# Water for Life: Architecture and Hydraulic Engineering in Medieval Rajasthan

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In a region so reliant on the summer monsoon that there are few permanent supplies of water apart from the great rivers and their surrounding topography where the water tables are high, human civilization relies on artificial techniques of saving water from one rainy season to the next. As Rajasthan is located in an arid and desert region, water procurement and conservation were of utmost importance. Water was made available not only to the towns in general but also to the fort-palace complexes themselves, using a variety of means. As a result, hydraulic structures constitute an important part of Rajputana architecture. A comprehensive examination of the development of waterworks and technological advancements in Rajasthan's traditional irrigation system during the medieval period is needed. The paper is an attempt to study the hydraulic architecture and engineering introduced by the rulers, which involve indigenous technology through which the people of Rajasthan stored and used water for agricultural and residential uses. It investigates the pre-modern technology used to gather, store, and circulate water.

Water might be obtained in the most basic form by digging regular wells, referred to as *chāh*or well.[1] Wells are traditionally made out of circular and occasionally square shafts line with stone. Due to the low water table, a simple well may not be able to provide the required function. In the Jaisalmer, Pokhran, and Jodhpur regions, for example, one can find extraordinarily deep masonry-line wells known as *kosita* or wells that were supposedly one *kos* deep. The Persian wheel, a device that utilised pin-drum gearing and harnessed animal power to work, was the only way to lift water from them. The metayers of the region, the Palīwals of Jaisalmer, Pokhran, and Jodhpur, established a unique technique of water conservation and collection. This approach involved channelling water into a natural depression near a seasonal river or drain and retaining it by erecting a *bund* and damming it. Such artificial depression built by human labour and surrounded on three sides by earthen embankments was called a *khadeen*. When it's full, it will provide irrigation water as well as aid in replacing the subsurface water level, which is now decreasing. The wet, water-rich soil would be used to cultivate cash crops as the water dried up. In the Jaisalmer region, such *khadeen*s can still be found at Kuldhara and Khaba. The *khadeen* at Kuldhara is approximately 2.5 sq km in area.[2]

Water conservation was also met in the pre-modern time by creating various types of waterworks such as *haūz*or *kūnd* (tank), *talāb* (pond), *naḥr* (canal)[3] and *samaṇd*or *sār* (artificial lake) to provide water to the city. Persian wheels were installed on some of them. However, in times of water scarcity and declining water tables, we see the employment of *bā'orī* (or *bāvadī*) which were step wells built on an 'inverted' building plan, with multiple stories going down into the ground instead of rising above.[4] With the help of these inverted structures, water deep inside could be reached with a flight of steps, and lifted in stapes. The step-wells known as *bā'īn, bā'orī, bā'vadī*, or *bā'olī*are indigenous Indian structures found throughout western and northern India, with the highest frequency in Gujaratand Rajasthan[5]. Likewise, the step-wells built in Delhi and other cities and towns under the rule of the Delhi Sultans (especially under Tughluqs and Lodīs)[6] and the Mughals followed the same tradition. It was constructed using an 'inverted' building plan, with several stories going down into the ground rather than rising above. The *bā'olī* is built in layers, with stairs leading down from one level to the next, allowing the lower tiers to emerge as the water table dropped during dry seasons.

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Even in the heat, this stepped layout allowed users to see the water level. The tiered galleries are frequently used as resting areas and are generally adorned with exquisite sculpture reliefs. The *bā'olī*were mainly built by royalty and rich inhabitants of the area as charity gestures or as a memorial to the seniors.

