Fig. 1
Jaigarh Fort, Jaipur, India. Adapted from a photograph by Anubhuti Chandna.

Water Heritage

Valuing the Tangible and Intangible

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From a contemporary perspective, this essay examines a series of qualities and heritage values identified in traditional water systems. It approaches these systems from a cultural landscape perspective, recognising that their heritage values extend beyond individual structures to the broader relationships, practices and knowledge they embody. This framework enables a more comprehensive understanding of these interconnected tangible and intangible values. Four projects are discussed: the Watermills of Sierra de Cádiz, Andalucía, Spain; the Salt Fields in Hainan, China; the Water Meadows in Harnham, England; and the Fort Water System and Stepwells of Jaipur, India. We deliberately do not focus on water management, as the potential for learning from the past to address contemporary climate change challenges is discussed more extensively in other essays.

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The Charter on the Built Vernacular Heritage (ICOMOS, 1999), a valuable and concise document that addresses the concepts and problems of fragile and vulnerable heritage, emphasises the insoluble relationship between construction and the cultural landscape. The expression 'Outstanding Universal Value' is repeated in the definitions of cultural and natural heritage. Nevertheless, until 2005, it was not described as a key concept in the Operational Guidelines for Implementing the World Heritage Convention. Paragraph 49 clarifies that 'Outstanding Universal Value means cultural and/or natural significance, which is so exceptional as to transcend national boundaries and be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community (UNESCO World Heritage Centre, n.d.-a). To be considered as having Outstanding Universal Value, at least one of the ten criteria established by the committee must be met (UNESCO World Heritage Centre, n.d.-b). The following can be:

- 'an outstanding example of a type of building, architectural or technological ensemble, or landscape that illustrates (a) significant stage(s) in human history'.

- 'an outstanding example of a traditional human settlement, land use, or sea use, which is representative of a culture (or cultures) or human interaction with the environment, especially when it has become vulnerable to irreversible changes'.

Researchers and academics in landscape architecture or architecture can map these values to extract their wisdom and preserve their heritage, preferably in physical form. If physical preservation is impossible or not visible for various reasons, drawings help document their value for future generations, allowing us to benefit from our ancestors' knowledge.

HERITAGE VALUES

Recognising that something has value means that the qualities that define it are of interest or importance to a person or group—appreciating and valuing an asset, whatever its nature, is a collective act that concerns and affects society. It comes from the synergy of all the agents involved: academics, users, inhabitants, and ultimately, public institutions and/or administrations. Research is carried out by constructing the state of the art, and the same applies to valorisation. Therefore, it seems relevant to examine the most outstanding and pertinent reflections on this subject from the academic world and review precedents to better understand and delve deeper into the nature of these architectures and systems, as well as their qualifications. The theoretical basis and knowledge of these traditional water systems will validate the validity proposed here.

Since the beginning of the 20th century, many architects and landscape architects have investigated and recognised the value of waterworks. Qualities such as functionality, integration into the landscape, adaptability, sustainability, and identity have been attributed to traditional and vernacular architecture throughout the 20th and 21st centuries by intellectuals and scholars (Vellinga, 2013).

The placement of a traditional water system is determined by the anonymous author's selection process after recognising, understanding, and adapting the site. According to Amos Rapoport, 'vernacular environments [...] is the result of 'selectionism,' an evolutionary process whereby environments gradually become congruent with activity systems, lifestyles, meanings, etc (Rapoport, 2000). Bernard Rudofsky already detected this as a lesson from vernacular architecture: 'Instead of trying to 'conquer' nature, as we do, they welcome the vagaries of climate and the challenge of topography' (Rudofsky, 1964).

Implicitly, the landscape value of waterworks and hydraulic systems is assumed because contemplating them implies recognising the territories in which they are inserted, as they generate dispersed focal points of attraction that favor their transit and understanding. These qualities are recognised in traditional water systems. As with every water system and its architectural elements, the choice of location, the transformation of the land, and the functional organisation of the building's parts are pivotal aspects of construction and require adjustment over time to optimize production. Traditional water systems fulfil their functions only if the land is considered a part of them.

In this sense, the site was chosen and read carefully, forming the starting point to explore the possibilities of a human-made water system. The functionality that determines the shape of water systems and their waterworks also defines their size and relationship to relief, thereby ensuring their integration and low-disruptive presence in the environment. Regarding adaptation to the environment, the shape of these systems and architecture vary depending on the place's physical conditions, adjusting to the topographic, climatic, and biological specificities of the soil where they are located. Furthermore, these systems have changed over time. This is because people lived close by or even 'in' the system and changed the system daily. The productive nature of these systems and their architecture imply that their forms express the specific functions for which they are created. Local and proximity materials were used to construct these systems because they are available resources. Using environmental elements, optimised construction, and time.

To illustrate these reflections and discuss these heritage values, four traditional water systems from different corners of the world are discussed: the Watermills of Sierra de Cádiz, Andalucía, Spain, which were created to gain energy from the streams for grain milling and now ruins; the Salt Fields on the Yanpu Peninsula in Hainan, China, a system that harvests salt from the sea that starts to crumble; the Water Meadows in Harnham, England, in which streams are seasonally directed to irrigate the fields and fertilise the ground, which was renovated a few years ago; and the Fort Water System and Stepwells of Jaipur, India, a system that harvested, distributed, and conserved water, which today is only partial at use but starts to gain recognition. In the last few years, the government and local stakeholders have intervened to preserve and restore them.

The analysis of these systems speaks of strategic decisions based on deep knowledge of the landscape, techniques, and processes for optimising results, both in productive terms and with respect to the environment. In that sense, the water systems in this article are discussed explicitly as informative systems that speak to people's history, their relationships with the territory, and the broader context, such as using local, non-polluting, and recycled/recyclable materials; employing low-tech approaches; or respecting specific climatic and geographic conditions. The projects show diverse heritage values inherent in traditional water systems, which we discuss in terms of site-specific integration, sustainability, infrastructure, network, and identity. Today, the Fort Water System and Stepwells in Jaipur are recognised as heritage sites, primarily for tourism. Nevertheless, they are part of the experience of Jaipur as a UNESCO World Heritage City.

