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Management of Water at Śṛṅgaverapura: An Early Historic Hydraulic System on the Ganga

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Abstract:*This paper explores the advanced hydraulic engineering and water management system at Śṛṅgaverapura, an early historic Ganga site near Prayagraj. An analysis of structural evidence, stratigraphy, and comparative studies examines the construction, function, and evolution of its multi-stage water tank system, which provided flood control, water filtration, and urban sustainability. The study contextualises Śṛṅgaverapura within broader early historic urban planning, comparing its water conservation strategies with those of Dholavira and Sanchi. Furthermore, it highlights the cultural and religious significance of water in ancient India, referencing the Ramayana, Arthashastra, and Dharmashastra.*

Keywords: *Ganga,Town Planning, Śṛṅgaverapura,Water Management, Urban Sustainability etc.*

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Introduction

Śṛṅgaverapura (Lat. 25°35′14″N.; Long. 81°39′E) an early historic site located on the banks of the Ganga near Prayagraj (Allahabad), Uttar Pradesh, provides significant insights into the ancient Indian town planning and hydraulic engineering.[1] The site, excavated by B.B. Lal Under

a project 'Archaeology of Ramayana Sites' between 1977 and 1986, reveals evidence of a well-organized urban settlement that flourished during the Maurya, Shunga, Kushana, and Gupta periods.[2] While Śṛṅgaverapura is traditionally identified with the mythological capital of Niṣādarāja Guha, as mentioned in the Ramayana, its archaeological remains highlight its importance as a centre of trade, water management, and flood control in early historic India. There gap in terms of analysing the role of the hydrological structure of Śṛṅgaverapura in creating the idea of hygiene and purity in early historic India by comparing it with Dholavira and Sanchi. This paper examines the town planning and hydraulic infrastructure of Śṛṅgaverapura, focusing on the spatial organisation of the settlement across different historical periods. It uses archaeological and literary sources to examine the complete idea of hydrology in early historic India. The structure, function, and connectivity of the water tanks and dam-like embankment. Comparisons with other early historic water management systems in India, such as those at Dholavira, and Sanchi.

Historical Background of Śṛṅgaverapura

The site is also associated with Rishi Rishyasringa, the sage who performed the Putreshti Yajña for King Dasharatha, leading to the birth of Rama and his brothers (as per the Ramayana). Śṛṅgaverapura is often identified with the mythological capital of Niṣādarāja Guha, the tribal king who assisted Rama during his exile to cross the Ganga. This association gives the site religious and cultural importance, particularly in later textual traditions. However, archaeological findings suggest that Śṛṅgaverapura was not just a legendary location but a flourishing early historic urban centre that played a crucial role in regional trade and settlement patterns. The Archaeological Survey of India (ASI) excavations (1977–1986), led by B.B. Lal uncovered extensive evidence of continuous habitation from the Maurya to the Gupta period.[3] According to Lal, the earliest settlement was characterised by Ochre Coloured Ware (OCW), marking its easternmost extension in the Ganga-Yamuna Doab region.[4] Where wattle-and-daub houses and reed-impressed mud plaster suggest early domestic architecture. Painted Grey Ware (PGW) sherds appeared in later levels, suggesting connections with western Uttar Pradesh and Haryana.[5]

The stratigraphy of the site reveals multiple construction phases, indicating urban growth, technological advancements, and socio-economic changes over time. The excavation findings can be categorized into four key historical phases.[6]

The Maurya Period (4th–2nd century BCE) has the earliest occupation evidence with mud-brick fortifications. The presence of terracotta ring wells indicates early efforts in water management (Lal, 1993).[7] Domestic structures made of mud and bamboo, suggest a semi-permanent settlement. During the Shunga Period (2nd–1st century BCE), the expansion of brick structures showed improvement in urban planning. NBPW disappeared at this time and was replaced entirely by Red Ware. Construction of the large brick tank (reservoir), central to Śṛṅgaverapura's water management system, was constructed during this period, indicating concern for hygiene and water management.[8] In the Kushana Period (1st–3rd century CE), there was large-scale use of baked bricks in architecture, replacing earlier mud-brick structures. The construction of the multi-stage water tank complex marked a significant advancement in water conservation.[9] Expansion of residential and public buildings, indicating urban prosperity. The presence of terracotta figurines and pottery reflects cultural and trade influences. Gupta Period (4th–6th century CE) The tank was eventually destroyed, leading to the abandonment of some areas of the settlement.[10] A decline in large-scale structural activity in later phases, suggests a possible shift in settlement dynamics. The findings from these phases demonstrate a clear trajectory of urban evolution, with Śṛṅgaverapura developing from a fortified early settlement to a structured urban centre with advanced hydraulic infrastructure.