The shape and structure of the steps, the vertical wall from which water is extracted, and the tiered galleries may vary between *bā'olī*s. Some *bā'olī*sare large and ornate, with stylized pillars, animal and god figurines, and other decorations. As is the case with the *bā'olī*sat Neemrānā, Maūji and Bhandarej, the stairs are usually straight and descend from the ground level to the water source. Others were provided with steps on three sides of the wall. The side excluded is from where water is drawn up directly from ground level. The steps begin at the ground level with a small landing provided for on both sides, like the two sides of an inverted letter 'V'. Four or five steps followed a small landing followed by another set of steps. This step structure is maintained until the well is reached, with repeated landings. The *bā'olī*sat Abanerīare an example of such structures. Another variation of the *bā'olī*structure includes 'L'-shaped steps that start from the sidewall and end at the wide platform facing the water point, rather than starting from the side facing the draw wall. In some cases, the steps begin on opposite sides and come together at a common point, from which they descend to the well, forming a 'T'. The *bā'olī*smay be distinguished by variations in the vertical draw-wall of the well. Water can be drawn from a platform using a pulley and a wheel in some instances. In smaller *bā'olī*s, the rope and containers were simply dropped into the water and then pulled up. In some other cases, such as Panna Mīan*bā'olī* in Amber and that in Govīndgarh, galleries for resting are also present.

During the medieval period, all of Rajasthan's significant fort-palace complexes and imperial cities were well-equipped with water resources such as *kūnd*s, *tankās*, step-wells and aqueducts, etc, which were all located within the enclosed area.[7] The Panna Mīan*bā'olī* at Amber has a *kūnd* from which water may be accessed from three sides by steps forming an inverted 'V'. Seating and facilities for performing fire rites were available on the upper platform. A resting area, accessible from both sides, is located beneath the platform, overlooking the water. Near to this *bā'olī*is the Maujiki*bā'olī*. We also have two big, architecturally stunning *bā'olī*s close to the city of Amber. The earliest of them is at a village named Abaneri near Bandikui, locally known as Chānd*bā'olī*, and is located in the Harsha Mātā temple complex. It dates from the 11th century. The Badī*bā'olī* lies about 11 kilometres from Dausā, in the village of Bhandarej. To access the water hole, the five-story Badī*bā'olī* had almost 150 broad stairs, each 20 metres wide; five floors with rest platform found on both sides.In Gwalior fort, the ĀssiKhambāis a huge circular step-well in the south-western corner of the Mān Mandir. It is encircled by a pillared arcade and protected by an enclosure wall with arched entrances. Gūjrī, Anār and the Sharad *bā'olī*are among the others. The fort of Kumbhalgarh [Mewār] also had several step-wells constructed in different catchment areas of the fort. These are often built by cutting into the rock and landing on the sidewalls. The Persian wheels were used to raise the water. The most important of these is Laṇgan*bā'olī*. It is enclosed with a fortification wall. It has three successive terraces with its conical end of the west and stepped landing on the east. Rānā *bāorī* and Bādshahī*bāorī*are the other *bāorī*s.

A significant number of lakes are also dug to store water during the rainy season and serve as water reserves for the surrounding villages. These water bodies were provided with marble steps and embankments. Pavilions, temples, and castles were frequently constructed to turn them into religious pilgrimage sites and pleasure resorts for the aristocracy. By erecting embankments or constructing dams, these excavated artificial lakes, as well as the surrounding rivulets, were filled with rainfall. Padmīnī's palace in Chittor, the Jal Mahal outside of Jaipur, and the Jag Mandīr at Kishor Sāgar near Kota are all well-known examples. Deeg has a formal garden with royal structures erected in between two huge tanks, and Amber's Mohan Barī is encircled by water in front of the fortress palace.

Pichola Lake, located 4.5 kilometres east of Udaipur, is one of the earliest *Samaṇd*or manmade lakes in the Mewār region. It was built by a Banjārā in the year 1362 A.D., under the reign of RānāLakha (1382-1421). It is 4 kilometres long and 3 kilometres broad, with a depth ranging from 4.32 metres to 8.5 metres. This was provisioned with water by constructing a dam nearby which in 1560, RānāUdai Singh II (1536-72) raised to a height of 15.24 metres. After the final sack of Chittor in 1568, RānāUdai Singh founded the city of Udaipur on the eastern bank of this lake by constructing a stone masonry dam in the Badī Pol area on the shore of the lake.[8]Aside from the City Palace Complex, the aforementioned lake has two island palaces, Jag Mandīr and Jag Niwās.