The selected projects have not (yet) been included on the World Heritage List. However, some acknowledge different kinds of statuses, showing that they are already considered valuable to society. The Watermills of the Sierra de Cádiz are ruined in the landscape and are not acknowledged as interesting study objects by archaeologists, architects, and landscape architects. Today, only a small group of villagers continues to produce salt using this traditional method. Rather than a means of making a living, it has become more of a performative practice aimed at attracting tourism, as salt production alone can no longer provide sufficient income for villagers. The Harnham Water Meadow belongs to a trust whose primary objective is to protect and preserve this delicate and unique environment for generations to come. Volunteers operate seasonal landscapes. Before discussing the heritage values of the projects, they are introduced.

WATERMILLS OF SIERRA DE CÁDIZ, ANDALUCÍA, SPAIN

The Sierra de Cádiz Watermill System is in a hilly area with many streams (Figure 2) and steep topography. The medieval origins of these devices are situated within pre-industrial architecture and confer historical value. The system used a series of slopes to generate the water pressure needed to drive the horizontal wheels of the mills during medieval times. In contrast, runoff from the slopes fed the ponds near the mills (Figure 3). Mills were positioned on meanders, forks, or points of confluence. In addition to positioning mills along watercourses, the system required proximity to

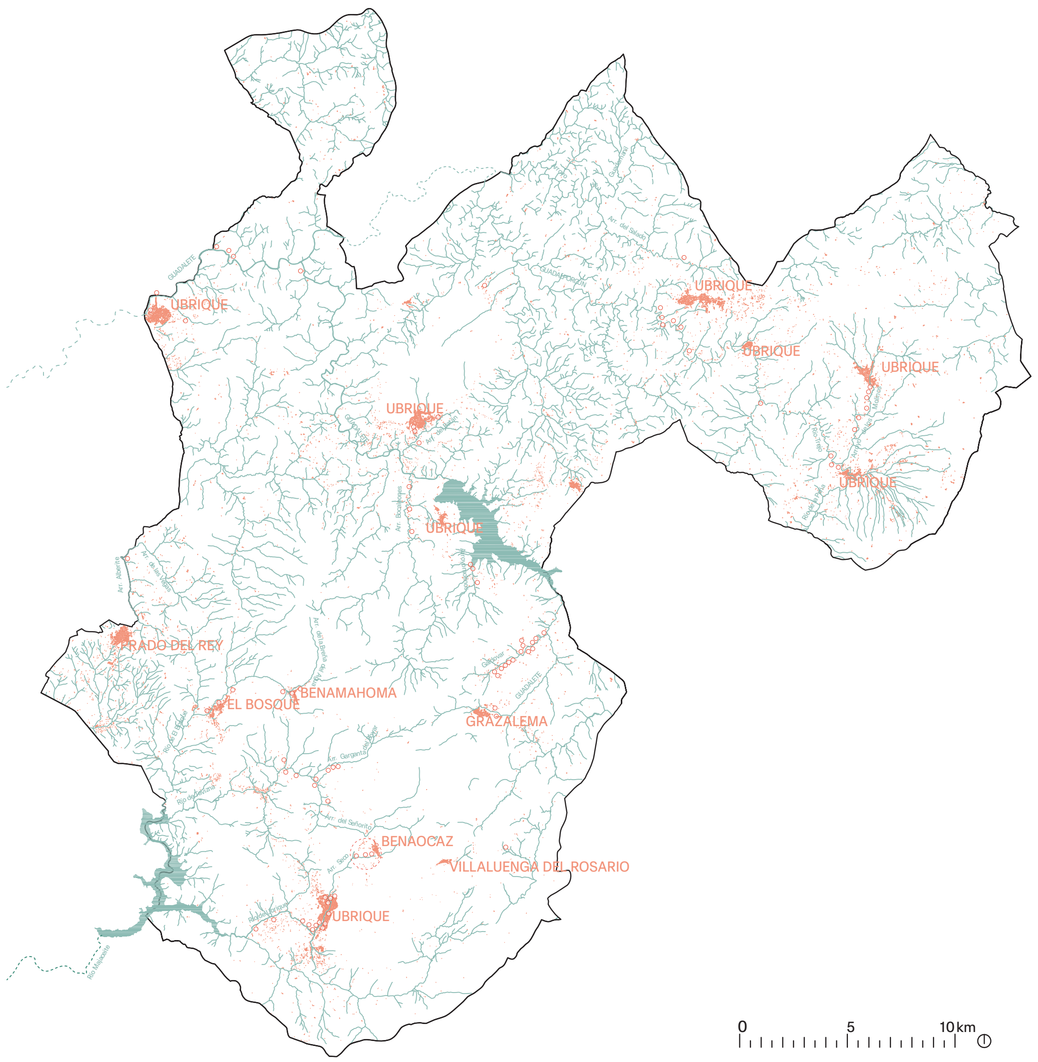


Fig. 2
Map of the physical and territorial environment of the Sierra de Cádiz: topography, hydrography and municipalities. Water mills are located along the riverbanks of the Sierra de Cádiz. Adapted from Rivero-Lamela (2019).

Fig. 3
Water mill 'Segundo' on the Arroyo Seco, Benaocaz (Sierra de Cádiz). Adapted from Rivero-Lamela (2019).

agricultural land and communication networks as well as a balanced spacing between mills. Given the scale of the territory and the considerable distance between the mills, the system hardly impaired the view of the landscape.