The site's strategic location along the Ganga facilitated riverine trade and agriculture, making it an important economic hub. The integration of water management features suggests that flood control and sustainable water use were key priorities for its inhabitants. Fortification and organised drainage reflect urban planning practices comparable to other early historic cities in North India. This section establishes Śṛṅgaverapura as an evolving urban centre, setting the stage for a detailed analysis of its water management system in the next section.

Management of Water at Śṛṅgaverapura:An Early Historic Hydraulic System on the Ganga

Water Management and Hydraulic System at Śṛṅgaverapura

One of the most remarkable aspects of Śṛṅgaverapura's urban planning is its sophisticated water management system, which includes a series of interconnected tanks and a dam-like embankment. These structures demonstrate an advanced understanding of hydraulic engineering, ensuring efficient water storage, filtration, and flood protection. Ramayana signifies the cleanliness and management of water bodies. In Ayodhya Kanda, When Ram leaves Ayodhya and reaches the bank of Ganga where Niṣādarāja welcomes him to his territory.[11]

> "Rama beheld the celestial and lovely river of Ganga with its tree tributaries, carrying clear waters without green moss and frequented by sages. The River Ganga was adorned with splendid hermitages within easy distance from one another, with pools overflowing with water, visited at suitable hours by celestial nymphs thrilling with rapture."[12]

These verses highlight the significance of the river in the epic *Ramayana*. The *Arthashastra* is a well-known source that codifies rules for water conservation, the protection of water bodies, and the imposition of fines for pollution.[13] *Manusmriti* also ordains punishment and fines for the destructing and polluting of the embankments of a tank, pond, channel or even a river.[14] The remains of the hydrological system of Śṛṅgaverapura serve as a living example of early Indian water management technology and infrastructure. The brick tank at Śṛṅgaverapura was constructed during the 1st century BCE, likely under the rule of Dhanadeva of Ayodhya.[15] It was designed to solve the water supply problem for the eastern sector of the settlement, which had expanded away from the Ganga by this period. Unlike other contemporary tanks (e.g., Mathura, which only stored rainwater), this tank was specially designed to be filled using a channel that diverted Ganga water.[16] Water was diverted from the Ganga's floodwaters into an 11 m-wide channel (Feeding Channel).[17] This channel was 5m deep, ensuring that water flowed steadily into the next filtration stage.[18] The water then moved into the Brick Tank through an Inlet Channel with a stepped ledge to further slow its velocity.

The system consists of three interconnected settling tanks arranged in a stepwise sequence to facilitate water filtration and controlled distribution. These are given names by ASI, Tank A, Tank B, and Tank C for understanding (See Fig. 1). A dam-like embankment, built with baked bricks and mud reinforcements, was constructed between the settlement and the river, serving as a protective barrier against floods. The tanks were designed for gradual water purification and distribution through a structured flow system.

Tank A: The first point of water collection from the river. It allowed coarse sediments to settle before passing water to the next stage. The secondary Settling Tank A is staircase in the southeast corner Connected to the primary tank. Through narrow water channels, this tank facilitated further purification. Finer sediments and impurities settle at this stage and can store 880,000 litres of water.[19] (See Fig. 2)

Tank B: The main drinking water reservoir. Water entered via Interconnecting Channel-1, which was 1.2m above the base of Tank A, preventing settled silt from entering Tank B. This is the last phase in the filtration process, storing relatively clean water for drinking, domestic use, and irrigation. This tank B ensured a steady water supply, even during dry seasons. The sequential arrangement of these tanks highlights a planned approach to water conservation and urban sustainability.[20] (See Fig. 3)

