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The Peshwa Nahar System: Sustainable Water Management in the Past and for the Future

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Abstract
Urban water infrastructure in India is currently focused on technocratic solutions, often disregarding sociocultural and environmental values. This article examines the eighteenth-century Peshwa-period *nahar* (aqueduct) system in Pune, within the broader context of three centuries of urbanization. Developed as part of the 2023 professional education course Water Systems Design: Learning from the Past to Design Resilient Water Futures, it employs the value case methodology and the framework of the UN Sustainable Development Goals (SDGs) to highlight ecosystem-based thinking reflecting traditional knowledge systems. Although today the *nahar* system is no longer functional, the authors argue that it can inform future design thinking and offers an important example for initiatives like India's Smart Cities program, offering a sustainable water management approach by integrating ecological and sociocultural values in infrastructure planning.

Policy Recommendations

- Safeguard the Peshwa *nahar* system, a sustainable and highly advanced traditional water technology and heritage infrastructure, in the context of the government of India's Smart Cities Mission.
- For future water system designs, understand and implement the core values of the Peshwa *nahar* system articulated here: (i) adapted to the local environment, (ii) sustainable and cost-effective, (iii) socioculturally inclusive and (iv) decentralized and reliant on climate resilient infrastructures.

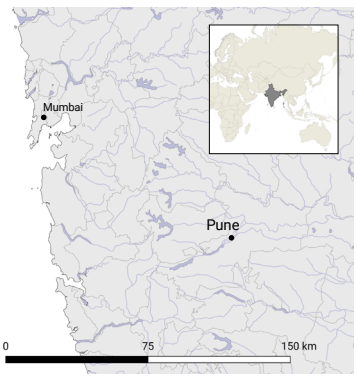
KEYWORDS

Pune
Heritage
Aqueduct
Smart systems
Water management systems

WATER ICONS

CLIMATE

Aw: Tropical savanna climate



< Fig. 1 Panoramic view of Katraj Lake, which waters serves the Katraj aqueduct (Source: Pallavee Gokhale, 2025).

Introduction: Temporal and Spatial Context

Inspired by the tradition of *karez* or *qanāts* from the Persian Gulf, the Deccan sultanates (from approximately the fifteenth to the mid-seventeenth century) built a number of important water systems using underground networks of aqueducts that sourced water from aquifers. In India, such systems are found in the cities of Ahmednagar, Bijapur, Burhanpur Chhatrapati Sambhajinagar and Daulatabad. Inspired by these systems, in 1750, Balaji Bajirao alias Nanasaheb Peshwa, who was the prime minister of Maratha Empire under the rule of Chhatrapati Shahu of Satara, began constructing a *nahar* system to supply drinking water to the city of Pune.[1] Two masonry dams were built on the southern outskirts of the city at Katraj on the Fadtari and Navlaicha streams, respectively (Palande-Datar 2021). Water was led by gravity through a 20 km-long network of aqueducts, masonry pipes, dipping wells, cisterns and joints, with more than 200 outlets in the city (fig. 1). The new aqueduct system thus supplied drinking water to the most densely inhabited parts of the city and almost every neighborhood. When the city of Pune grew, three new *nahar* were built, the Nahar-e Ambegaon,[2] Raste and Chaudhari, which became part of the Peshwa *nahar*.

This system is now recognized as heritage because of its eighteenth-century technology and architecture, understanding of hydrology, and central role in the growth and development of the historic city. However, this transformation from utility to heritage is complex: in the same period that it has been designated heritage, the local population has become apathetic toward the *nahar*. There is also a perception that if something is official "heritage," it has lost its function.

Changing Spatial and Social Contexts

The Peshwa *nahar* system, a testament to exemplary engineering, administration and city-planning, consisted of several cisterns/reservoirs (*haud*), dipping wells (*uchvāsa*) and underground man-made aqueducts (*nala*/*nahar*) (fig. 2). This system provided water to the core city areas as recently as the mid-twentieth century, but it was neglected thereafter and damaged during years of rapid residential and infrastructure development.