Each mill was built specifically on the slope of the riverbank. Although all mills had horizontal wheels and tower penstocks (a wide vertical pipe through which water flows, also known as the 'Aruba penstock'), they modified their formal system to use compact, regular prisms on banks with smooth topography or several irregular volumes on the more rugged terrain. Moreover, their hydraulic infrastructures, the retaining pond, the long irrigation channels, and the channels that linked the mills differed according to the landscape (a wheel and a bucket, where there was less demand or a greater concentration of mills, or two wheels and two buckets for better production to supply higher demand) without changing their function or internal operation and mechanisms, but with varying basic external infrastructures to obtain the most significant productivity. (Figure 4)

Regarding operation and functionality, in the case of water mills, the complex topography of the Sierra de Cádiz places these mills in their own natural space, which requires a functional understanding of the topography to conveniently adapt to the immediate area. The result is a simple architecture that is well suited to its function and is obtained economically and effectively. There were no contradictions between the forms and functions of these buildings. Grinding grains to produce flour immediately affects the form of mills. (Figure 5)

Their construction, most of which had two floors, consisted of a mixed structure with load-bearing walls of irregular stone masonry built with sand and lime mortar, 60-80 cm thick, and plastered with lime and wooden beams. The limestone used was the primary rock in the Sierra de Cádiz. Because of the region's heavy rains, roofs need to be sloped. The structure is made of wood, reeds found in the area, and Arab tiles. The use of Arabic tiles is an example the Islamic past, dating to the Nasrid period between the

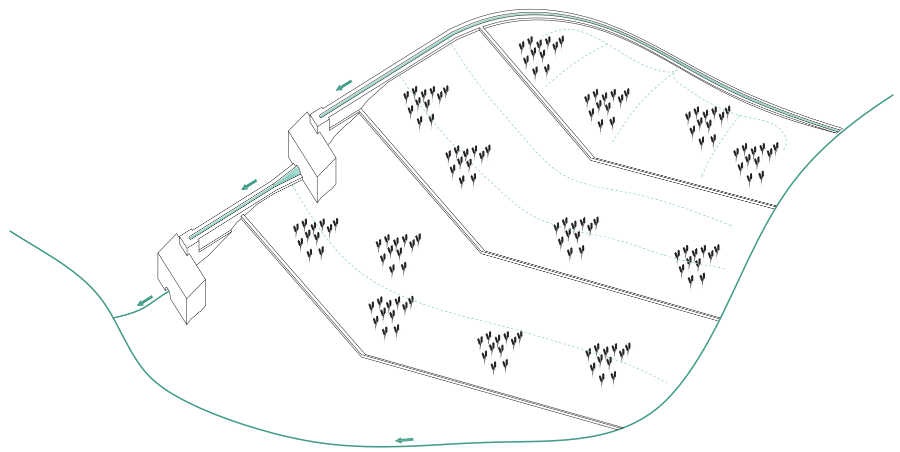


Fig. 4
Two mills use the same water pressure to generate energy while supplying the irrigation system. Adapted from Rivero-Lamela (2019).

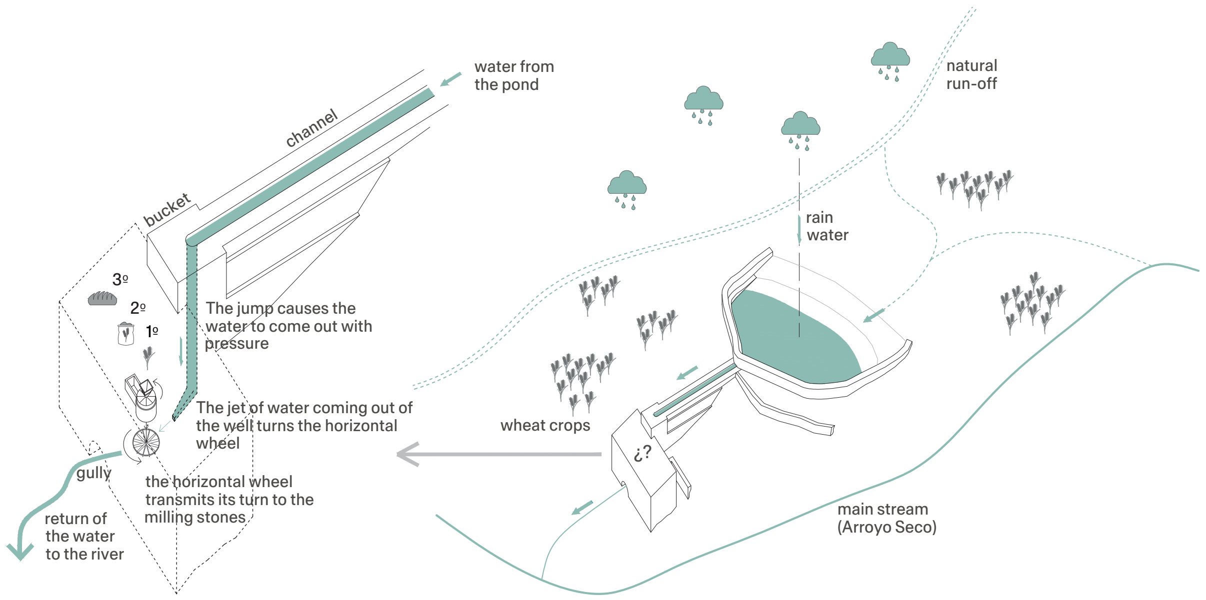


Fig. 5
Functional diagram of the mill, drawn according to the ruins found. Adapted from Rivero-Lamela (2019).

13th and 15th centuries. All these materials are used to build infrastructure that adequately addresses the different levels of the slopes where they are located, channelling or storing water, and terracing their immediate surroundings. Despite the differentiating nuances, the constructive and structural characteristics of mills in all regions are generally expected.

SALT FIELDS IN HAINAN, CHINA

The Sea Salt Fields are located along the bayshore on Hainan Island (Figure 6). In addition to harvesting salt, salt fields serve as buffers between villages and the sea. During high-tide periods, these stone salt fields significantly reduced the impact of waves on the bank and served as breakwaters to protect villages. Salt fields form a unique cultural landscape along the shores of the volcanic island. The stones at the beach were rearranged into fields surrounded by low walls to allow seawater to remain longer in the intertidal zone, making the edges of the salt fields suitable habitats for mangroves and other intertidal organisms. (Figure 7)

The form of the salt field is related to tidal movements. The ancestors of the salt village constructed a system based on the intertidal zones and height differences. Therefore, seawater can naturally flow into pools (fields) during high tide periods. The final process of the salt harvesting system uses sculptured volcanic stones. Salt can be harvested by exposing a thin layer of salty brine on top of a stone-shaped flat bowl to intense sunlight.

