



Bāravas: An Architectural Exploration of the Traditional Groundwater Storage Structures of Pune, India

RESEARCH PAPER

MANAS MARATHE 

**Author affiliations can be found in the back matter of this article*

]u[ubiquity press

ABSTRACT

This paper explores the architecture of *bāravas*, which are stepped ponds, built traditionally in western India for storing and fetching groundwater. It attempts to understand their architecture, construction technique and spatial qualities through case examples of two *bāravas* found in Pune, built during the 14th century. The data is obtained mainly through field research carried during November 2018 and documented in the form of field notes, sketches, maps, photographs and drawings. Secondary sources of literature such as books, journal articles, gazetteers and translations of old Sanskrit texts in English and regional language Marāṭhī were useful to crosscheck and supplement the observations made on the field. The findings reveal that *bāravas* are location-specific, adhere to the hydro-geological conditions of the site, and make the invisible groundwater visible to the users. They transcend their utilitarian function and also serve as interactive community spaces. In conclusion, the paper highlights the need to document, revive and reuse *bāravas* so that they once again become a visible part of the settlement fabric as community spaces and encourage people to share and value groundwater.

CORRESPONDING AUTHOR:

Manas Marathe

Marathwada Mitra Mandal
College of Architecture,
Savitibai Phule Pune
University, IN

ar.manasmarathe@gmail.com

TO CITE THIS ARTICLE:

Marathe, M. 2021. Bāravas: An Architectural Exploration of the Traditional Groundwater Storage Structures of Pune, India. *Ancient Asia*, 12: 1, pp. 1–15. DOI: <https://doi.org/10.5334/aa.207>

Traditional groundwater storage structures such as cisterns, stepwells, tanks, and wells in India performed an array of functions – cultural, religious, social, and utilitarian. They have served as sites to access groundwater, meeting places for women fetching their daily water, sacred precincts for holy bathing and the performance of religious rituals, and also community places for interaction and celebration (Hegewald 2002:1; Jain-Neubauer 2016: 9–11). At the same time, these spaces display the creative imagination, architectural skills and hydrological knowledge of the artisans. Their construction was realised through the collective efforts of the community, with the financial support and patronage of the rulers and elite (Agarwal et al. 2001: 6; Chakravarty 2006: xxi–xxiv; Jacob 2013: 3–4). These structures once dotted the landscape of many ancient Indian settlements. However, with changed urban realities, pressures of urban growth and technological advances, few of them survive today.

As explained by Hegewald (2002: 214), new technological advances made water provision possible to individual houses directly through faucets, pipes, pumps, and other means. Instead of carrying and bringing water from the traditional water structures, it was convenient for people to utilize water offered by taps in their houses. Thus, many of the traditional water structures went into disuse. Moreover, with the decline in the powers of local rulers and other wealthy people, the patronage and financial support essential for their construction on a public level did not exist anymore. Consequently, there was a discontinuity in the construction of any new traditional groundwater structures at the community level and simultaneously gradual neglect of the already existing ones (ibid).

Today, despite being small in number, historic wells, cisterns and other groundwater storage structures continue to fulfil the water requirements of many people in small towns and villages of India (Agarwal and Narain 1997; Pyati 2007). Their hydraulic technology, subterranean architecture and ornamentation have long been the subjects of study for architects, art historians and engineers. For instance, Jain-Neubauer (1981) has done excellent documentation of about sixty stepwells found in Gujarāṭa state and discussed their general architecture, structural features, sculptures and ornamentation. Mishra (1993, 1995) has done a detailed study of the traditional rainwater and groundwater storage structures of Rājasthāna. (Mate, 1998, 2006) has studied the history of water management and hydraulic technology in ancient India, wherein he has discussed the salient features and technical details of groundwater storage structures such as of *kūpas* (wells), *vāpīs* (stepwells) and *kunḍas* (stepped ponds).

Hegewald (2002) has taken a socio-cultural approach to understand how ideas, beliefs and concepts about water prevalent in India, have manifested themselves through water structures such as *kunḍa*, ornamental pools, tanks, and water palaces of South Asia, and especially India. Recently, Gupta (2016) and Pandey (2016) have presented the salient features of subterranean water structures such as *bāvadīs* or *bāolīs* (stepwells) and *kunḍa* found in western India in the states of Gujarāṭa and Rājasthāna. Similarly, Pāṭhaka (2017) has documented the history and evolution of several groundwater structures found in Mahārāṣṭra. Marathe (2019) has specifically studied the groundwater storage structures found in Puṇe district. He highlights their architectural features and their ecological as well as cultural significance.

Apart from the key studies mentioned above, there is limited research that aims to explore the architecture of traditional groundwater structures in India. Further research in this direction is essential for two main reasons. Firstly, as pointed out by the National Institute of Hydrology (2018), traditional groundwater structures display the knowledge about groundwater management and hydrology that was prevalent in ancient India. This knowledge, when unearthed and explored further, could assist in deriving time-tested tools and techniques for sustainable groundwater management.

Secondly, as argued by Nawre (2018: 54), some of these water structures are as old as human settlements. They have been developed, refined over several years and have served as critical regional infrastructure. Despite their heritage value and potential in functioning as vibrant public places at the community level, their conservation and adaptive reuse have received little attention. Therefore, exploring the possibility of repairing, conserving and reusing traditional groundwater structures within the settlement is necessary.

With these considerations in mind, this paper explores the architecture of *bāravas*, which are stepped ponds, built for storing groundwater. The name *bārava* is commonly used in the state of Mahārāṣṭra for big *kuṇḍa* having one or more intermediate landings in between the flight of steps (Pāṭhaka 2017: 54). Therefore, specifically in this paper, *bāravas* denote *kuṇḍas* that are elaborate, with one or more intermediate landings or platforms. Keeping this salient feature in mind, this paper presents two examples of *bāravas* and attempts to answer the following questions– What are the architectural and hydrogeological features of *bāravas*? What was their socio-cultural and religious significance? What learnings can one draw from them in the present context?

The study of *bāravas* discussed in this paper was conducted during November–December 2018, in the two peri-urban areas of Puṇe district of Mahārāṣṭra, as shown in **Figure 1**. It is difficult to estimate the total number of *bāravas* existing in Puṇe at present. However, Pāṭhaka (2017) has listed 14 *bāravas* found in different parts of Puṇe, out of which this paper studies two of them built during the 14th century at Mañcara and Loṇī Bhāpkara.