Since its creation in the 1750s, this system that provided for primary needs slowly transformed into an abandoned historical structure. Eventually, the Peshwa *nahar* became recognized as heritage by local communities and administrative authorities. This transition from "core utility" to "heritage" can be linked to contemporary social and political upheavals. The feelings of "belonging" and "pride" that citizens had toward this system changed over time (fig. 3). Through the intricate design adapted to the landscape and employing traditional water management communities such as the Beldars and Mehars, the Peshwas had ensured that the system ran effectively and efficiently (Mathur et al. 2022). By building new aqueducts and expanding the overall network in the 1790s, their court created a conducive environment for the growth of new areas of the city. Into the nineteenth century, regular maintenance and usage of the Peshwa *nahar* system ensured its operation. Then, in the late 1870s, the Bombay Act No. VII led to its gradual degradation.

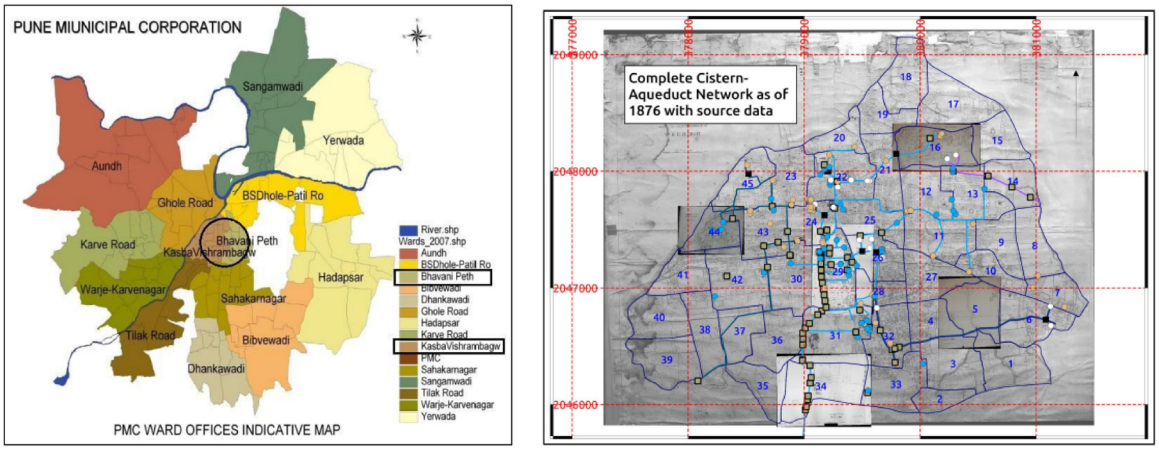
During the early colonial period, the East India Company (EIC) continued to ensure the system was being used and maintained. However,

1. As necessary, non-English words have been Romanized using the Library of Congress romanization tables.

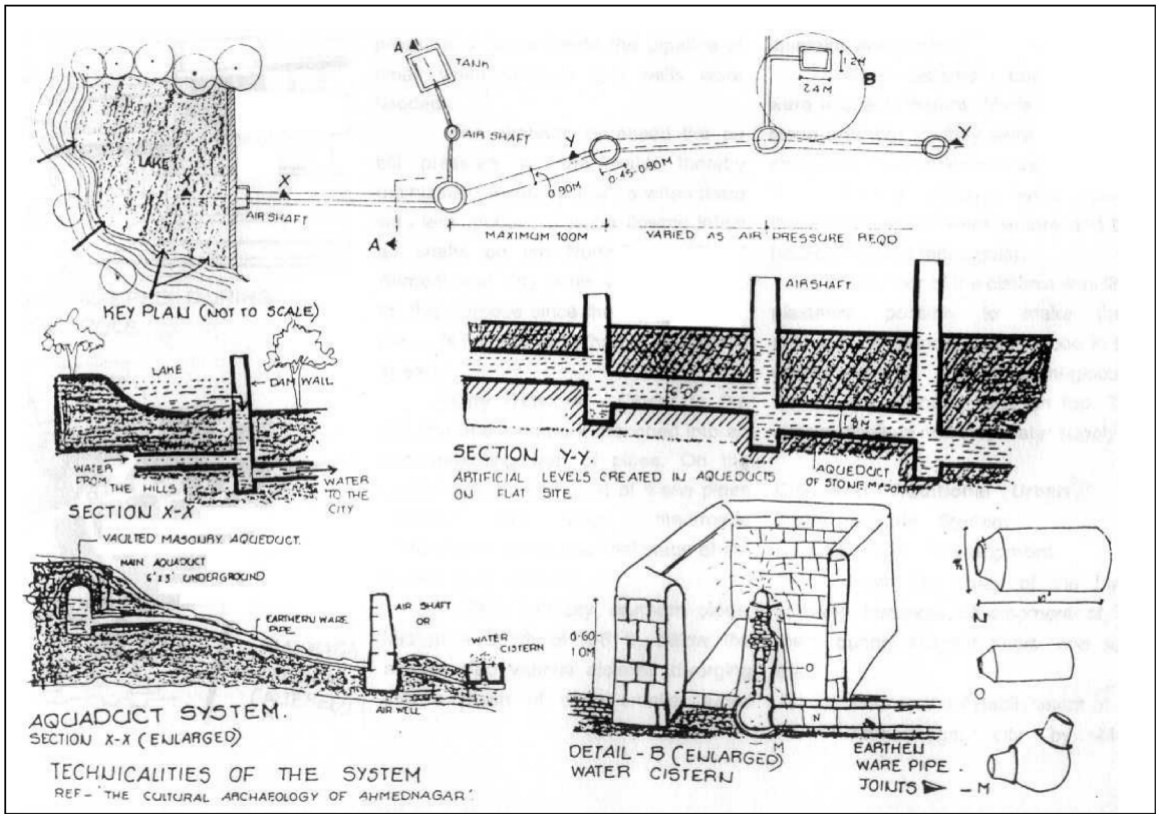
2. The Nahar-e Ambegaon was also known as the Nana Phadanavis system, after the patron.