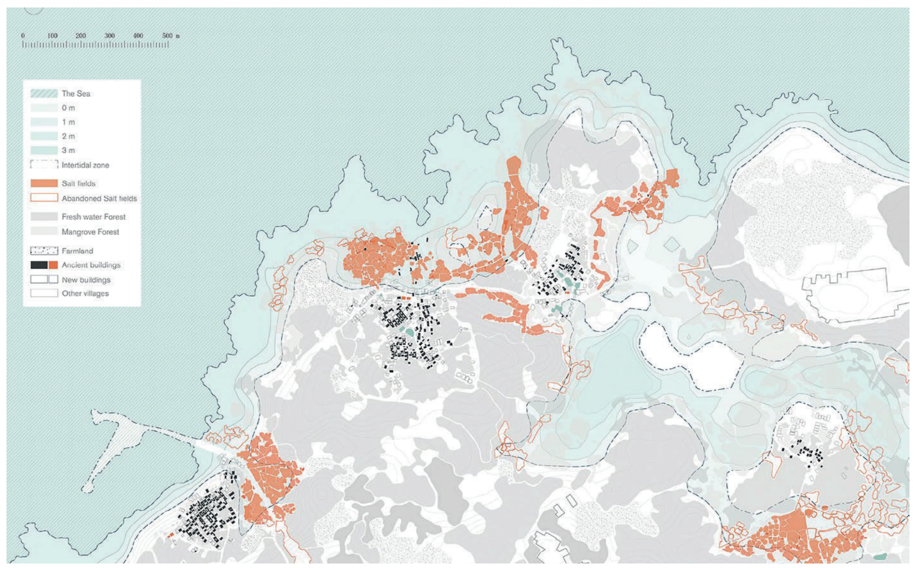


Fig. 6
A unique cultural landscape formed by salt fields. Adapted from Yan (2021a).

Fig. 7
Mangroves protect the salt fields formed by volcanic rocks by dissipating wave energy. Adapted from Yan (2021a).

Ancient villagers and the sea acted in the same space at different times—the users of this spectacular landscape changed throughout the day, a month, and even a year. Salt farmers harvest salt from salt mud during low-tide periods, and fish can breed in the same pools when weather or tidal conditions are unsuitable for salt production. This flexibility makes it possible for more stories to happen at the same time and creates more biographies of the landscape.

The high temperature and wide intertidal zone of Danzhou make salt winning possible. With the guidance of volcanic stone ditches, salt-field structures enable the refinement of seawater into usable salts. In ancient times, this mode of production was a means of survival for the villagers in this area of Hainan. (Figure 8)

Volcanic stones (from ancient geographical movements) and sand from local beaches are the primary construction materials for salt fields. Moreover, with the help of stone structures, mangrove forests grow more stably along the edges of fields. These small forests also serve as a buffer zone in front of the artificial structure facing the sea, reducing the damage from solid waves to salt field structures.

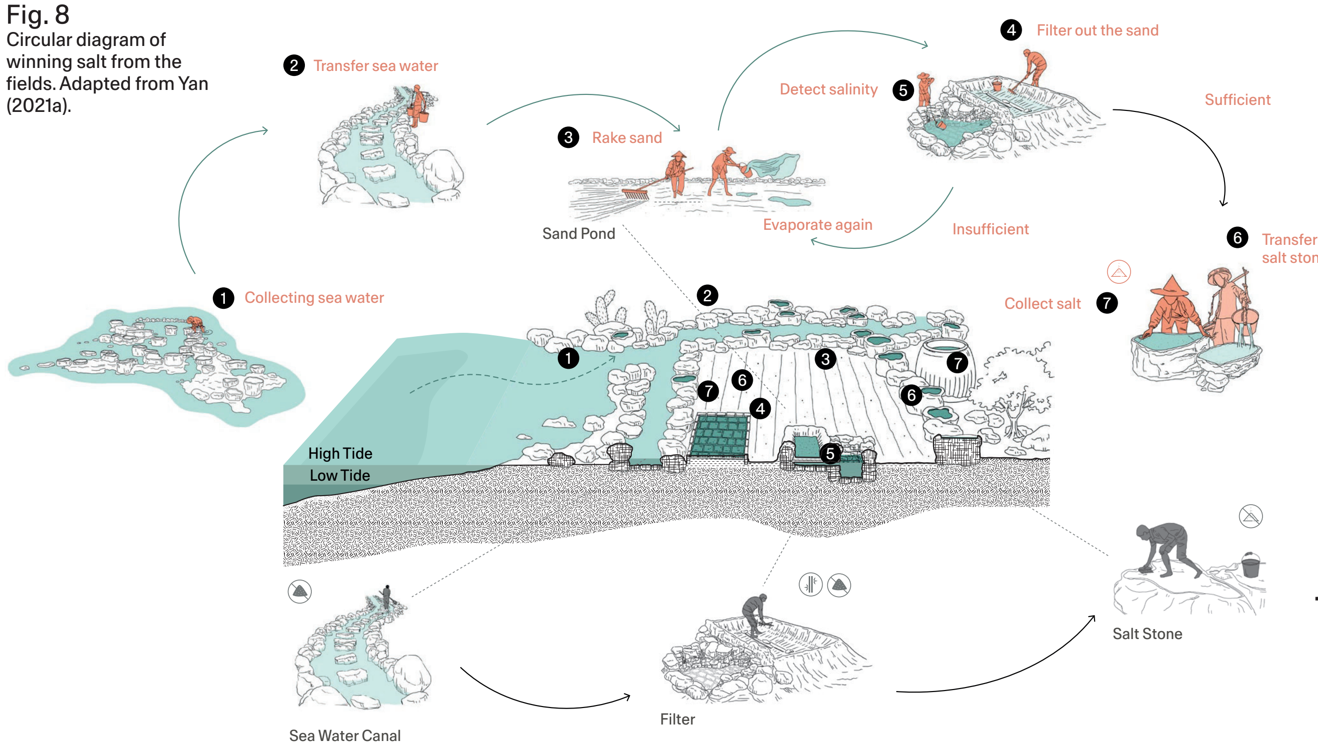


Fig. 8
Circular diagram of winning salt from the fields. Adapted from Yan (2021a).