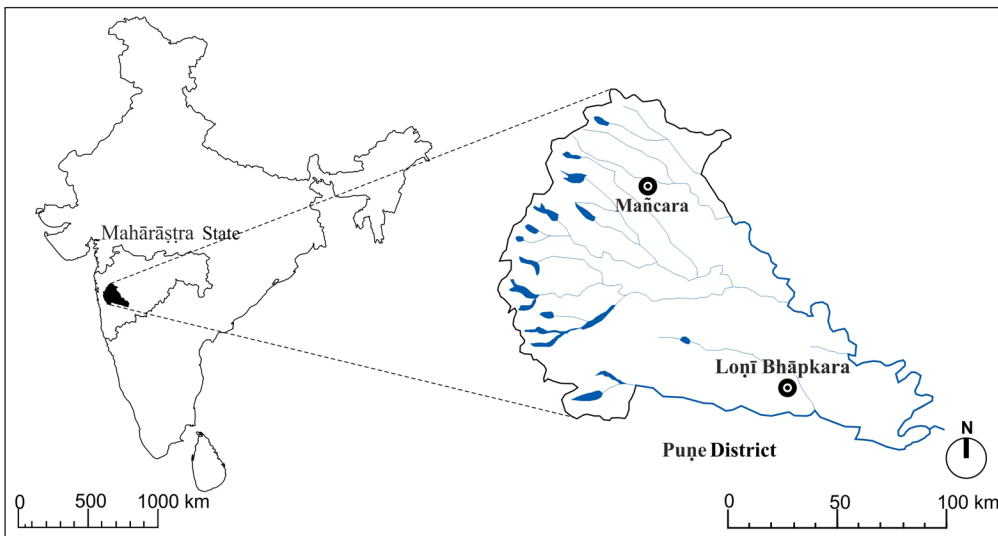


Figure 1 Map of Puṇe district showing the location of the two sites selected for research.
Source: Author. Adapted from DCO, 2014 and MSBTPCR, 2011.

For this paper, data was collected primarily through field research, direct observation and documented through field notes, sketches, photographs, maps, and measured drawings of structures. The descriptive information and drawings presented in this paper are based on the observations made during field research, unless and otherwise referenced specifically. Settlement plans showing the location of *bāravas* have been prepared with the aid of Google Earth Pro software. Actual measurements of *bāravas* taken during field research were useful for preparing their architectural drawings. Data obtained through secondary sources of literature such as journal articles and books in English as well as Marāṭhī,¹ District Gazetteers² and English translations of Saṃskṛt texts³ were useful to crosscheck and supplement the observations made on the field.

Before discussing the two case examples, the next section first introduces the reader to the *bārava* in general with respect to its overall form, construction features, and socio-religious significance.

2. BĀRAVAS: AN INTRODUCTION

Bāravas are elaborate versions of *kuṇḍas*, which are stepped ponds resembling a funnel, with their size decreasing from top to bottom (Jain-Neubauer 1981: 1), as shown in **Figure 2**. They may be square, oblong or sometimes octagonal, with depth varying considerably depending on the level of groundwater (ibid). They can be distinguished from tanks based on their surface area, step formation and overall depth.

¹ The Marathi sources include the book *Mahārāṣṭrāṭīl bārava sthāpatya āni pāramparik jalvyavasthāpan*, the article *Bārava*, both written by Pāṭhaka in 2017 and 2018 respectively and the article *Bhāratīya Jalavyavasthānchā Māgavā*, written by Kulkarī in 2018.

² The two gazetteers mainly referred at two places for this research are the Gazetteer of Bombay Presidency (GBP), Vol XVIII, Part III: Poona (1885) and the Mahārāṣṭra State Gazetteer: Land and its People (1968).

³ These include the translation of the old Sanskrit text *Bṛuhat-saṃhitā* written by Varāhamihira (500 A.D.) done by Sastri and Bhat (1946).

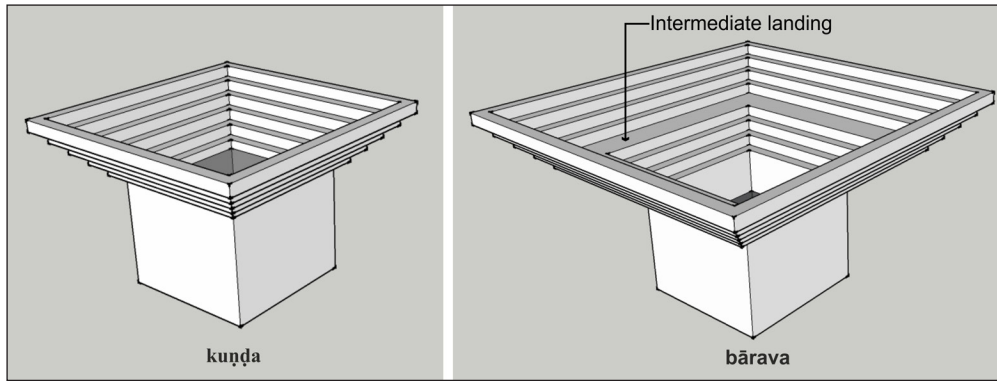


Figure 2 Sketch showing a typical kuṇḍa and a bārava.
Source: Author.

Bāravas are in many ways different from tanks, which are large, shallow water reservoirs with an extensive catchment area. As tanks usually store rainwater, they do not penetrate deep inside the ground and are lined by shallow flights of parallel steps (Hegewald 2002: 2). Owing to their large surface area, the rate of evaporation of water stored inside them can be quite high. On the contrary, bāravas have a small surface area. They penetrate deep into the ground to access groundwater. Their sides are lined with a steep flight of steps. Due to limited surface area at the bottom of bāravas and considerable depth below ground, the rate of evaporation of water from them is low. Nonetheless, there do exist certain hybrid types, and identifying them as tanks or bāravas may not be possible always (ibid).

Bāravas have one or more intermediate landings or platforms for standing and fetching water. Pāṭhaka (2017: 38) believes that the name bārava may have originated from its unit of measuring length called 'bāva'. One bāva is equivalent to 1.5 m; bārā i.e. twelve such bāvas make one bārava. Therefore, many bāravas have square-shaped plans, with their sides measuring approximately 18 m ($12 \times 1.5 = 18$ m). However, there seems to be flexibility in this rule. Depending on the local conditions, several bāravas may have their sides a little shorter or longer than 18 m (ibid). The name bārava is popularly used in Mahārāṣṭra for denoting elaborate versions of kuṇḍas. Additionally, bāravas are also referred to as bāva, *jalamāṇḍavī*, *puṣakarnī* and *vāpī* in Gujarāt (Kulkarnī 2018: 20).

2.1. CONSTRUCTION FEATURES OF BĀRAVAS

Selection of a suitable site containing good quantity and quality of groundwater was an essential prerequisite before commencing the construction of bāravas (Mate 1998: 18–19). Since ancient times, people seem to have developed their traditional knowledge about suitable site selection for constructing bāravas through systematic observation of the terrain over a period. An ancient text named *Bṛuhat-saṃhitā*, written by Varāhamihira (500 AD), has a chapter on the exploration of aquifers and springs. It mentions certain guidelines for finding appropriate sites for constructing groundwater structures after observing the colour, texture, smell, and touch of the soil and the type of vegetation growing in the soil. Two of these guidelines are mentioned below:

There is usually sweet water at places that have a cover of Munja grass, reeds, and where the earth is black or red, mixed with pebbles. Copper-coloured earth mixed with gravel will yield water of an astringent taste; red-brown earth, brackish water; a pale white ground produces saltwater; and blue earth, sweet water. (Sastri and Bhat 1946: 478–479)

Based on such guidelines, the finalisation of site happened before beginning with the actual construction. In the construction of bāravas, there was a need to take special care of the forces acting on their sides – the soils pressure from the external sides, hydraulic pressure from the internal sides and the self-weight of the steps (Pāṭhaka 2017: 33). Often, the sides of bāravas had a slope greater than the natural land-gradient outside. Consequently, they needed a large mass of steps to buttress the inward thrust of the soil on the walls. In some cases, additional stones were set within the steps to provide additional anchorage and prevent them from sliding away. These stones served as extensions of steps and functioned as seating platforms for people (ibid). Adjacent steps were joined either using a tongue and groove joint or by pouring molten lead in between their grooves to hold them together, as shown in **Figure 3**.

