. 33: Bukka aqueduct, Hampi, Karnataka

Naher system of Medieval Deccan

Another famous and prominent water management system is noticed in the Deccan region, particularly in Burhanpur (Madhya Pradesh), Daulatabad, and Aurangabad in Maharashtra. This system collects and stores water at the foothills in a huge well due to the gravity and seepage into the subsoil. From this huge well emanates a canal (*naher*) with air shafts

at regular intervals to the nearby town or city, in which the water flows due to gravity. No other pumping or siphon system was created for the movement of water.

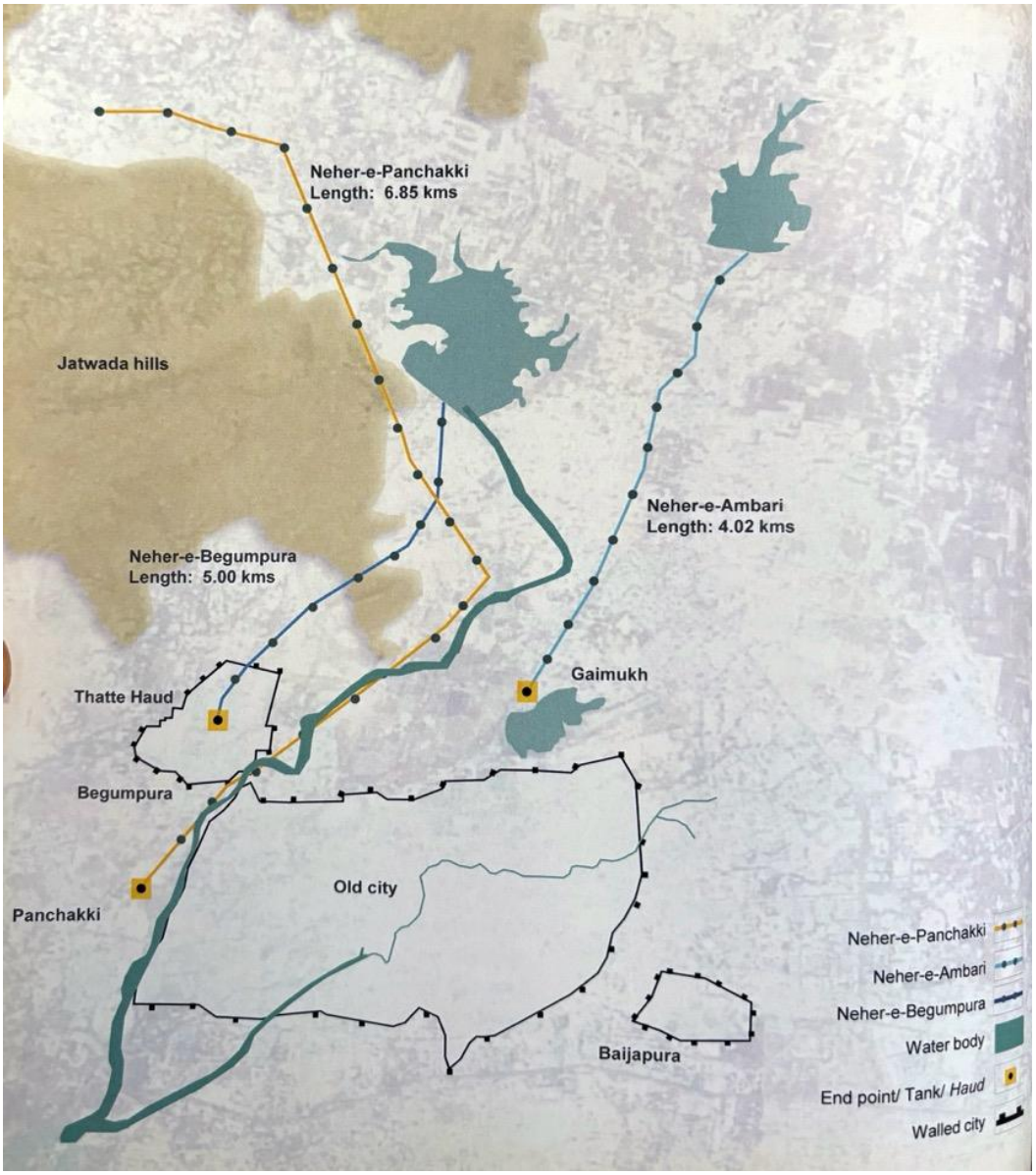

Fig. 34: Naher system of Shambhaji Nagar (Aurangabad) (Courtesy: Mona Iyer, CEPT)