A Old Pune - Encircled in Centre; Outlined Areas in Legend

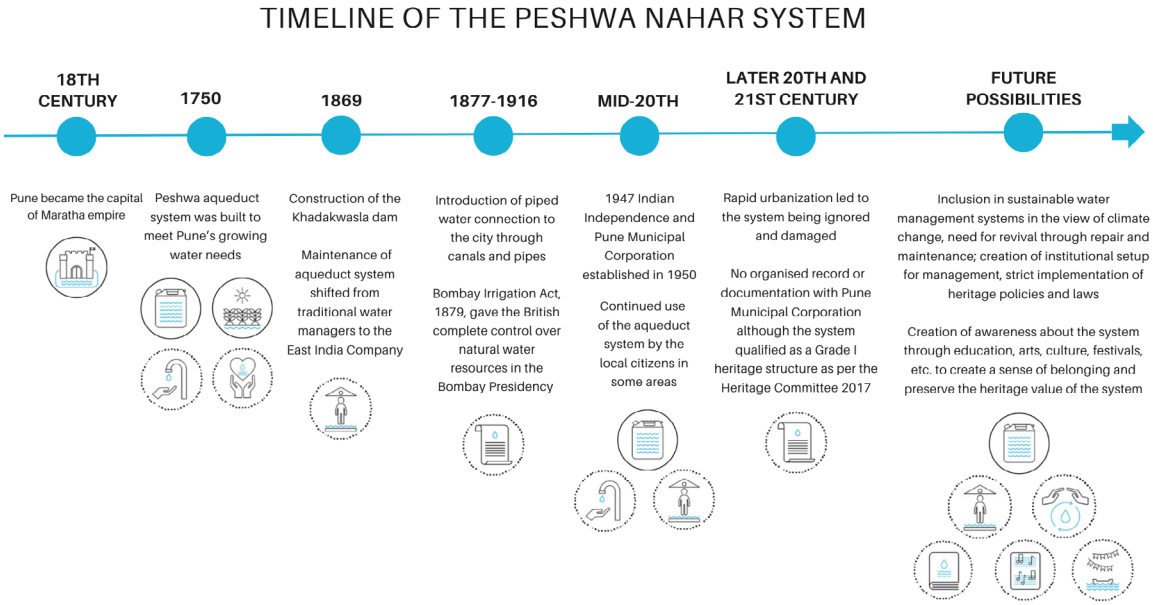
B GIS Data Creation From Old Maps and Texts



^ Fig. 2a Map showing the location of core city areas (*peths*) in the city of Pune (Source: Pune Municipal Corporation, 1987). Fig. 2b GIS data creation of the Cistern-Aqueduct Network as of 1876 from old maps and texts. The blue line identifies the aqueduct network; dipping wells by yellow squares; joints in the system by black squares; cisterns by blue and yellow circles (Source: Gokhale and Deo, 2016).