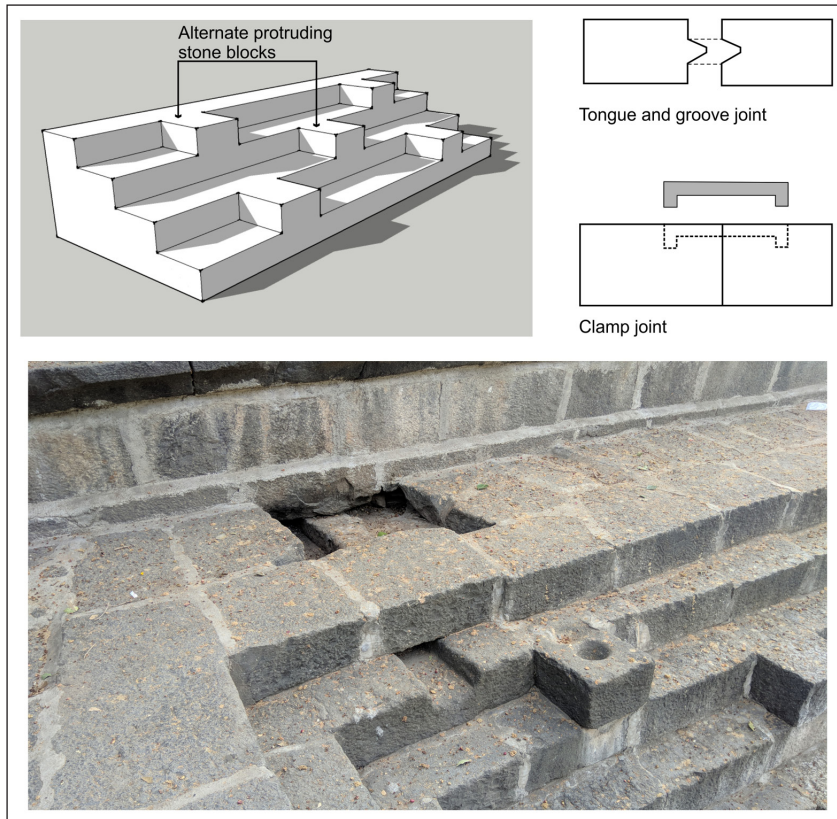


Figure 3 Sketches showing step profile and joinery.

Source: Author. Based on field observations.

Some *bāravas* have a well shaft in the centre of their basin (Hegewald, 2002: 122). Groundwater, shallow aquifers or springs feed the well shaft, which opens up into a funnel in the shape of a stepped inverted pyramid structure. The topmost landing of *bāravas* sometimes has a small outlet for draining out the water and maintaining the level of water inside. Most of them have a half-metre or more thick and one to three-metre-high parapet wall around their perimeter as a protective edge.

2.2. THE SOCIO-RELIGIOUS SIGNIFICANCE OF BĀRAVAS

Bāravas were not mere utilitarian structures. They were places for social gatherings, resting places for travellers and even pleasure structures for people to enjoy the water (Mahārāṣṭra State Gazetteer 1968: 138). A shade-giving tree with seating around it and a water structure next to it used to be a common sight in most of the medieval villages of Mahārāṣṭra and Puṇe (ibid). While some *bāravas* were located within the settlement, some were located at the entry or the boundary of the village (Pāṭhaka 2017: 17). Many of them served as resting places for travellers, who would pause at them for some time and quench their thirst by drinking the cool water of the *bāravas*. Sometimes, the name of the village itself was 'Bārava'. During field research, one such village was found in the Junnar district of Puṇe, named Bārava after the old *bārava* that once existed there. Such examples show how water structures were an inseparable part of many villages.

Certain *bāravas* had one or more pillared pavilions known as *maṇḍapas* along their sides. Sometimes, these pavilions protruded into the *bārava* and had certain mechanical devices such as a pulley or a wheel for lifting water (Hegewald 2002: 130). Some pavilions have a seating arrangement. Rich carvings, motifs and figures of different deities decorated the sides of the pavilion. It was a pleasurable experience for people to sit in such pavilions. *Bāravas* were public structures whose water could be shared by all the people of a village.

The motivation behind the construction of *bāravas* was often religious. The concept of attaining spiritual merit by performing acts of charity has a special significance in the Hindū religion (Kane 1974: 890). The ancient religious texts mention various acts of charity such as donation of money, land, cows, and so on to the needy. In these charitable acts, religious texts give gifting of water structures the highest value amongst all the other types of donations and are believed to give the highest spiritual reward to the donor (ibid). While donating a water structure, the donor had to follow two rules. The first one was that the donor must completely give up his ownership of the water structure. The second one was that the water structure should be in the common interest of society and should not benefit a few individuals alone (Kane 1974: 892–893).

After performing certain rituals of offering flowers and rice to the water and surrounding landscape, people imagined *bāravas* to be holy and fit for use (Kane 1974: 891). Often, the performances of these rituals took place on days of special cosmic events such as solar eclipses, lunar eclipses and summer and winter solstices (ibid). The concept of donation and attaining spiritual merit encouraged several rulers, traders, guilds of artisans and elite to construct *bāravas* for the common good of the society (Mate, 2006). Certain *bāravas* have stone inscriptions mentioning the names of donors who constructed and donated them to the community (Mate, 2006). The *bāra*va at Mañcara discussed later, is one such example.

Many *bāravas* were located within temple precincts where they functioned as bathing structures for devotees to whom purifying themselves by taking a bath before entering a temple was one of the religious rituals. As explained by Hegewald (2002: 25), ritualistic bathing prepares a person internally for crossing a border. Immersion of the body into water is symbolic of death and reappearing from water is symbolic of gaining rebirth. Here, death symbolises the dissolution of one's sins and pollution, while rebirth symbolises that one is pure and in the right state of mind for entering the sacred terrain of the divine. Thus, *bāravas* also acted as thresholds marking boundaries between the sacred and the profane (ibid). Their parapet wall separated the terrain of land from the terrain of water. The external sides of the parapet walls are plain, while their internal sides often have rows of beautifully carved niches. These niches once housed idols of different deities (Dandawate et al. 2006: 4), who were believed to ward off evil powers from the water (Hegewald 2002: 128). One may safely assume that placing idols of deities within the niches could have also been a way to remind people about the sacredness of water structures and thereby discourage them from polluting their water.

The various features of *bāravas* mentioned above have been further elaborated and illustrated through two case examples – the *bāravas* at Mañcara and Loṇī Bhāpkara, both dateable to the 14th century.

3. THE BĀRAVA AT MAÑCARA

Mañcara is a small town in the northern part of Puṇe district. The *bāra*va is located to the west of the present town near a stream known as *Kharḍī Nālā* as shown in **Figure 4**.