Manholes or air shafts were placed at regular intervals to allow the free movement of water. Further, following the gravity, at several places, the pipeline is visible just on the surface, while at several other, deep trenches had to be dug at places even 10 m in depth. Sambhaji Nagar (Aurangabad) in Maharashtra had at least fourteen such natures during the medieval period; only two are still functional (Fig. 34).

Fig. 35: Manholes of the *naher* system of Shambhaji Nagar (Aurangabad)

Among these two, one is locally known as Thatte Naher (Naher-i-Begumpura), after the family name Thatte, who was instrumental in maintaining it. The *naher* system is credited to have been created by Malik Ambar (c. 1549-1626 CE). He dug the first naher in 1618 CE for Aurangabad city. The system of *nahers* used to be referred as Naher-i-Ambari. The other famous *nahers* are Naher-i-Panchakki, Naher-i-Chavni, Naher-i-Khokhadpura, Naher-i-Shahnoor Hamvi, Naher-i-Begumpura.

Fig. 36: Surface as well as sub-terranean canals for the pipeline

Khadin System of Rajasthan

In Rajasthan, another system, known as *khadin* water collection during the rainy season, could be noticed at places like Jodhpur and Chittorgarh. In this system, the natural contour was utilised to channel the flow of water into a lake or reservoir. At several places, it has been observed that the water percolates into the sub-soil, enriching the water table. Wells were dug nearby for a regular supply of water. At Chittorgarh, atop the hill, and within the fortification, several contour levels were utilised to create a large number of water reservoirs, a few of which are still functional even today (Fig. 37). Water lifting is another important engineering marvel of the medieval forts and palaces, perfected and improved upon an already existing system. This is known as the *rehant* or Persian Wheel system for water lifting. This allowed water transportation at lower levels, wherein the water source lies at the top of hills near the palaces. A good example is the palace complex at Fatehpur Sikri, wherein water was lifted in five levels until it reached the reservoirs and water tanks on top of the hill. The water lifting mechanism was also successfully used at isolated and independent tanks, as observed in the Toorji ka Jhalra stepwell in Jodhpur. This tank was mostly used by women.

Fig. 37: Water management on top of Chittorgarh hill by utilising the slopes and storing water in the form of reservoirs

Canals and Irrigation Networks of India

We have seen the importance of irrigation networks in ancient India; excellent examples from Sudarshana Lake and the reservoirs of south India have been looked into. It had always been a practice to create such a large-scale water management system, as seen at the Kallanai dam across Cauvery in Tamil Nadu. During the medieval period, examples of the maintenance of canals are known from the period of Muhammad-bin Tughluq (c. 1290-1351 CE), and he even created a ministry named Diwan-i-Amir-i-Kuhi. Instances of clearing abandoned water channels to divert water are also known from the period of Firuz Shah Tughlaq (c. 1351-1388 CE). Shah Jahan (c. 1628-1658 CE) realigned a canal now known as West Yamuna Canal for irrigation purposes. The contractor who constructed the canals even got 10% of the produce as an incentive.

Conclusion

Based on the above, it can be surmised that water management in ancient India was time immemorial, and evidence from different regions of India clearly indicates the creation of different water management systems. From the simple and indigenous water diversionary systems of Balochistan to the sophisticated damming systems of Kallanai, Indians were experts in creating. The creation of water structures was clearly meant to conserve water, which was

available during the monsoon season, so that it could be utilised effectively during the lean period. Often, such water structures were meant to recharge the groundwater resources. The hallmark water transportation system noticed at Halebidu, Vijayanagar, and Sambhaji Nagar (Aurangabad) speaks volumes about the large-scale ventures undertaken in ancient India. The canal management system during the medieval period also speaks volumes about achieving maximum agricultural productivity based on irrigation networks. The ancient systems are before us; it is our responsibility to learn from the past and devise better strategies to meet future challenges, that too, in the event of climatic fluctuations and aridity posing serious threats.

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