WATER MEADOWS IN HARNHAM, ENGLAND

Water meadows are irrigation systems built in the chalk river valleys of Wessex, southwest England. The positioning of these water meadows in the lower riverbeds made it possible to use the slightly alkaline water and the river sedimentation as a natural fertiliser (Figure 9). In the case of Harnham water meadows, water from the Nadder and Avon rivers was used to create seasonal flooding. This enriched the soil, increased hay production, and contributed to the more extensive English agricultural 'Sheep-Corn system' (Cook et al., 2003).

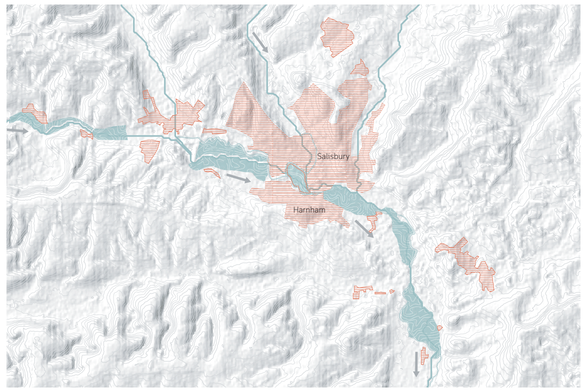


Fig. 9
(left) Tributaries within the River Avon catchment converge around Harnham and Salisbury. Adapted from Bazrafkan (2021).

Fig. 10
(right) Example of a 'bedwork' system by the River Avon (near Salisbury). Adapted from Bazrafkan (2021).

Water meadows are altered in such a way as to control the flow of water for a pasture-productive system. The' catchwork system' was one of the earliest systems used in medieval times. These 'field gutters' were formed by parallel channels that followed the contour lines of the hill slopes. Thus, water flowed from a higher level into the valley. The 17th-century 'bedwork system,' as used in the Harnham water meadows, was a more complex system of carriers, ridges and drains. They were characterised by curved ridges perpendicular to the primary water channel, also known as the herringbone layout, to distribute water on relatively flat river valleys (Figure 10). This latter system required more expertise and expense, so unlike the 'catchworks' created by hill farmers, 'bedworks' were often a product of wealthy landowners and large estates (Bird et al., 2017).

Controlled flooding of the Harnham water meadows relied on minor height differences and waterworks (made of local materials) that could be adjusted to provide adequate water flow. Two mills at Salisbury and Harnham were integrated into the water system, thereby increasing the water level upstream through impoundment. The water was then directed through the meadows in the so-called 'supply channels, with small wooden hatches (sluice gates) and small aqueducts. The water could then trickle down the constructed ridges, enriching the soil (Cook et al., 2008). Eventually, the surplus water was rediverted from the grasslands to the drainage ditches and channels back into the Avon River. (Figure 11)

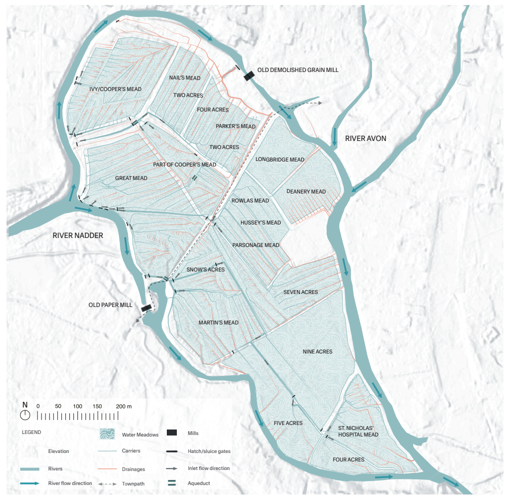
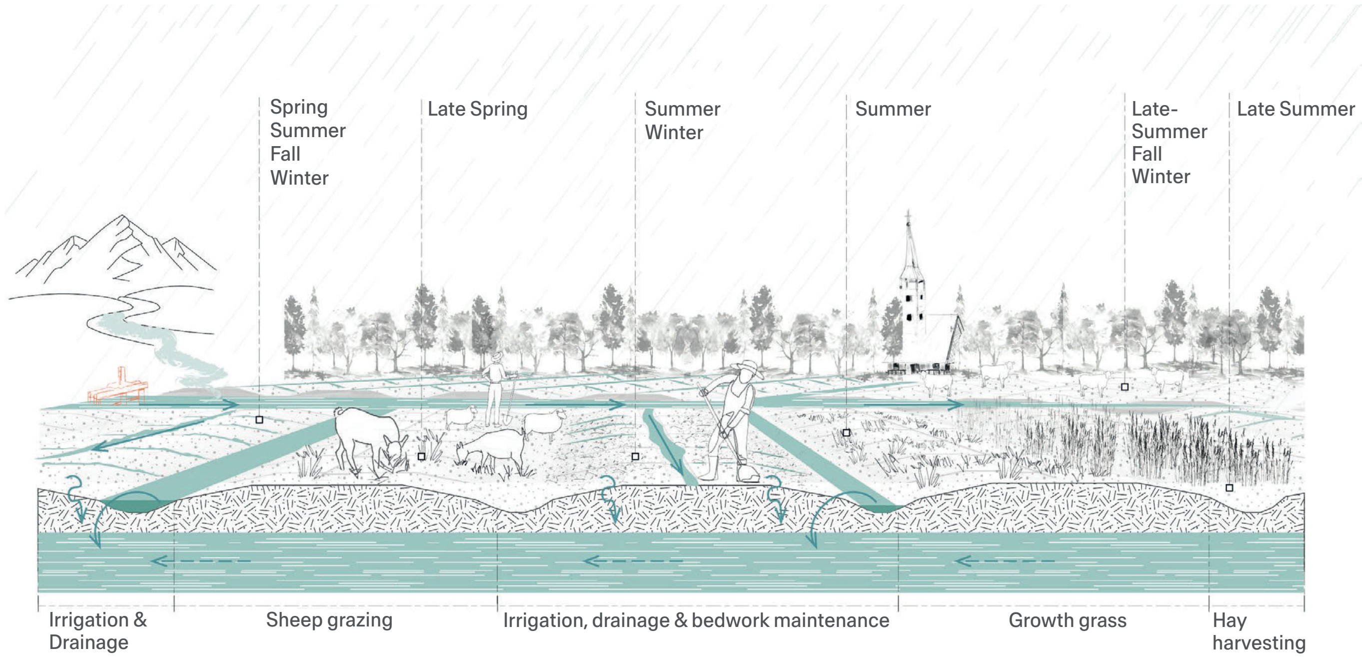


Fig. 11
(right) Plan of the water system. Based on the 1787 enclosure map by Tim Tatton-Brown. Adapted from Bazrafkan (2021).