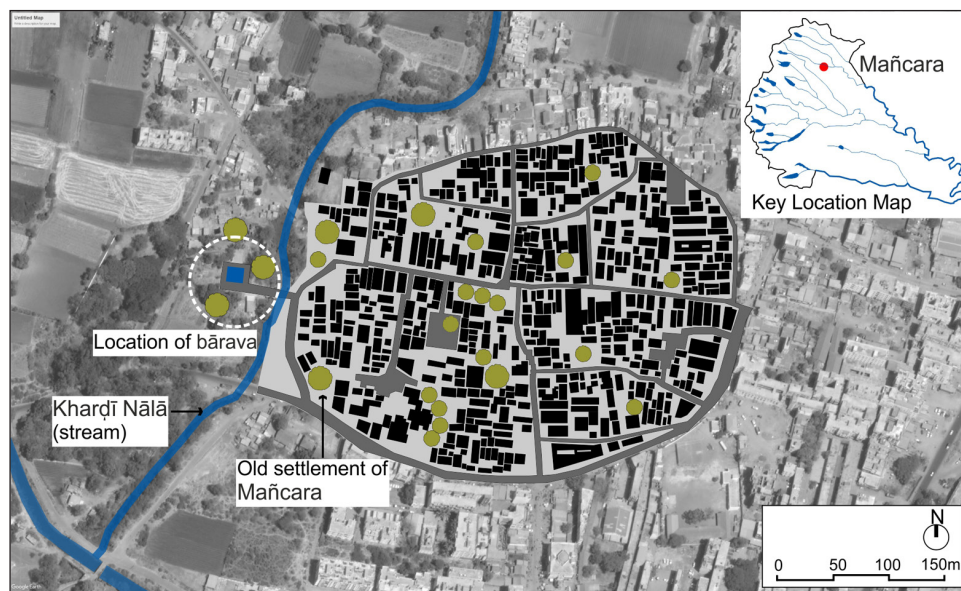


Figure 4 Plan showing the settlement of Mañcara and location of *bāra*va.

Source: Author. Data of field research carried on 29-11-2018 superimposed on Google Earth Pro 7.3.2.5491. Mañcar.

The Gazetteer of Bombay Presidency Vol. XVIII Part III (1885) has a mention of the *bāra*va here, which says,

To the west of the town, beyond a watercourse, is a fine (....) reservoir about twenty-five yards square with two flights of steps leading to the water. Except the west wall which has a niche (3' x 2'6") with carved side posts and sculpted foliage, the walls of the reservoir are plain. Within the niche is a much worn (...) inscription difficult to read. (GBP-XVIII Part-III 1885: 259)

The stone inscription mentioned in the Gazetteer dates back to 1344 A.D., whose language is Sanskrit and script is Devnāgarī (Mandake, 2003: 52–54). It states that the village head of Mañicar (original name of present Mañcara village) found a suitable spot having ample groundwater and constructed this bārava for the villagers to overcome their difficulty of finding adequate water during years of drought. It further states that the village head dedicates this bārava for the common good of the villagers (ibid). Thus, the stone inscription reveals that the bārava is more than 650 years old structure, built to provide water during the occurrence of droughts in Mañicar.

The description of the bārava in the Gazetteer supports the observations made during field research. Accordingly, the bārava is nearly a square with two flights of steps and three-level drops. At the topmost entry level, its side is about 22 m; at the intermediate landing level, its side is 19 m; and at the bottommost basin level, its side is about 11 m. The depth of the bārava is about 10.7 m from the level of water to the topmost portion. It is difficult to estimate the exact depth of the bārava due to the silt deposited at the bottom of the bārava.

The bārava has a 2.7 m high parapet wall around it. There are two entrances to the bārava – one along the southern side and another along the eastern side, each having a single flight of eleven steps, leading to the intermediate landing, which is 2.6 m below the ground level (see [Figure 5](#)). A half-metre wide and equally high seating platform is present at the intermediate landing. A peculiar feature of this bārava is the presence of a small drainage channel at the eastern corner of the intermediate landing for draining the water. As a result, water cannot rise above the level of the intermediate landing, thereby maintaining the water level inside the bārava.

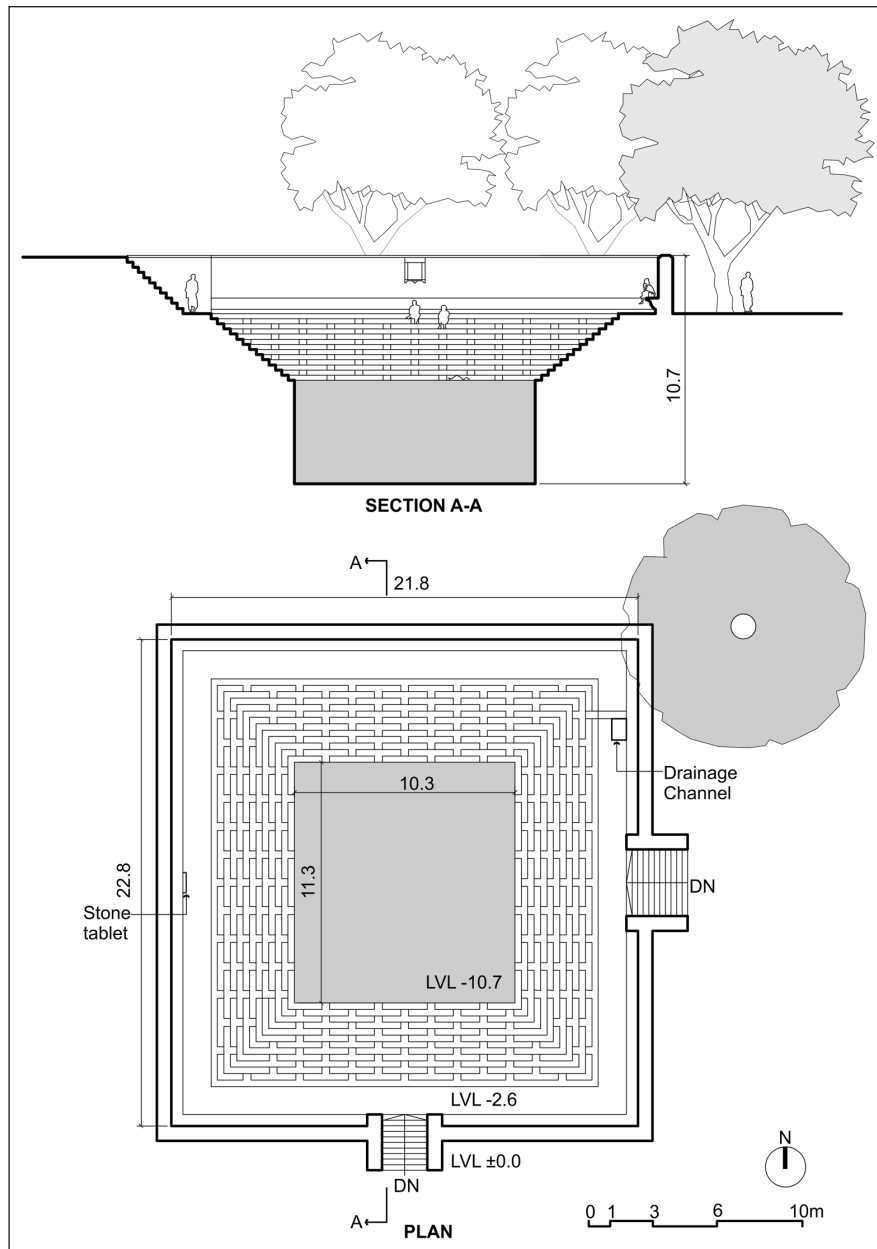


Figure 5 Plan and section of bārava at Mañicar.

Source: Author. Field research carried on 29-11-2018.