Rājasamudra, also known as Rāj Samaṇd, is a manmade lake located north of Kankroli and about 64 kilometres northeast of Udaipur. The lake was built by Rānā Rāj Singh (1652-1680),[9] and measures 6.64 km by 2.9 km with a maximum depth of 16.5 m. It has a dam built at its southwestern extremity. It is primarily nourished by the Gomtī's water, although it also receives a significant amount of rainfall from the neighbouring hills.[10] Luckily, we have a significant contemporary Sanskrit text entitled *Rājaprasāsti Mahakavaym* of Ranchhoda Bhatt, a court

poet of Rānā Rāj Singh who was endowed with the task of composinga history of Mewar.[11] The completion of work at Rāj Samaṇd is commemorated in his work.[12] The foundation for the dam was laid in January 1662 A.D., at the spot where the River Gomtī flowed from north to south through a small valley flanked by two mounds.[13] The project cost ninety-six lakhs rupees to complete. According to *Rājaprasastī,* the construction of this lake began to alleviate the suffering of a starving populace during the famine of 1662 A.D. Excavation of the lake, construction of the dam and the *ghāt* took a total of fourteen years. According to *Rājaprasastī*, the Rājasamudrawas inaugurated on Thursday of the month of *māgha,* in the *vikramasamvat*1732, which corresponds to Thursday, January 20, A.D 1676.[14] The dam forms an irregular section of a circuit, surrounding the waters except between the north-west and northeast points, and covers an area of about three knots. The northern portion of its embankment is called *Nav Chowkī*. Flights of nine steps at each level descend to the edge. There are three *chhatrī*s or pavilions, are beautifully carved, featuring gods and goddesses, animal images, floral and geometrical designs, and more. The gateways or *tōraṇa*s, which were once five but are now just three, are likewise ornately carved and adorned. White marble is used throughout the pavilions *tōraṇas*. The temple of Kankroli, one of Krishna's seven forms (*sarūp*), is located on the embankment. The entire structure is ornamented with beautiful sculptures and a genealogical sketch of the founder's family is inscribed in conspicuous characters. The famous *Rājaprasastī* in Sanskrit, with twenty-four panels[15] and a detailed history of Mewār in general and Rānā Rāj Singh in particular, can be seen in niches all over the *Ghāts*. This inscription is regarded to be one of Rajasthan's longest Sanskrit inscriptions. During the reign of his successor, Rānā Jaī Singh (1680-98), the engraving was completed. The *Rājaprasastī* also marks down several measurements of the dam. According to it, the foundation is 471 metres long from east to west and 535 metres long at the summit. The foundation below the earth's surface is 50 metres wide, while the top is 9 metres wide. The foundation has a depth of 20 metres and a height of 32 metres from the surface to the top.[16] Rāj Samudra's sculptural motifs include Krishna Līla, *mīthūna* figures, āvarana devatas, animal figures, *apsarā*s, and musicians and so on. These themes are also carved on the frieze and ceiling slabs of the *chhatrī*s.

The Jaī Samaṇd Lake built by Rānā Jaī Singh (1680-98) in 1685, is situated at a distance of 45 kilometres, Udaipur. It is the world's second-largest artificial lake, with a surface area of 36 square kilometres, a breadth of 14.48 kilometres, a depth of 31.91 metres, and a diameter of 48 kilometres. The lake has a marble staircase that leads into the water. A palace with a courtyard stands at the lake's northern end, while a pavilion with twelve columns stands at its southern end. There are six magnificent *chhatrī*s erected at intervals along the embankment, as well as a shrine dedicated to Narmadēshwar Mahadeo. A finely carved elephant on a pedestal with its trunk turned upwards stands in front of each of these *chhatrī*s. RoothīRāni Mahal and Hawā Mahal are two palaces in the southwest corner of the embankment.Similarly, the Bālsamaṇd Lake at Jodhpur [Marwār] was made by building a dam across a natural depression. It has a huge catchment area, and the dam has a pleasure palace and was previously home to enormous plantations.