Tank C: Likely used for ritual purposes, evidenced by terracotta figurines of Hindu deities (Kubera, Shiva, Parvati, Hariti, etc.) found at the site. It can store 116,000 liters of water. Excess water was discharged through Tank C, flowing through six spill channels before being returned to the river via an Exit Channel. Engineers designed a “Crest” (raised passage) in the waste weir to control the outflow and prevent erosion.[21] (See Fig. 4)

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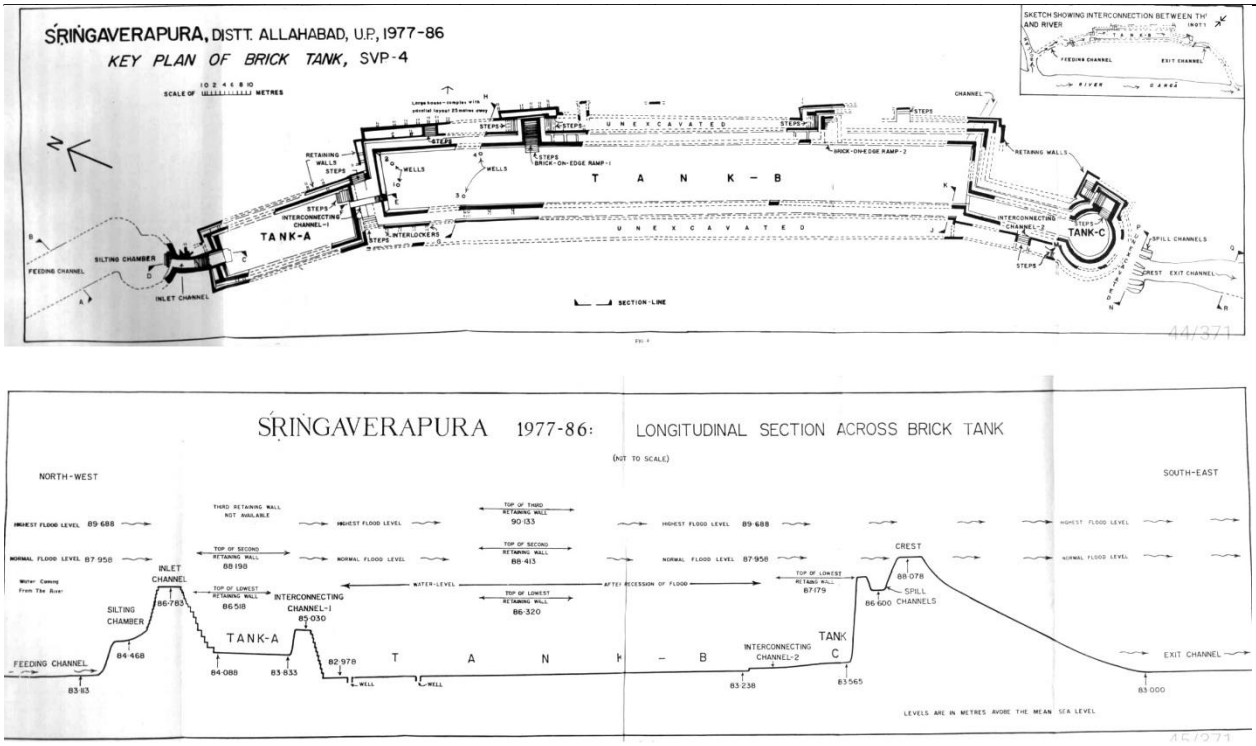

Fig. 1 Complete Plan of Brick Tank and Its Longitudinal Section (Lal, 1993).[22]

The embankment acted as a controlled outlet, ensuring that excess water did not overwhelm the settlement or the agricultural fields. Its multi-layered construction shows evidence of periodic repairs, indicating long-term use and maintenance. Sub-soil wells were dug into the tank bed, ensuring water replenishment from underground sources even during dry months. Around the 1st century CE, an unprecedented flood from the Ganga severely damaged the tank, collapsing its retaining walls.[23] A young individual's skeleton was found in the debris, suggesting fatalities during the disaster. The tank was abandoned for several decades, and a mud tank was built over the ruins of the brick tank to collect rainwater, but it lasted only 50 to 100 years. The area was repurposed as a residential complex by the 3rd century CE.[24]