Another striking feature of this *bārava* is the design of its steps. The steps are 0.25 m wide and 0.17 m high. At every level, protruding stone blocks, placed at regular intervals in between two adjacent steps, provide anchorage to the steps and prevent their sliding due to the thrust of the soil from behind. In addition to their functional requirement, these protruding stone blocks form nice seating platforms for people. They also create an interesting rhythmic pattern and cast beautiful shadows during the daytime, highlighting the aesthetic side of structural elements.

In short, the stone inscription, the drainage channel at the intermediate landing level and the rhythmic pattern of steps stand out as prominent features of this *bārava* as shown in **Figure 6**. However, this *bārava* is a standalone structure, i.e. it is not part of any larger public or religious building complex. On the contrary, the *bārava* at Loṇī Bhāpkara is part of a temple precinct, wherein the idea of sacredness has shaped its architecture as seen in the next section.



Figure 6 Photographs showing the features of the *bārava* at Mañcar.

Source: Author. Field research carried on 29-11-2018.

4. THE *BĀRAVA* AT LOṆĪ BHĀPKARA

Loṇī Bhāpkara is a village in the southern part of Puṇe district. The *bārava* here dates back to the 14th century (Mate 1998: 106). It lies about 500 m away, towards the north-west of the village settlement as shown in **Figure 7**. The *bārava* is part of a temple precinct that originally housed a temple dedicated to Viṣṇu and a temple dedicated to Śiva⁴ (ibid).

Within the sacred precinct, the *bārava* forms a focal point for both the temples as shown in **Figure 8**. The *bārava* is nearly a square with its side measuring 21 m at its topmost part. It has two intermediate landings and its side reduces to 14 m at the bottommost part. According to the locals, a shaft is present within the bottommost part of the *bārava*. However, due to the accumulation of silt and dirt, it was difficult to confirm the existence of the shaft during field research. The depth of the *bārava* is 6.8 m. The entrance to the *bārava* is from the centre of the southern side. One can reach the level of the first landing by descending seven steps from the ground level.

A two-metre-high parapet wall runs along the edge of the first landing. The external sides of the wall are plain, while the internal sides have beautifully carved niches. The northern and western sides have seven niches each. The eastern side has four niches and the southern side has six niches. Thus, the four sides have 24 niches in total. According to Dandawate et al. (2006: 4), there is a possibility that these niches once contained 24 idols of different incarnations

⁴ According to Hindu religious belief, Viṣṇu and Śiva are the supreme Gods who maintain and regenerate this creation. Therefore, in India, there are many temples dedicated to both these supreme Gods. Particularly in this case, on interviewing the villagers, it was found that the original Viṣṇu temple was damaged in the 1990s and therefore a new temple dedicated to Dattātraya (considered to be an incarnation of three supreme Gods – Brahmā, Viṣṇu and Śiva) was built in its place. Today, the Śiva temple stands as it is and the Dattātraya temple stands in place of the Viṣṇu temple. This information is supported by the study of (Dandawate et al., 2006).

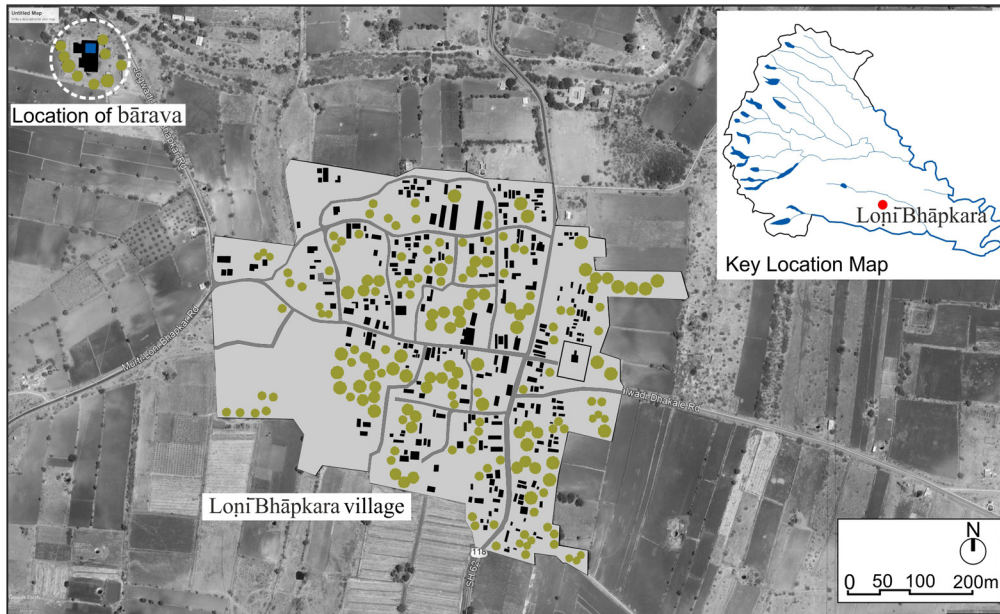


Figure 7 Map showing the settlement of Loṇī Bhāpkara and location of bārava.

Source: Author. Data of field research carried on 21-11-2018 superimposed on Google Earth Pro 7.3.2.5491. Loṇī Bhāpkara.