When Akbar (1556-1605) conquered Chittor in 1568, Rānā Udai Singh II (1536-72) abandoned Chittor. He withdraws to the Giro Valley in the Aravalli. He created Udai Sāgar, a lake near the valley's entrance, some years before the catastrophe. Between the mountains, he built a dike, which blocked up another mountain stream.[17] In the subsequent period, Rānā Fatēh Singh (1884-1903) erected the Fatēh Sāgar [Udaipur] to the north of the Pichola Lake, which is surrounded on three sides by hills. This lake was originally built in 1678 by Rānā Jaī Singh (1680-98), however owing to heavy rains during Bhīm Singh's (1778-1828), the previous dam collapsed. The current embankment, which is 2.5 kilometres long and 1.6 kilometres broad, was erected by Rānā Fatēh Singh. The lake is connected to the Ahār River via a 6.4-kilometre canal. All feasible attempts were to take to collect rainwater in the fort of Kumbhalgarh as well, by creating dams, *bā'orī*s, and wells at various locations according to their necessities. At various sites, there are around 10 dams and more than twenty *bā'orī*s. The dams are constructed out of enormous stone masonry walls that run between two hills' small passageways. *Badvabūnd* is the largest and highest dam in the area. It is constructed on the low side of Rām Pōl, encompassing the fortress's maximum catchment area. The top of the wall is around 128 metres long, while the bottom is approximately 103 metres. The base is roughly 68 metres wide, whereas the top is only 15 metres wide. This is accomplished by giving the outside face a moderate slope. In all there are three massive walls one after another, flowing in the east-westward direction to provide more strength to the construction.The dam is currently at a height of around 10 metres. The upper section of the wall contains a series of niches that are most likely to contain sculptural decorations. Up to the bottom of the dam, there is a tiered landing with an arch-shaped structure in the centre for raising water through the Persian wheel. There is also a provision for the flow of excess water on the western margin of the dam with the help of the top two outlets drain, one above the other with a socket. Towards the north of Badva*būnd* or *tālāb*,

another dam is built just after the meandering of the gorge named Chipola *būnd*.[18]

Similarly, the Maota Lake at Amber was the main source of water for the fort-palace complex. The water system here involves gathering rain from the hillsides into the Maota Lake and raising it to the top of the *Diwān-i Khās* terraces via a seven-story lifting mechanism. In the first stage, Persian wheels were used to lift water from the lake along the eastern front of the KēsarKiyarī garden. The water was collected in two storage tanks built on the terrace overlooking the garden. From there, a second clay pipeline was channelled into another storage tank at the foot of the second phase. This point is made of four independent yet interconnected structures that are arranged in ascending order. Each building featured its pulley and rope system, as well as an intake-cum-storage tank at the bottom. Leather bangs strung over a pulley with a rope were used to transport water from the lowest storage tank to the next higher one. In the same way, with the aid of these Persian wheels, water was transported from the first storage tank, which was placed on the lowest layer, to the last one, which was built on the first floor of Balidān Gate or Dhruv Gate. Each construction is more or less 10 to 13 metres in height, taking the water gradually to approximately 45 metres. The last point of lift again employed a set of Persian wheels. It comprised a long wooded shaft rotating on its axis-supplied power to the axle of the wheel, which had a rope with several earthen buckets attached to it. The rotating drum moved then up through the water in the storage tank. The pots filled up with water in the process and were then carried up, pouring out into a collection channel at the very height of the mechanism. The water was then distributed throughout the palace using an earthen pipe network.

In the Marwār region, Sūr Sāgar, a small lake with the remnants of a pleasure palace on its embankment, is located 3.2 kilometres north of Mehrāngarh fort. It gets its name from Rāja Sūr Singh (1595-1619) who built the dam in 1607, but the palace was added in 1672 by his grandson Rāja Jaswant Singh I (1638-1678). The palace is built in the Mehrāngarh fort palace-style surrounds a *chahārbāgh* with water channels.[19] The Mehrāngarh fort has two small artificial lakes, called the Rāni Talābin the east and the Gulāb Sāgar in the south, from which the garrison drew up water in buckets. Within the fort is a *kūnd* or reservoir, dug from the rock at a depth of 27 metres that may be filled from these tanks, as well as wells.[20]Aside from that, Fatēh Sāgar and Padma Sāgarare two other dams in the city proper.