^ Fig. 3 Section drawings and technical components of the aqueduct system (Source: Kamalapurkar, 2006).



^ Fig. 4 Timeline showing the chronological development of the Peshwa *nahar* system in Pune since its inception and showing link with associated tangible and intangible water categories based on an assignment of the 2023 professional education course Water Systems Design: Learning from the Past to Design Resilient Water Futures (Source: Radhika Mulay, 2023).

instead of employing local caretakers, the EIC hired prisoners from Yerawada jail to maintain the infrastructure (Mathur et al. 2022). This was in line with the systemic disruption taking place in management practices of local and traditional water management systems across India as maintenance was outsourced to those who were not the beneficiaries of the system. This resulted in a declining sense of stewardship toward the *nahar*. At the same time, the increasing reliance on dams, canals and piped water systems introduced by the British as modern sanitation made decentralized water management systems such as the *nahar* appear obsolete.

In 1879, the Bombay Irrigation Act (Bombay Act. No. VII of 1879) permitted the construction and maintenance of any water systems in the broader public interest and gave the British complete control over natural water resources in the Bombay Presidency. This legal change caused new planning practices in water infrastructures and the city water supply began to be provided through canals and pipes. There was no attempt to incorporate traditional water systems in the new water management practice.

Once the centralized water supply was established, the aqueduct system was never formally recognized as a reliable alternate source of water. However, the Peswha *nahar* system continued to be used as an informal water supply until the second half of the twentieth century, even providing potable water relief during the infamous 1961 Panshet floods.[3] During the post-flood period, core areas of the city un-

3. On July 12, 1961, its first year of storing water, the Panshet dam on Ambi River near Pune burst, causing massive flooding and huge loss of life and property in the city (Brahme and Gole 1967).

derwent an intensive process of rehabilitation and redevelopment and the Peshwa *nahar* was physically disrupted and polluted; eventually its integrity was permanently damaged. Despite these events, some of the cisterns continued to receive water from the fragmented segments of the system.

Work to get the system recognized as heritage only began in the 1990s, after years of urbanization. Before then, there was little conception of "heritage" as an entity of administrative interest (Madan 2011). It was only in the twenty-first century that the idea of "heritage" was formally accommodated in the bureaucracy of the Pune Municipal Corporation (TNN 2018). The association of this water system with Peshwa rule, its significance in the growth of the city, and tangible remnants (in the forms of Katraj Lake, dipping wells and a few abandoned cisterns) qualified it as a Grade I heritage structure (Heritage Committee 2017).

Lost Opportunities

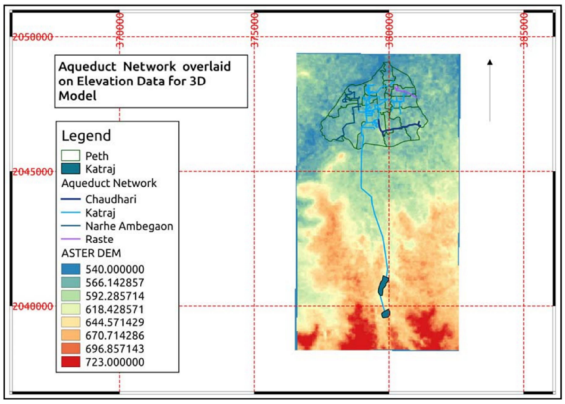
Although different values of water such as utility, purity and life, and sacrality have persisted in societies since antiquity, the concept of "water heritage" and its appearance in discourse concerning local histories is relatively recent (Goralnik et al. 2022), and the theoretical and administrative frameworks are still evolving. Awareness of the notional and archaeological value of the *nahar* system has also only recently developed. Although for some people, the system has long evoked a sense of belonging and pride, it is only recently that there have been organized efforts at preservation, documentation and conservation. We are now at the stage of preserving this system only in memory. Even that is challenging when there is no official record of this system – even of occasional encounters of the remnant infrastructure during construction activity – and there are no initiatives to conduct salvage archaeology or even hasty documentation. There have been no initiatives to sensitize people in the relevant areas or train them for the possible preservation or documentation of this system. Except for the lakes, almost every tangible form of this system has been erased from the landscape with no comprehensive record left by the administrative authorities. The existing documentation of its expanse and complexity consists of colonial maps from the 1870s and local surveys carried out as part of *Pune Nagara Samśodhana Vrtta* (vols. 2–4) in the 1940s, and then by M.S. Mate in the 1990s. Gokhale (2016) has used these archival materials to experiment with the possibilities of virtual reconstruction and digital experience.