The presence of water filtration tanks and a dam-like embankment at Śṛṅgaverapura suggests that water management was a central aspect of its urban planning. The use of baked bricks and controlled water channels reflects engineering skills comparable to those seen at sites like Dholavira and Sanchi. The system highlights the importance of the Ganga in early historic settlements, where water conservation was not only a practical necessity but also a cultural and

religious priority. This structured approach to water management ensured a sustainable water supply, flood protection, and urban resilience, making Śṛṅgaverapura a key example of hydraulic engineering in early historic India. The system at Śṛṅgaverapura can be better analysed with other hydraulic systems that were present before it and its contemporary.

Other Ancient Water Management Systems

The hydraulic engineering at Śṛṅgaverapura reflects an advanced understanding of water conservation, filtration, and flood control in early historic India. To fully grasp its significance, it is essential to compare it with other ancient water management systems, such as those at Dholavira, Sanchi. Dholavira (c. 2500–1500 BCE) is known for its sophisticated reservoir system, discovered by Jagat Pati Joshi (1968), and excavated extensively by R.S. Bisht from 1990 to 2005.[25] It is situated on Khadir Island in the Great Rann of Kachchh, Gujarat (23°53'18.27" N, 70°12'47.89" E) in the Rann of Kutch and surrounded by a saltwater lake.[26] Settlement at Dholavira is divided into a citadel, middle town, and lower town, all enclosed within massive fortifications.[27] Unlike Śṛṅgaverapura, which relied on river water filtration, Dholavira's system was based on rainwater harvesting through interconnected reservoirs and underground drains. The site has 16 large reservoirs located along the city's periphery and within its fortification walls, indicating a planned and hierarchical water distribution system.[28] These reservoirs were connected by a series of drains and channels, allowing for controlled water flow and sediment filtration.[29] The largest reservoir was located near the citadel. Both sites exhibit stepwise water purification, but Śṛṅgaverapura's tanks were specifically designed for settling sediments from the Ganga, whereas Dholavira's tanks primarily stored water for drought resilience.

Fig. 2 Tank- A[30] Fig. 3 Tank- B

Fig. 4 Tank- C and River Ganga

Sanchi (Madhya Pradesh) is a major Buddhist site dating from the 3rd century BCE to the medieval period.[31] It features rock-cut water channels and reservoirs used for monastic communities. The first mention of reservoirs at Sanchi was by Alexander Cunningham (1854), who identified three ancient embankments between Sanchi and Satdhara. The Sanchi area contains at least 16 reservoirs built across short valleys and hill gaps. Which collected runoff from the surrounding hills, ensuring water availability for irrigation and monastic use.[32] The Betwa and Bes (Halali) rivers played a crucial role in regional water management, influencing settlement patterns. Stone-faced embankments were used to reinforce the dams, ensuring water retention and controlled distribution.[33] These were primarily designed for irrigation, particularly rice cultivation. Some reservoirs had spillways to control overflow during the monsoon, similar to early historic flood control methods in Śṛṅgaverapura. The two largest reservoirs were linked to the Buddhist monasteries, suggesting a close connection between Buddhist settlements and hydraulic infrastructure. Unlike Śṛṅgaverapura's stepwise tank system, Sanchi's reservoirs were spread across valleys to collect rainwater and runoff. Both sites show planned water conservation but differ in their dependence on rainfall vs. river-fed hydrology.[34] The presence of monastic water storage at Sanchi suggests that Śṛṅgaverapura's tanks could also have had ritualistic

significance beyond just drinking and irrigation. Both systems demonstrate planned water storage, but Śṛṅgaverapura's structure was more complex due to its multi-tank system and steps.

Feature	Śṛṅgaverapura	Dholavira	Sanchi
Water Source	River (Ganga)	Rainwater	Stored Runoff
Main Structure	Settling Tanks, Dam	Large Reservoirs	Rock-Cut Cisterns
Function	Filtration, Flood control	Drought Resilience	Monastic Water Supply
Engineering Type	Stepwise filtration system	Interconnected Reservoirs	Rock-Cut Tanks

Fig. 5 Key Similarities and Differences with Dholavira and Sanchi.