The Gadhi Sār is the primary source of water for the town of Jaisalmer. Maharāwal Gadh Singh strengthened the embankment in 1334 A.D. to create this natural reservoir. Gadhi Sār is the name given to it in his honour. Later, on the lake's shore, a beautiful double-storeyed gateway was erected as an entrance.[21] The embankment is decorated with palaces and *chhatrī*s, and it includes an integrated platform. Two pavilions, a small pleasure palace, and two enormous circular islands were also built in the waters of this *sār*. Similar islands have funeral monuments or cenotaphs in a different locations. Badā Bāgh [funerary garden], Amar Sāgar and Mūl Sāgar are the names of these places. The latter two dams have been named after their builders, i.e., Rāwal Amar Singh (1659-1701) and Rāwal Mūlraj II (1762-1819) respectively.[22] Nagaur is no exception when it comes to water issues. The city cleverly designed around eight lakes, all outside the fort, and called after several queens and kings like Samas Tālāb, Ginnani Tālāb, Bakht Sāgar, Pratāp Sāgar, Zada Tālāb, Lāl Sāgar, Shakkar Tālāb and Dulyon Tālāb. Of these, the Ginnai Tālāb is inside the city wall. The water system in the fort is not only extensive but is also supported by sophisticated canals.[23]

Deep stepping basins, known as *kūnd*s, are another common element of Rajasthan's water architecture. These structures, which combine the qualities of a well and a reservoir, generally have a decent shaft in the middle or at the edge of their catchment area. A *kūnd*'s top perimeter is usually square or rectangular, with bilateral flights of stairs organised in pyramidal blocks. They were called *tānka* if they were merely in the shape of a deep tank. The pyramidal steps buttress the strongly sloping walls and provide resting platforms and working surfaces at regular intervals for washing, drying and even resting. The *kūnd*swere also known as *tālāb*at one point.

There are nine reservoirs in Chittor [Mewār], including GaumūkhKūnd, Chitrangad Tālāb, Surya Kūnd, Hathi Kūnd, Bhimlat, KukreshwarKūnd, Sukhadiya Tālāb, Annapurana Tālāb, Patta tank, and others. The Gaumūkhkūnd, also known as MandakiniKūnd, is located south of the Mahāsati enclosure. Water flows from the mouths of the cows sculpted in stone on the wall of a pillared hall and had a little room to the north. Two entrances are supposed to lead to the vast underground tunnels known as Rāni Bhandār in the area.Chitrangad Tālāb is said to have been built by Chitrangad Morī, the fortress's founder. It has an uneven shape and is surrounded on the south side by a masonry embankment with niches containing pictures of Hindu Gods and Goddesses. The Kukreshwar Kūnd is a perennial source of water for the inhabitants, located west of the Kukreswar temple and bordering the defensive wall. It was constructed in the eighth century and afterwards restored by Maharānā Kumbha (1433-68). The Sukhadia Tālāb or reservoir is located on the south of the Bhimlāt and the east of Padmīnī Palace. It has massive masonry built embankment on the northern side with recessed

niches that accommodate the sculptural figure of Hindu divinities. The magnificent Padmala pond, on whose southern side stands the Jogī Mahal, is located at the base of the Ranthambhor Fort [Mewār]. There were five tanks within the fort.

The fort of Gwalior is known for its numerous tanks, wells, and cisterns. Some of these appear to have been quarried from which stone was extracted and used to construct the fort's buildings and walls. Fifteen main tanks still contain water today, but there are at least as many others that have dried up. Many of these tanks, including Rāni Tāl, featured elaborately adorned twin galleries. Furthermore, some, such as the Gangola, were encircled by a screen enclosure. The Sūraj Kūnd, which measures 106 to 46 metres, is the earliest construction. It is noted as the work of Sūraj Pāl.[24]Mānsarovar, Rāni Tāl and Cherī Tāl likely to have been constructed during Rāja Mān Singh Tomar (1486-1516). The other most important are the Rāni Tāl, Cheri Tāl, Sās Bahu *Kund*, Gangola *Kund*, [near the Telī Mandir], Katorā Tāl [behind the Telī Mandir], Ek Khambā Tāl and Dhobī Tāl.