Fig. 12
(left) The person responsible for managing the water meadows was known as the 'drowner'. Adapted from Bazrafkan (2021).

Drowning of the meadows occurred in a cyclical maintenance system (Figure 12). During the flooding seasons (winter/early spring/summer), the meadows were irrigated for 3-7 days and drained again for a couple of days. In mid-March, when the grass reached a height of 150 mm, grasslands were used to graze sheep. Towards the end of May, the sheep were removed, allowing the grass to grow into hay. Dairy cattle graze from June until the end of September, causing problems for the meadow surface and water banks. This led to the requirement for bed work maintenance at the end of the fall (Figure 13). These farming steps were taken to irrigate the grassland, bringing nutrients and oxygen into the soil so that (typically) two cuts of hay a year could be taken, making water meadows a productive pasture system. During flooding seasons, water meadows appear to be naturally flooded, whereas during dry seasons, the waterworks and ridges show evidence of an advanced human-made agricultural infrastructure.

Fig. 13
Circularity drawing of the seasonal farming steps. Adapted from Bazrafkan (2021).



FORT WATER SYSTEM AND STEPWELLS OF JAIPUR, INDIA

Jaipur is a city located in eastern Rajasthan, India. As part of a hot and dry climate zone, it experiences frequent water shortages. Thus, the local inhabitants mastered the use of limited water resources and designed structures that helped them use and conserve water efficiently. Some of these practices are still used in villages across the regions. The main principle behind these indigenous practices is 'rainwater harvesting, ' which is deeply rooted in the social fabric. These practices are eco-friendly and contextual, and base their logic on following natural processes, encouraging community participation, and allowing for a more equitable distribution of benefits. Two systems were discussed in the analysis of traditional water systems. Today, they are part of the city's urban realm: aqueducts of forts and stepwells. Although the two systems operate on different scales and principles, they together form a holistic water-harvesting system for the city.

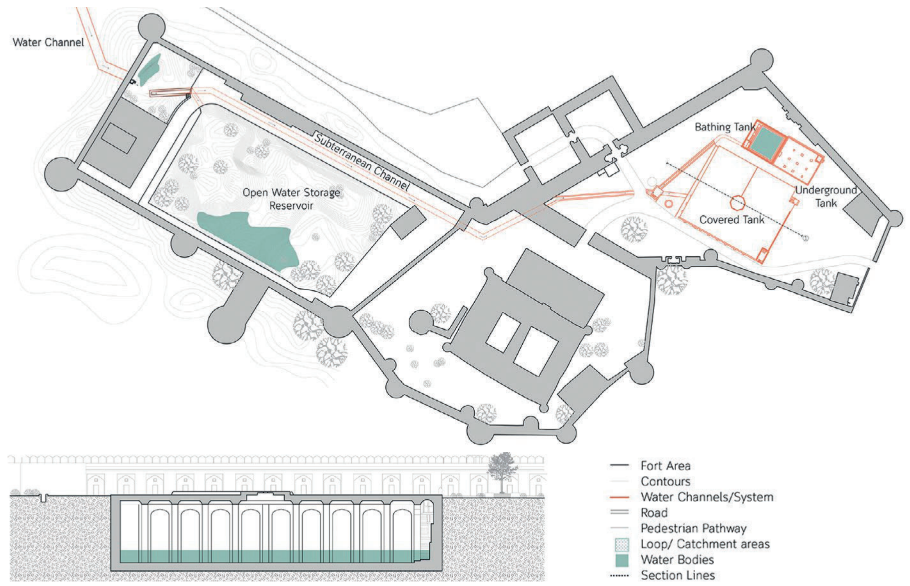
JAIGARH FORT WATER SYSTEM

Situated on the north hill of the city, 2000 ft high on the spurs of the Aravali range, the fort was built for defense, but the most exciting feature lies in the water catchment system. The system consisted of water channels totalling 3.5 km (Figure 14), designed to follow the topography, running along the hills before entering the fort walls through a common channel. The hillock is outlined with water ducts approximately a kilometre long, forming three elliptical loops. Between the loops, the water passes through an aqueduct raised on five bastions and 39 arches, which carries water from one hill to another to avoid sudden dips between hills. Small cisterns were installed at the junctions to facilitate the flow.

Along this route, the channels change their direction at sharp angles to promote the sedimentation of debris and runoff. The water falls into a rectangular opening on the floor that carries it into the fort through a subterranean channel. The first catchment area allowed debris to settle. Once filled, the water was directed towards the next reservoir through a channel inclined upward to 25 °. By opening a sluice gate, clean water flowed through underground channels to the central tank of the fort. Once water crosses the second gate of the fort, the channel leads to a water cistern with two sluiced openings. First, the water is directed to a large underground tank (Figure 15) holding 60,00,000 gallons of water. The tank ceiling rested on 80 arched pillars. The second opening leads to a bathing tank with a flight of steps down to the water. Adjoining the open tank towards the south is the third covered underground tank with nine holes on its ceiling to draw water for domestic and drinking purposes. This tank was intended only for clean water.

Fig. 14
Detailed catchment network of the Jaigarh water system (plan), conceptual diagram of the system, and a photograph of the water channel entering the fort. Adapted from Chandna (2019).