Value Proposition for Sustainable Urban Water Infrastructure and Heritage Conservation

A heritage structure such as this aqueduct system becomes especially relevant at a time when cities like Pune are facing water scarcity problems. Employing the SDG framework in retrospect, it is possible to use the value case approach (D'Agostino and Hein 2024) to examine the Peshwa *nahar* system as an example of water system design thinking which integrates environmental, social, economic and cultural aspects of traditional water knowledge systems with advanced technology.

Extrapolating Sustainable Development Goals from the Past: Sustainable Gravity-led Technology

The Peshwa aqueduct system is an example of a highly advanced water management tech-



^ Fig. 5 Aqueduct network overlaid on elevation data. The coordinates are in a WGS 84 UTM 43N projection system. Katraj masonry dam lakes can be seen towards the south. The tentative alignment of Katraj aqueduct can be seen flowing north to the core, i.e., the *peth* area of Pune (Source: Gokhale and Deo, 2016).

nology that combines traditional knowledge systems and was designed in accord with the local geohydrology. The dams built at a higher elevation accumulated rainwater runoff from the hill slopes and from freshwater springs (fig. 4). Due to the natural gradient in the topography of the land, water percolated into the first tank, allowing silt to settle down before flowing into the second tank. Water then flowed into masonry aqueducts (*nala/nahar*) where airshafts or dipping wells (*uchvāsa/ooswas*) were built at intervals of approximately 90 to 100 meters. These prevented the obstruction of air, along with manual desilting, and allowed water discharge to be monitored. The aqueduct also received an additional supply of water through many springs, and in some cases from independent adjoining wells. For the discharge of excess water, the network was finally connected to Mutha River through an underground channel at the Omkareshwar and Amruteshwar ghats on the riverbanks (Palande-Datar 2021). Although highly advanced, this gravity-led network demanded little energy and was therefore sustainable and affordable.

Linking Technology and Traditional Knowledge with Sociocultural and Historical Legacy

Although the *nahar* system of Pune was built by the rulers and their nobles for their residences, historical records indicate that the system was also designed to support the water demands of local people (Diddee and Gupta 2000). Around the core city of Pune, several cisterns, both public and private, were built on the dense network of aqueducts, making drinking water available to neighborhoods. These cisterns, popularly known as *hauds*, were also places of daily public interaction, ritual, social gatherings, and aesthetic displays in the form of fountains (Kamalapurkar 2006). The water system, with its combination of traditional knowledge, newer technology and intricate understanding of complex surface and groundwater interactions, was therefore a symbol of sociocultural and historical achievement.

However, it is also crucial to note that, similar to other water sources, all the cisterns were not accessible to the lower castes, who were assigned separate wells in the low-caste neighborhoods. Historical anecdotes mention a movement led by reformer Mahatma Phule, which demanded equal access to these systems for all the communities in the core city areas (Joshi and Paralikar 1976, Damle 2023). Thus, the history of the Peshwa *nahar* involves social justice dimensions involving access to fresh water. When analyzed through the prism of the SDG framework, these aspects point to various goals, including reduced inequality, access to clean water and sanitation, and sustainable communities and cities, all of which were addressed in the design and implementation of the Peshwa *nahar* system.

In retrospect, another important social aspect to consider, as an externality of the tradition-

al patriarchal family system, is gender inequality. The burden of fetching water typically fell on the women of the household, and was thus unequally distributed. When seen through the lens of the gender equity aspirations of the SDG framework, this aspect would have needed strategic sociocultural intervention.

Local and Decentralized Management

Apart from the tap water system, the rapid rise in the dependence on groundwater and mobile water tankers in Pune is an outcome of unprecedented rise in demand for water year round. The unregulated tanker services acts as an alternative water supply and distribution system to the municipal water supply due to the nexus between the tanker lobby, builders and politicians. There are no strict regulations regarding the recharge of aquifers, daily extraction rates or the number of wells permitted, if any, in designated areas. In this context, the aqueduct system, which was still functioning and in use daily in some parts of the city until the mid-twentieth century, is an example of an alternative, environmentally sustainable, cost-effective and decentralized water supply, especially valuable during periods of water scarcity.