The Jaigarh Fort, which is situated directly above the Amber Palaces, also has a series of water tanks. These tanks appear to have been the fort's main supply of water, as they were filled with rainwater channelled through an elaborate system of conduits and water ducts covering the neighbouring hills. Just at the point where the ducts enter the fort is a natural depression in the rocks which acted as the first point of collection of water, which probably was used to water the animal. Two huge subterranean covered tanks, known locally as *tānka*, are constructed in the fort's forecourt. The first of them has a capacity of 60,000 gallons of water at any given moment. It is connected to a smaller subterranean tank by a network of channels, which most likely provided drinking water for the fort's occupants. Only pure water, free of external contamination, was collected after passing through multiple stapes.

The water supply system at the Nahārgarh Fort, which was next to the Jaigarh Fort, was considerably more complex. Two large storage *kūnds* or tanks (*tānka*) were reached by a lengthy set of stairs carved out of natural depressions in the rock that snaked downhill in a crescent pattern to the water level. Another set of steps that run directly from the summit to the water point also provides direct access to the water. Many channels are covered in stone slabs and lead to storage tanks below ground level. Small tanks were built apart from the larger tanks, and the water from them was reserved for the animals housed in the fort.

Without the construction of connecting channels from *bā'olī*s, tanks, or reservoirs, no water system would be complete. Rainwater falling on the hills had to be delivered into these water reservoirs, which necessitated the construction of channels. Though these water channels are encountered almost everywhere, the greatest examples of their construction can be seen near Jaipur in the hill forts of Jaigarh and Nahārgarh. The hydraulic system built around these channels in these fortresses not only added to their essential strength but also met the everyday requirements of its occupants. The hills surrounding both of these strongholds, one from the 17th century and the other from the 18th, are crisscrossed by a network of water channels that loop around and surround them. These loops are constructed in such a way that rainfall falling on these hills is collected and channelled to reservoirs within the forts, rather than being wasted. This would be done by utilizing gravity's inherent power.

Syed Ali Nadeem Rezavi and the late Rajiv Sharma of the Centre of Advanced Study, Department of History, Aligarh Muslim University (India), were the first to document the layout and significance of these ducts and aqueducts at Jaigarh and Nahārgarh fort.[25] The water channel network begins on the hillocks and forms three loops before entering the fort walls, starting from the south. These loops around the hillocks are constructed in such a way that rainfall falling on the hills is gathered in these channels and gravity-fed towards the fort. The waterways begin at a hilltop about 3.5 kilometres from the Jaigarh fort's southern walls. This hilltop is encircled by water ducts that form an oval circle that is about a kilometre long. Water is channelled westward through a channel to an aqueduct supported by five bastions and thirty-nine arches. Interestingly, the channels change direction over their entire journey using abrupt acute curves rather than smooth bends. It is possible that this was done to block the flow of the debris from the hills along with the water. An east-oriented 1.83 m wide and 330 m long channel begins at the confluence of the western and eastern ducts and terminates near the fort's southern walls, where the Jaivana is now located. The water is allowed to fall through a rectangular hole on the floor, which leads to a subterranean tube that carries the water inside the ramparts. The water, then further, is channelled into a 29.5 m long channel with a floor that inclines upwards around 25 degrees as it enters the fort wall. The debris from the water carried in from the hills settles more easily due to the upward slope. If the water is clean, it is transported down a subterranean conduit to the fort's central tanks, known as *tānka,*which is completely covered from above supported by 81 arched pillars, by opening a sluice gate. It is designed in a square form, with each side measuring 47.4 m and a depth of around 12 m. A set of steps drop below to the north, where a ramp is constructed to collect water. If the water does not need to be kept in this enormous reservoir, the

channel sends it to a rectangular open tank, popularly known as a bathing tank, through the second gate of the cistern. The third tank, like the *tānka,* sits adjacent to this open tank to the south and is covered with a roof with nine holes on its ceiling to facilitate the lifting of water from it. The Jaigarh Fort was able to survive a protracted siege because of this innovative technique of capturing rainfall on the hills and then diverting it to the fort. This method also handled the difficulty of transporting water from deep below the hillock's lakes. The fact that water is still transported over the same dilapidated and uncared channels and viaducts throughout the rainy season attest to their effectiveness. The water is still taken from the *tānka* to meet the requirements of the fort's visitors and residents. Even though it is not an isolated case, Jaigarh is an excellent example of the hydraulic engineering of medieval Rajasthan.