Fig. 15
Water network within Jaigarh Fort (plan at bottom left and photograph at right), and section of the underground tank. Adapted from Chandna (2019).



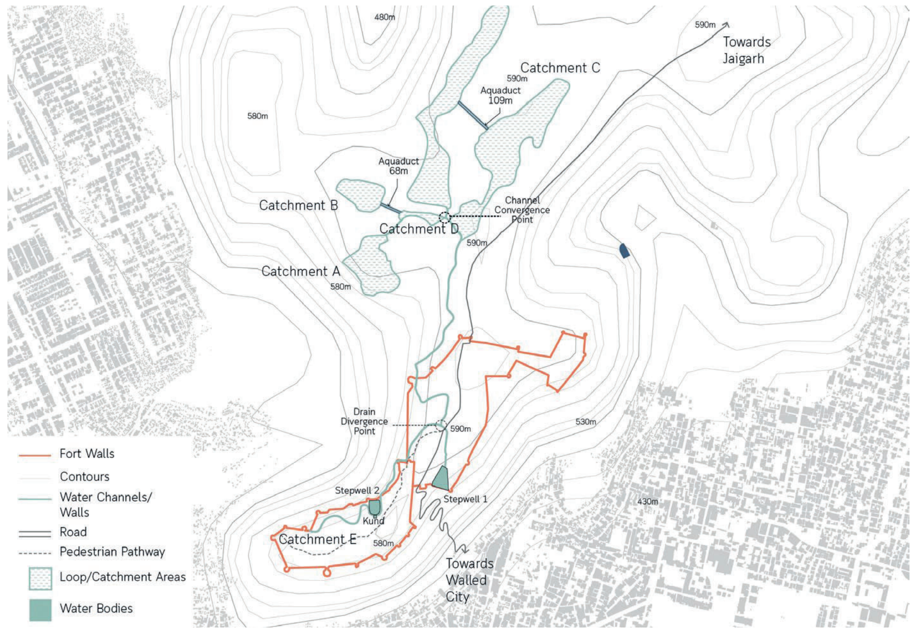
Underground tanks are advantageous because they minimise evaporation, prevent pollution, and provide natural water cooling. However, some channels and viaducts have deteriorated over the years owing to a lack of maintenance, resulting in ineffective system performance. However, some water is still collected and caters to the needs of tourists and inhabitants of the fort.

NAHARGARH FORT WATER SYSTEM

Located some distance from Jaigarh Fort and overlooking the city, Nahargarh Fort functioned as a residential royal fort, with a maze of courtyards and chambers for nine queens. Apart from providing basic facilities, the fort has a self-sufficient, elaborate water system with catchment areas extending approximately 6 km from the fort.

The main idea behind the networked system is to collect, control, purify, and store as much water as possible. Similar to the Jaigarh fort, this system forms five catchment loops that spread organically across the hill, connected through tiny channels and aqueducts (Figure 16) to bring water to the fort. The catchment beds were designed with gradient and undulating surfaces in mind. The runoff from these beds was collected and directed through a long drain that entered the fort, where it bifurcated at a distribution point with a cistern to switch the flow. (Figure 17)

Fig. 16
Network of water catchments and the distribution system within Nahargarh Fort. Adapted from Chandna (2019).



Unlike Jaigarh, the Nahargarh fort has two large stepwells (baolis) and a tank (kund) (Figure 18). The water from the distribution point flows in two directions towards the Stepwells. While ordinary people and animals used Stepwell 1 for bathing and recreation, Stepwell 2 was used for the royal family. Catchment area E, which lies within the fort, collects runoff from the fort area and directs it to the kund. The kund and stepwell 2 were interconnected to ensure maximum storage and adequate water distribution for various purposes.

Fig. 17
Water channels and aqueducts carry water to the Nahargarh fort. Adapted from Chandna (2019).

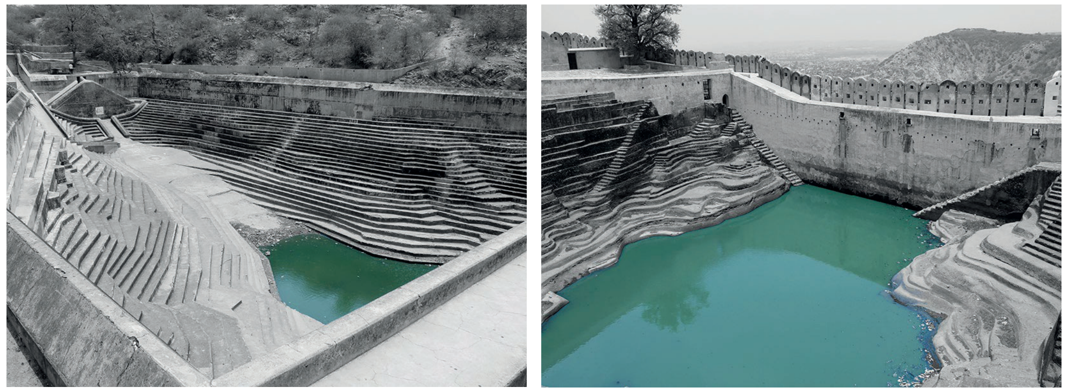
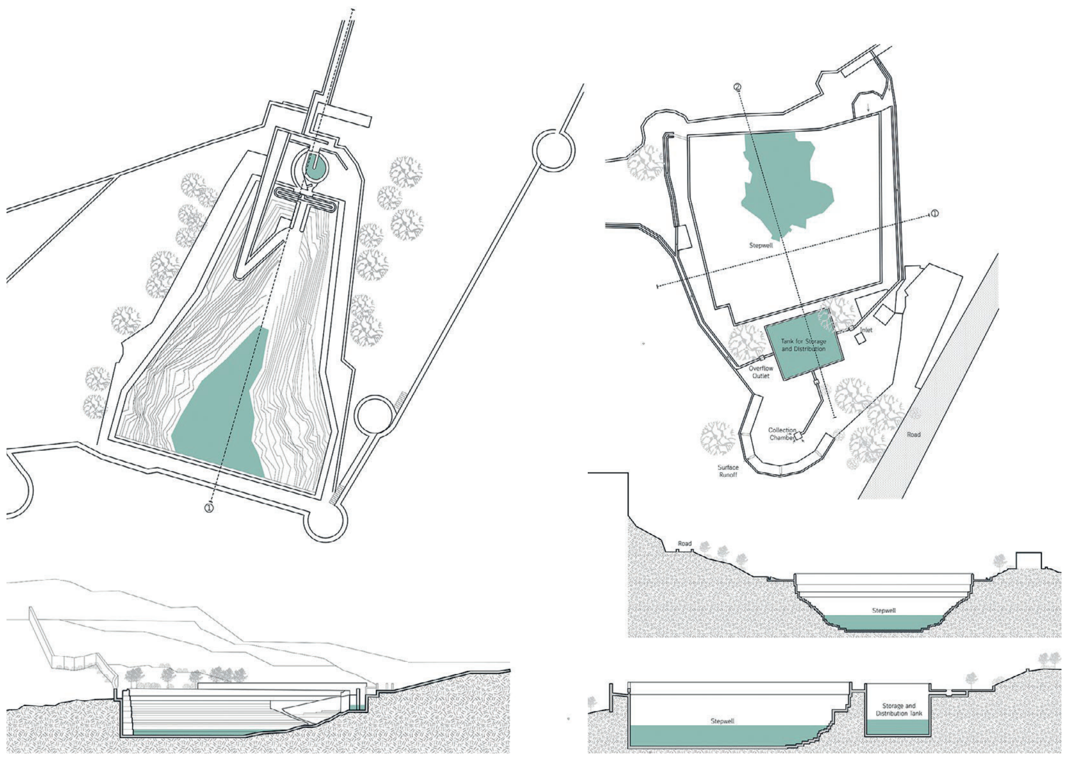