Surveys conducted by Bhagvat and others (2004) from 1992 to 2004 noted that some *wadas* (large mansion or house), especially in the core city areas of Budhwar, Guruwar, Shukrawar and Shaniwar were still using the water from the cisterns (fig 5). In areas expanding beyond the core city, it was observed that a few dipping wells were still in use for drawing water and that few water tankers were filled by pumping out water from these (Bhagvat et al. 2004; Gokhale 2016). It has been observed that local residents have been aware of the connection of these water outlets to Lake Katraj and aware of

Fig. 6 Images of the aqueduct system, including the underground network (*nala/nahar*), dipping wells (*uchvāsa*), and cisterns/reservoirs (*haud*) being used for daily activities and for rituals taken from an archival video highlighting the documentation work undertaken by Shrikrishna Bhagvat, Shriram Bhagvat, Nandkumar Bangude and Sharad Lonkar from 1992 to 2004 (Source: Personal collection of photographs, sketches, videos, notes and news articles by Shrikrishna Bhagvat and Shriram Bhagvat, 1992 to 2004).

their antiquity and origin in the Peshwa period (Gokhale and Deo 2016). The density of this network in the core city areas reveals the potential of this system of uninterrupted potable water supply in the densely populated areas and points to the relevance and utility of these structures even today.

The Creation of an Ecosystem of Flows and Networks

Pune's historic *nahar* system has the potential to exemplify and shift our understanding of "smart cities," which need sustainable, affordable and socially just systems that address climate change challenges and provide water in urban areas. Making use of ancient methods of sustainable water resource management

and consumption could be appealing to city dwellers as well as urban planners. This would be compatible with the Indian government's Smart Cities Mission commitment to innovation, while making it possible to conserve a sustainable and highly advanced traditional water technology and heritage infrastructure (Ministry of Housing and Urban Affairs 2024).

Within India, Smart City goals often focus on globally inspired, world-conjuring projects. For these projects to be sustainable in the long term, they need to be based on an awareness of local ecosystems and an ability to adapt to them. In this context, the *qanāt* or the *karez* system that was adopted from the Gulf of Persia and moulded to the local context of the city of Pune, is in fact a testament to the possibilities of a globally inspired water management system. Unlike the original design from central Asia, where the water was being sourced from aquifers, due to the presence of abundant monsoon rainfall, the Peshwa aqueducts collected surface water runoff (used as a water source), along with base flows from natural springs. The rest of the system relied on fundamental principles of gravity and pressure, in line with the local topography.

It is worth pondering that in many similar cases of water management, opportunities and outcomes have often been constrained by technology and communication. However, the competent use of available resources resulted in systems that continue to sustain communities and if maintained, can be functional even after centuries.

Conclusion and Future Possibilities

Today, the heritage and cultural value of the partially remaining structure of the Peshwa *nahar* persists. The associated pride and sense of belonging felt by citizens of Pune should be tapped as a force for the system's conservation and preservation. It is also important to demystify people's absolute dependence on centralized water supply systems and supplementary unorganized systems like tankers, which exist due to political patronage and not necessarily because of any benefit to society. It is important to diversify water supply sources by moving toward local and decentralized systems. In times of climate change, using already existing decentralized water systems will help make it possible to adapt to the water stresses of the future. In the present case, though the historic system cannot be fully recovered, its core values can be borrowed and implemented to create a sustainable water infrastructure. The aqueduct system is a perfect example of a "value case," since it combines climate resilient infrastructure, effective partnerships and innovative water management along with the potential for heritage preservation (D'Agostino and Hein 2024). In addition to water's obvious value as a utility, it is important to consider how local stakeholders may see opportunities for job creation and education in the need to create local bodies and institutions for maintenance and management of the system.

The existing research, data and documentation concerning the Peshwa *nahar* system can aid the development of educational museums and historical, recreational and cultural tours, which could involve local citizens, student bodies and university departments. Because this is a Grade-I heritage structure, implementation of these strategies would require a robust framework at the municipal corporation level (Heritage Committee 2017). This could be achieved with a successful bid for Corporate Social Responsibility funding to preserve the last remnants of the water system and by

connecting with programs such as “Adopt a Heritage" proposed by the Ministry of Tourism (2020).

The Peshwa *nahar* system merits a cohesive and collaborative approach that not only safeguards the historic structure but has the potential to become a model for future water system design.

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