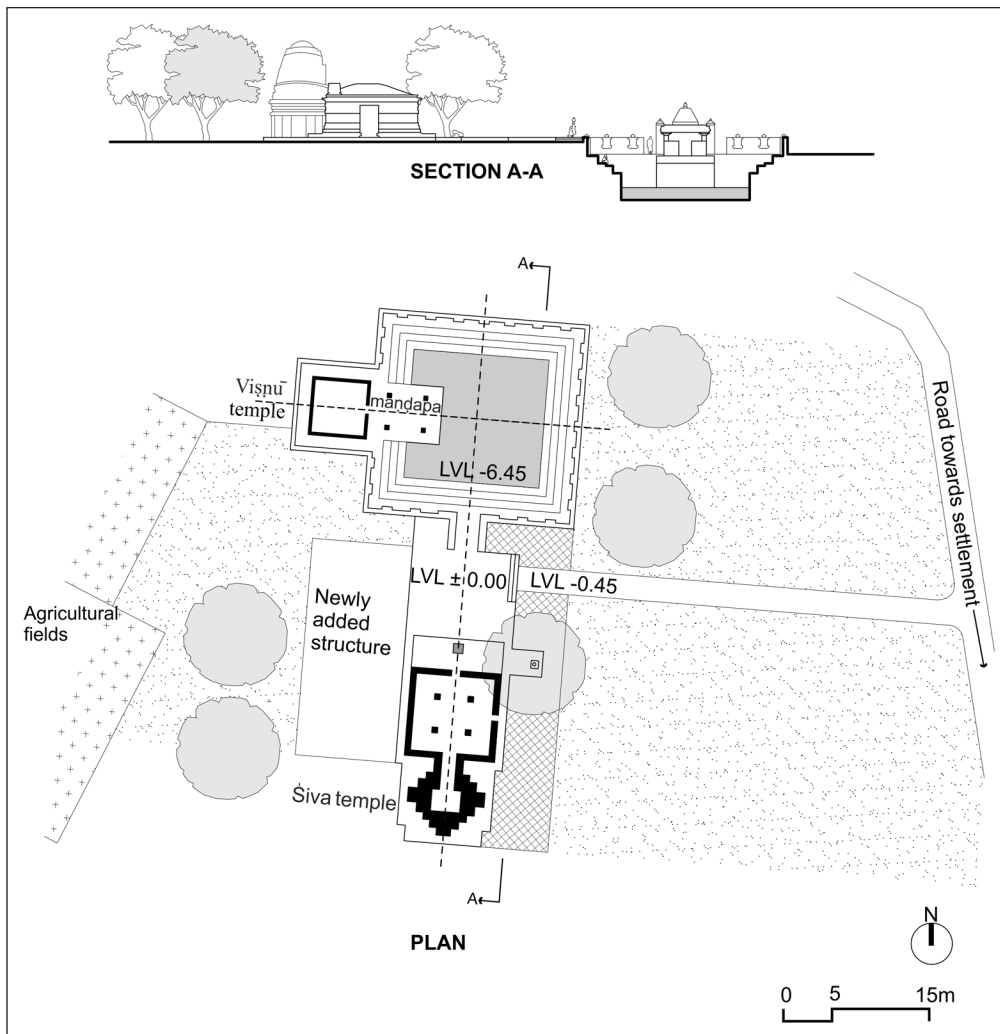


Figure 8 Plan and section of the temple precinct at Loṇī Bhāpkara.

Source: Author. Field Research carried on 21-11-2018.

of Viṣṇu. Besides, there are two more niches on the sidewalls of the entrance. As mentioned before, the idols were believed to ward off evil forces from the bārava and encouraged people to keep the water structure and its surroundings clean and free from pollution. Such details highlight the water management practices of health and hygiene.

A special architectural feature of this bārava is the existence of a protruding maṇḍapa on its western side in front of the Viṣṇu temple as shown in **Figure 9**. In plan, the maṇḍapa is a square, with its side measuring 5 m. Four circular columns present at four corners of the maṇḍapa,

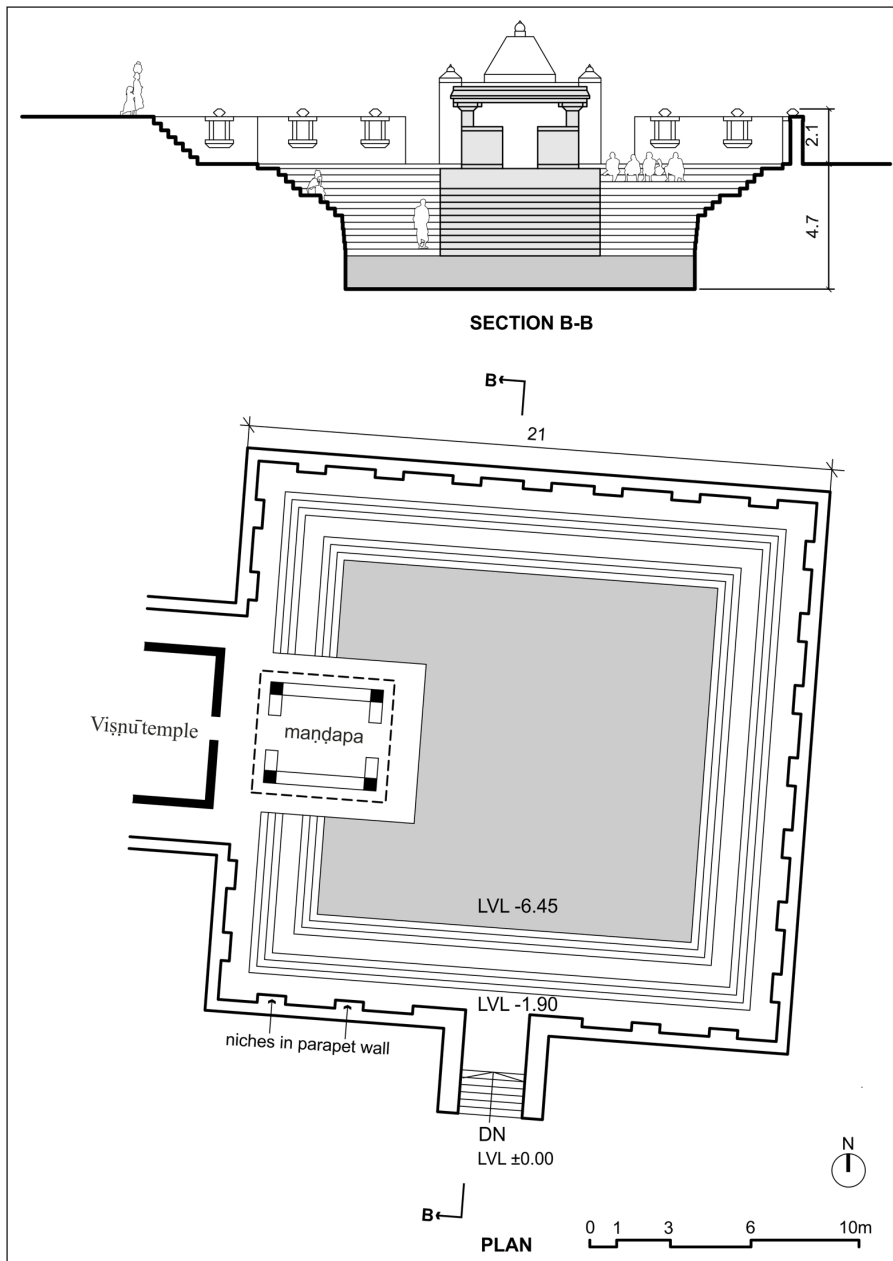


Figure 9 Plan and section of the bārava within the temple precinct of Loṇī Bhāpkara.

Source: Author. Field Research carried on 21-11-2018.

support the stone roof on to their brackets and capitals. In between the four columns, there is a stone seating, with the 1.5 m high wall of maṇḍapa itself acting as the backrest. The walls of the maṇḍapa have column motifs carved on its external side. The panels in between these column motifs contain figures of different deities in elegant postures. The pavilion is believed to once contain a big sculpture of *Varāha* – an incarnation of Viṣṇu having the face of a wild boar and the body of a human being (Pāṭhaka 2017: 103). Currently, the sculpture lies within the temple precinct in a damaged condition. The maṇḍapa served as a seating place for the devotees. Moreover, because of its protraction, people could utilise it for drawing water from the bārava by lowering a vessel tied to a rope.

The steps of this bārava are simple. Their width is 0.27 m while their height is 0.25 m. The height of steps is more than the usual height of steps, i.e. 0.15–0.18 m. Probably, it was essential to have such high steps to achieve the overall depth of bārava within a limited space, thereby putting a restriction on the lateral spread. Due to their height, the steps are slightly uncomfortable for ascending and descending but are quite comfortable for sitting. Thus, the bārava at Loṇī Bhāpkara occupies a focal position within the entire layout of temple precinct; its artistic maṇḍapa and beautiful niches on the internal side of the parapet wall stand out as prominent architectural features as shown in **Figure 10**. Here, the bārava becomes a part of the temple geometry and attains sanctity.



Overall view of the bārava



Manḍapa panel with ornamentation



Niche

Figure 10 Architectural features of the bārava at Loṇī Bhāpkara.

Source: Author. Field research carried on 21-11-2018.

5. OBSERVATIONS ABOUT BĀRAVAS

The two case examples discussed so far illustrate the various architectural features of bāravas. Although they are located at different places, showing variation in their forms, certain characteristics and architectural principles followed while constructing them are common to all, as explained below.