This comparative analysis highlights that Śṛṅgaverapura's water management system was unique for its integration of flood control, filtration, and stepwise purification, setting it apart from contemporary sites. Dholavira, a settlement from the first urbanization in the Indian subcontinent, provides valuable insights for comparing the techniques of the second urbanization. Despite its arid and saline environment, Dholavira efficiently conserved rainwater, ensuring a sustainable water supply for its residents and enabling the city to flourish. This highlights the efficiency of its state administration and its advanced specialization in hydrology. In contrast, Sanchi reflects the lifestyle of the monastic order, as key sections of its reservoir system are located near monasteries. Monasteries were typically situated close to settlements, cities, and trade routes, facilitating interaction with local communities. They provided medical and spiritual services to the people and, in return, received food and other essentials from nearby settlements.

Analysis of Sanchi's water management system reveals the significant role of monasteries in managing water resources. Water has historically been a contested resource, essential for agriculture and daily life in settlements. Any control over water resources often implied proximity to political power. The strategic location of water reservoirs near Sanchi's monastic complex suggests close ties between monasteries and the state and their involvement in agricultural communities. Buddhist monastic institutions were generally expected to remain detached from economic affairs. They may have exercised some influence over resource management in Sanchi. In Śṛṅgaverapura there is no such evidence appeared related to the monastic site so there must be a state functionary who managed this complete hydraulic system.

Potential Questions about the Maintenance

The grand structure and estimated use of the Śṛṅgaverapura hydraulic system point out the general query about its management body. There may be a work specification related to different work associated with the hydraulic system. There must be engineers who maintain its structure in different seasons because the river changes with the seasons. In rains its level increases and in winter it decreases. There is more frequent service is needed for its maintenance and efficient uses that is its cleanliness. There must be a group or a body responsible for its regular cleaning. So it could be used for daily water necessities. Additionally, it raises important questions: Who were the people responsible for maintaining the cleanliness of these water bodies? Given the need for regular cleaning, a specialised group of workers must have been assigned to this task. Were they the same individuals responsible for cleaning towns and streets? Were they the puṇkhas and caṇḍālas mentioned in the *Jātaka* stories and *Dharmaśāstra*?

In the present day, the Dom community is seen at Manikarnika Ghat in Banaras, cleaning the ghat by segregating cremation waste (See Fig. 6). They are responsible for overseeing cremation rites, removing unburned remains, and ensuring that corpses do not enter the river, particularly near water intake points. Their work is vital for maintaining both religious customs and environmental hygiene along the sacred ghats of Varanasi. They are considered untouchables and rank the lowest in the caste hierarchy.[35] They can be regarded as the present-day caṇḍālas by their social conditions. Archaeology and ancient texts are unexplored in this direction, but the focus must be given to tracing the real heroes behind the cleanliness of water bodies.

Fig. 6 People of the Dom community cleaning corpus ash, Varanasi[36]

Conclusion

The excavations at Śṛṅgaverapura reveal an advanced and well-planned hydraulic system, demonstrating a deep understanding of water management in early historic India. The presence of three interconnected settling tanks and a dam-like embankment highlights the strategic use of natural river resources for filtration, storage, and flood control. The sequential flow of water through these tanks ensured progressive purification, making it suitable for domestic, agricultural, and possibly ritualistic purposes. Śṛṅgaverapura's urban evolution from the Maurya to the Gupta period reflects continuous innovation in hydraulic engineering, aligning with broader trends seen in other contemporary settlements such as Dholavira, and Sanchi. However, its unique river-based water filtration system, unlike the rainwater harvesting of Dholavira or the rock-cut reservoirs of Sanchi, sets it apart as a distinctive model of floodplain water management.

By integrating structural evidence, stratigraphic analysis, and comparative studies, this paper highlights how ancient Indian urban centres effectively adapted to environmental challenges through technological advancements in hydraulic engineering. The Śṛṅgaverapura water management system serves as a crucial case study in early historic town planning, offering

valuable insights into the scientific and cultural dimensions of water conservation in ancient India.

It also reflects an awareness of sanitation, hygiene, and public health in daily life.

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[36] Figures 6 &7 Photographed taken on February 9, 2025, by the author on his field visit to the Rajghat archaeological site in Varanasi.