Thus, the hydraulic architecture of medieval Rajasthan is culturally and architecturally significant. The major supply of water is the torrential rains that fall during the summer monsoon's four months. Therefore, the *bā'olī*s, *kūnds* and *tankās* were constructed to store the seasonal water. Besides that, throughout India's history, droughts and famines have been a serious issue. Therefore, the Rajput kings commissioned the construction of huge dams and reservoirs of various sorts to meet the water supply demands of the vast urban population within the fort-palace complexes and imperial cities. These imperial commissions were crucial to the city's development.

**Notes**

1. Iqtidar Husain Siddiqui, "Water Works and Irrigation System in India during Pre-Mughal Times", *Journal of the Economic and Social History of the Orient*, Vol. 29, No. 1, 1986, p.63.
2. Syed Ali Nadeem Rezavi, 'Kuldhara in Jaisalmer State-Social and Economic Implications of the Remains of a Medieval Settlement', *Proceedings of the Indian History Congress,* 56th Session, Rabindra Bharati University, Calcutta, 1995, pp. 312-332.
3. Irfan Habib and Faiz Habib, "Mapping the canal system of Firoz Shah including an abortive Sarasvati 'restoration", *Studies in People's History,* 4, 2, 2017, pp. 146-161.
4. Anthony Welch, "Hydraulic Architecture in Medieval India: the Tughluqs", *Environmental Design,* Vol. 2, 1988, pp. 74-81.
5. B.D. Chattopadhyaya, "Irrigation in Early Medieval Rajasthan", *Journal of the Economic and Social History of the Orient,* Vol. 16, No. 2/3, 1973, pp. 298-316; *Note on Irrigation in Rajputana: A Brief Summary of the Investigations* made during 1903-05 with suggestions by the Consulting Engineer, Scottish Mission Industries Col, Ltd., Ajmer, 1905.
6. For see also Jennifer E. Lort, *Curious Seen: Baolis of the Delhi Sultanate*, unpublished thesis submitted for the Degree of Art, University of Victoria, 1995; Iqtidar Husain Siddiqui, "Water Works and Irrigation System in India during Pre-Mughal Times", *Journal of the Economic and Social History of the Orient*, Vol. 29, No. 1, 1986, pp. 52-77.
7. See also Natalie H. Shokoohy, 'Waterworks of Medieval Bayana, Rajasthan', *Bulletin of the Asia Institute,* New Series, Vol. 18 (2004), 2004, pp. 19-42; S. P.Vyas, "Water Supply System in the Fort of Jodhpur", *Proceedings of the Indian History Congress,* Vol. 68, Part Two, 2007, pp. 1422-1427.
8. Huge Davenport, *The Trials and Triumphs of the Mewar Kingdom*, Maharana Mewar Charitable Foundation, Udaipur, 1975, pp. 47-51.
9. Seventh day of the dark fortnight of the month of *Magha* in the Vikrama year 1718, thus regularly corresponds to Wednesday, the Ist January, 1662 A.D.
10. Rajiv Sharma, 'Raj Samand Dam- An Achievement of 17th Century Civil Engineering', *Indian History Congress*, 53rd Session, 1993, Warangal, Cyclostyle in the Department of History, Aligarh Muslim University, Aligarh, 209-218.
11. *Rajaprasasti Mahakavaym* of Mahakavi Ranchor Bhatt, edited by Moti Lal Menaria, Udaipur, 1973.
12. As the poet himself informs his *Rajaprasasti* was inscribed on stone slabs as per orders of Rana Jai Singh son of Rana Raj Singh in the year 1678 A.D. Kavi Raj Shyamal Das has given the text of these inscriptions in his *Vir Vinod*, Vol. II, Pt. I, Appendix, Delhi, 1986.
13. *Rajaprasasti*, Serg 9, Verse 14, p. 92.
14. *Epigraphia Indica,* Vol. XXIX, published by the Director General Archaeological Survey of India, New Delhi, 1987, p. 3.
15. The full inscription was published in the *Epigraphia Indica,* Vol. XXIX, published by the Director General Archaeological Survey of India, New Delhi, 1987, Appendix 1-90.
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