5.1. LOCATIONAL AND HYDROGEOLOGICAL SENSITIVITY

A strong connection with the local conditions of site is a common feature of most traditional water structures in India (Jacob 2013: 3), including bāravas. From the two case examples of bāravas, we observe that the prevailing local conditions such as nature of terrain and depth of groundwater have influenced their size, overall form and architectural detailing. They vary subtly from one another. For instance, the bāravas at Mañcara and Loṇī Bhāpkara are both squares in plan with approximately the same size (21 × 21 m); however, their overall depths vary due to the difference in the depths of aquifers at both the places.

Simultaneously, we observe that the topography and subsurface conditions determine the shape of bāravas and the profile of their steps. For instance, the sides of the bārava at Mañcara are set at a steep angle, greater than the natural slope of the ground. Therefore, to prevent the sliding of the sidewalls due to soil pressure, placing of additional stone blocks in between the steps is essential to buttress and counteract the inward thrust of the soil. Such an arrangement of stone blocks is not required in case of the bārava at Loṇī Bhāpkara, as its sides are not set at an angle steeper than the natural slope of the ground. These instances show that within a broad set of architectural principles in place, there was inherent flexibility in achieving the ultimate form of bāravas based on the structural requirements and specificities of the site.

Water structures such as *bāravas* also exhibit the hydrogeological knowledge of the artisans who constructed them several centuries ago (National Institute of Hydrology 2018: 99–100). Most of the *bāravas* found in *Puṇe* and *Mahārāṣṭra*, including the two examples discussed here, have been carved out from hard basalt rock, which constitutes a substantial portion of the terrain. The layers of basalt have little porosity and are largely devoid of water (CGDB 2013: 7–8). Only those layers that have cracks and openings in between them due to weathering and rupturing, serve as potential spaces for storage and movement of groundwater. Generally, such spaces occur up to a depth of 20 m below the ground surface and they form the shallow aquifers that recharge easily with rainwater. Those occurring at greater depths of 40 m or more are normally confined aquifers, which take time to recharge (ibid).

The artisans seemed to have considered these hydrogeological facts while constructing *bāravas* in *Puṇe* and *Mahārāṣṭra*, which are usually 7–10 m deep (Pāṭhaka 2018), similar to the ones discussed in this paper. Because of their restricted depths, they tap water from shallow aquifers that recharge easily due to rainwater during monsoon and do not damage the deeper confined aquifers that are difficult to recharge (ibid).

During field research, it was observed that both the *bāravas* contained a reasonable quantity of water. While lack of periodic cleaning and accumulation of water hyacinth had polluted the water of the *bārava* at *Loṇī Bhāpkara*, regular maintenance and cleaning had kept the water of the *bārava* at *Mañcara* clean and fit for domestic usage. Since majority of the households at the two places have access to tap water, people do not use the water from *bāravas* for drinking but do use it for bathing, washing clothes and cleaning utensils, as observed during the field research. Additionally, they tend to use more water from the *bāravas* during the summer months, when water supply from taps is irregular. Thus, it is significant to note that even after so many centuries; *bāravas* have managed to keep their value intact, especially in times of water scarcity.

In short, location-specific design and sensitiveness towards the hydrogeological conditions of the site stand out as prominent architectural features of *bāravas*. Both these features have made them durable as well as sustainable.

5.2. BĀRAVAS AS SOCIAL SPACES MAKING INVISIBLE GROUNDWATER VISIBLE

The case examples of *bāravas* show that they are not mere utilitarian structures that store groundwater. They are interesting spaces for people to appreciate the presence of water within settlements. Although people's lifestyle and religious values may have changed, they still use *bāravas* as community spaces, as observed during the field research. Many people use the *bārava* at *Mañcara* for swimming and bathing and the *bārava* at *Loṇī Bhāpkara* as a place for gathering and meeting each other. The villagers after working in their farms enjoy the shade and quietness provided by the *bāravas* to have their mid-day meal and take some rest during the hot afternoon hours. Occasionally, even students utilise the quiet space for studying. Thus, *bāravas* transcend their utilitarian function by incorporating aesthetic merit and become social spaces for community interaction.

Apart from being the much necessary social spaces within the settlement, another significant characteristic of traditional water structures such as *bāravas* is that they make the invisible groundwater visible to the people (Rudolph-Cleff and Shankar in press). Their funnel-shaped form and arrangement of steps give people the pleasure of experiencing the seasonal fluctuation of the stored water. Along with the changing water level inside *bāravas*, their appearance also changes. During monsoon, their steps are invisible as the water level inside is highest. With the end of monsoon, the steps start becoming visible slowly, one by one, as the water level inside begins to fall gradually. While in summer, the entire arrangement of steps becomes visible as the water level inside is lowest. This phenomenon is not only pleasurable but also useful to the people for comprehending the quantity of water stored inside *bāravas* by counting the number of steps exposed above the surface of the water. Thus, visibility of water plays a dual role – it enables people to appreciate its changing aesthetics and simultaneously recognise its value.

From the discussion so far, one may safely conclude that bāravas are excellent examples of traditional architecture that has flourished in Pune and elsewhere in India for many centuries. This architecture is location-specific, respects the hydrogeological conditions of the site and makes the invisible groundwater visible to the people. Due to these architectural features, bāravas transcend their utilitarian function of storing groundwater and serve as interactive community spaces with socio-cultural and socio-technical identity.

Despite their architectural value, many bāravas and other similar groundwater structures exist today in a neglected state. Many of them remain hidden from the eyes of people as trees and bushes have grown from their walls. Over the period, their usefulness as water storage structures has declined with people gaining easy access to tap water. Consequently, people have turned many of them into places for dumping construction waste and household garbage, which has polluted their water and damaged their structure. Before people damage them any further, it is essential to take immediate steps for their protection, documentation and conservation.

Bāravas, when conserved, would not only function as utilitarian structures but could serve as shared community spaces for people to come together, interact and enjoy the presence of water within the settlement. Despite a change in people's lifestyle and religious practices, they still visit temples frequently. Therefore, even if bāravas within temple precincts may not be useful for bathing or performing religious rituals, they could still be repaired and maintained and used as designed sit-outs for people.

Today, modern water infrastructure is separated from the realm of settlement design and architecture and fails to generate interesting spaces that invite people to enjoy, admire and value groundwater. As pointed out by Perysinaki (2010: 2), modern water infrastructure lacks the potential to shape settlement form and disallows people to see, hear, touch and experience the presence of groundwater. Therefore, taking a lesson from bāravas, we need to work on alternate designs and technologies that do not keep groundwater extraction process hidden but instead make it visible to the people.

Ultimately, we must acknowledge the traditional hydrogeological wisdom embedded in the architecture of bāravas. Wherever possible and appropriate, we should attempt to conserve such groundwater storage structures that have withstood the test of time and have heritage value. Possibly, structures such as these would encourage people to share, respect and value groundwater, when it once again becomes a visible part of the settlement fabric.

NOTE

This paper follows the Library of Congress Romanisation system for transliteration of non-Roman words. However, the non-roman names of books and authors that are already transliterated in English have been retained as they are.

ACKNOWLEDGEMENTS

I would like to thank Prof. Dr-Ing. Annette Rudolph-Cleff and Prof. Dr Gerrit Jasper Schenk, both from Technical University Darmstadt, Germany for giving me their valuable comments for this research paper. I am also thankful to the reviewer whose comments helped me in improving the paper.

COMPETING INTERESTS

The author has no competing interests to declare.

AUTHOR AFFILIATION

Manas Marathe  orcid.org/0000-0002-8648-8005

Marathwada Mitra Mandal College of Architecture, Savitibai Phule Pune University, IN

- Agarwal, A and Narain, S. 1997. *Dying Wisdom: Rise, fall and potential of India's traditional water harvesting systems*. New Delhi: Centre for Science and Environment.
- Agarwal, A, Narain, S and Khurana, I. 2001. *Making Water Everybody's Business: Practice and Policy of Water Harvesting*. New Delhi: Centre for Science and Environment.
- CGDB (Central Groundwater Development Board). 2013. *Ground Water Information, Pune District, Maharashtra*. Central Region, Nagpur: Ministry of Water Resources, Government of India. http://cgwb.gov.in/District_Profile/Maharashtra/Pune.pdf.
- Chakravarty, KK. 2006. Towards a sustainable water policy. In: Chakravarty, KK, Badam, GL and Paranjpye, V (eds.), *Traditional Water Management Systems of India*. Bhopal, New Delhi: Indira Gandhi Rashtriya Manav Sangrahalaya, Aryan Books International; Indira Gandhi Rashtriya Manav Sangrahalaya; Aryan Books International. pp. xix–xxviii.
- Dandawate, PP, Joshi, PS and Gajul, BS. 2006. Traditional systems of water management in Maharashtra. In: Chakravarty, KK, Badam, GL and Paranjpye, V (eds.), *Traditional Water Management Systems of India*. Bhopal, New Delhi: Indira Gandhi Rashtriya Manav Sangrahalaya, Aryan Books International; Indira Gandhi Rashtriya Manav Sangrahalaya; Aryan Books International. pp. 3–7.
- DCO (Directorate of Census Operations). 2014. *District Census Handbook Pune*. 28. New Delhi.
- GBP-XVIII, Part-III (Gazetteer of the Bombay Presidency: Volume XVIII Part III: Poona). 1885. Bombay.
- Google Earth Pro 7.3.2.5491. Mañcar: 19°0'17.45" N, 73°56'23.34"E. Eye Alt. 802 m.
- Google Earth Pro 7.3.2.5491. 08-01-2019. Loṇī Bhāpkara: 18°13'41.14" N, 74°23'04.56"E. Eye Alt. 1.42 km.
- Gupta, D. 2016. Urban planning at Bundi: Subterranean water structures. In: Jain-Neubauer, J (ed.), *Water design: Environment and histories*. Mumbai: Marg Foundation. pp. 32–47.
- Hegewald, J. 2002. *Water architecture in South Asia: A study of types, developments and meanings*. Leiden, Boston, Köln: Brill.
- Jacob, N. 2013. *Jalyatra: A journey through India's water wisdom*.
- Jain-Neubauer, J. 1981. *The stepwells of Gujarat: In art-historical perspective*. New Delhi: Abhinav Publications.
- Jain-Neubauer, J. 2016. Introduction. In: Jain-Neubauer, J (ed.), *Water design: Environment and histories*. Mumbai: Marg Foundation. pp. 8–31.
- Kane, PV. 1974. *History of Dharmashastra: Ancient and Medieval Religious and Civil Law*. Vol. II, Part II. Pune: Bhandarkar Oriental Research Institute.
- Kulkarni, M. 2018. Bhāratīya Jalavyavasthāncā Māgovā. In: Ghorpaḍe, A (ed.), *Bhavatāla: Udaka rākhile yuktine*. Pune. pp. 18–23.
- Maharashtra State Gazetteer. 1968. *Maharashtra – Land and its people*. Bombay: Directorate of Government printing, stationery and publications, Maharashtra State.
- Mandake, G. (ed.) 2003. Mañcar yethīl ī.sa. 1344 madhīl shilalekha. In *Shodha nibandha saṅgraha*. Akhila Mahārāṣṭra Itihās Paṛiṣad. Adhivēṣan Akrāve. 2002–03. Chāndvaḍa.
- Marathe, M. 2019. Reimagining water infrastructure in its cultural specificity: Case of Pune, India. PhD. Darmstadt, Germany: Technical University Darmstadt.
- Mate, MS. 1998. *A History of Water Management and Hydraulic Technology in India (1500 B.C. to 1800 A.D.)*. New Delhi: D.K. Publishers Distributors Pvt. Ltd.
- Mishra, A. 1993. *Āj bhi khare hain tālāb*. New Delhi.
- Mishra, A. 1995. *Rājasthāna ki rajat bānde*. New Delhi: Gandhi Peace Foundation.
- MSBTPCR (Maharashtra State Bureau of Textbook Production and Curriculum Research). 2011. *Geography*. Pune: Prabhat Printing Works.
- National Institute of Hydrology. 2018. *Hydrologic knowledge in ancient India*. Roorkee, Uttarakhand. <http://nihroorkee.gov.in/publication/hydrologic-knowledge-ancient-india>.
- Nawre, A. 2018. Between community and culture: The criticality of landscape infrastructure reuse in India. *Journal of landscape architecture*, 13(3): 54–63. DOI: <https://doi.org/10.1080/18626033.2018.1589141>
- Pandey, A. 2016. Bawdi: The eloquent example of hydraulic engineering and ornamental architecture. *International Journal of Research Granthaalayah*, 4(1): 217–222. http://granthaalayah.com/Articles/Vol4Iss1/28_IJRG16_A01_39.pdf. DOI: <https://doi.org/10.29121/granthaalayah.v4.i1.2016.2867>
- Pāṭhaka, A. 2017. *Mahārāṣṭrātīl bāraḥva sthāpatya āni pāramparik jalvyavasthāpan*. Pune: Aparānt.
- Pāṭhaka, A. 2018. Bāraḥva. In: Ghorpaḍe, A (ed.), *Bhavtāla: Udak rākhile yuktine*. Pune. pp. 76–81.
- Persynaki, AM. 2010. *How do waterscape projects combine landscape design and natural processes to create dialogues that engage both culture and nature? The case of the Boston park system and the solar city*. France: World Wide Workshop for Young Environmental Scientists. <https://hal.archives-ouvertes.fr/hal-00521475/document>.

- Pyati, AT.** 2007. The well in every house: The story of Ravur village. In: Iyengar, S (ed.), *Waternama: A collection of traditional practices for water conservation and management in Karnataka*. Bangalore: Communication for Development and Learning. pp. 95–100.
- Rudolph-Cleff, A** and **Shankar, P.** In press. Making the invisible, visible. In: Carrecedo, OG-V (ed.), *Designing resilience in Asia. Thinking the unpredictable, designing with uncertainty*. Actar Publication.
- Sastri, SV** and **Bhat, RM.** 1946. *Varahamihir's Brihat Samhita: With an English translation and notes*. Mysore: V.B. Soobbiah and Sons.

TO CITE THIS ARTICLE:

Marathe, M. 2021. Bāravas: An Architectural Exploration of the Traditional Groundwater Storage Structures of Pune, India. *Ancient Asia*, 12: 1, pp. 1–15. DOI: <https://doi.org/10.5334/aa.207>

Published: 09 February 2021

COPYRIGHT:

© 2021 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See <http://creativecommons.org/licenses/by/4.0/>.

Ancient Asia is a peer-reviewed open access journal published by Ubiquity Press.