Fig. 18
Stepwells 1 and 2 at Nahargarh Fort. Adapted from Chandna (2019).



STEPWELLS OF JAIPUR

Water holds profound significance in Hindu cosmology, where it is regarded as the boundary between heaven and earth. For centuries, stepwells and stepped ponds, known by regional names such as *bavdis*, *bawadis*, *baolis*, and *vavs* (Figure 18) have formed enduring, circular water systems that have sustained communities by harvesting, storing, and providing access to water across generations. Integrated into everyday life, these structures are serving as important places for social interaction, cultural and religious practices, and, today, tourism. Built mainly between the 7th and mid-19th centuries, these structures usually range from three to nine stories deep, forming a passage into the terrain and helping escape the heat, thus becoming community spaces and being invested with religious meanings. Fed either by rainwater harvesting or by natural springs, these stepwells were mainly used for bathing and washing. However, some were built to cater to specific buildings or complexes, such as temples and gardens; some were used by commoners residing within the settlement, while others were part of highway infrastructure, where travellers/commuters and pilgrims would stop, park their animals, take shelter in the covered arches, and rest. Usually commissioned by royal and wealthy patrons, scholars estimate that by the 19th century, thousands of stepwells of varying grandeurs had been built across the country.

The structure of a stepwell usually combines two elements: a vertical shaft/well, protected from direct sunlight by a full or partial roof from which water can be drawn, and the surrounding steps, along with passageways and chambers as spaces for people. The well is lined with stones, which allow the water inside to freely fluctuate with the surrounding water table.

Approximately 50 stepwells in Jaipur have been identified, but only a few have been mapped and are partially conserved. Their concentrations can be observed around the town of Amber (Figure 19). To meet people's needs, the city had a well-functioning water system that included stepwells built within the settlement and along transportation routes. Thus, during the monsoon season, the descent to the water table is shorter, and the well fills and reaches higher levels while recharging the water table. Water is always available through the water table even during dry periods.

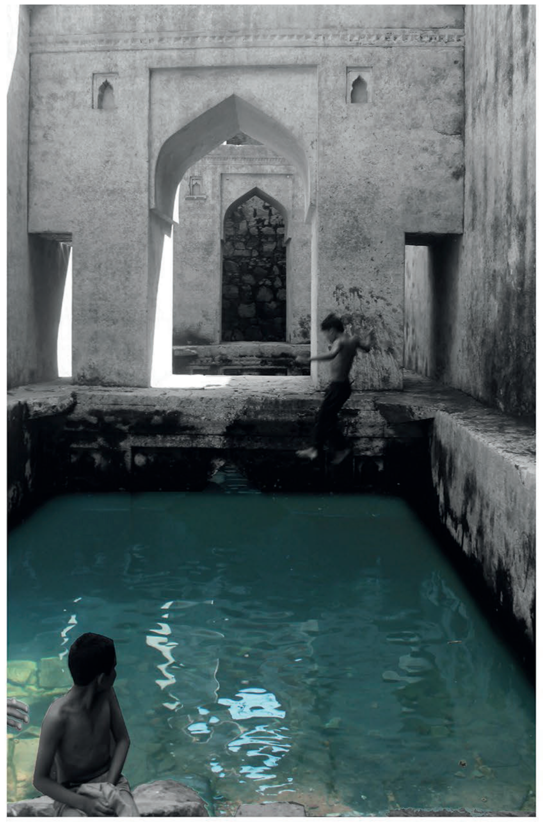
However, these structures gradually declined during British rule, as the authorities feared unsanitary conditions at these drinking and bathing spots and replaced them with centralised water pipes and pumps. Most of

Fig. 19
Panna Meena Kund, Amber. Adapted from Chandna (2019).

them have either dried up due to overuse or inadequate recharge from rain or contain polluted water due to lack of maintenance and government neglect.

The architecture of these bawadis varies according to the material scale, layout, shape, location, and when they were built. They have been found in rectangular, circular, or even L-shaped buildings constructed from stone masonry, rubble, or brick, and can have as many as four entrances. No two stepwells are identical, whether utilitarian or straightforward, complex or ornamented, depending on who commissioned them. Jaipur can be categorised into five typologies (Figure 20) based on access, water source, architectural style, additional spaces, and location.

Fig. 20
Typologies of stepwells. Adapted from Chandna (2019).

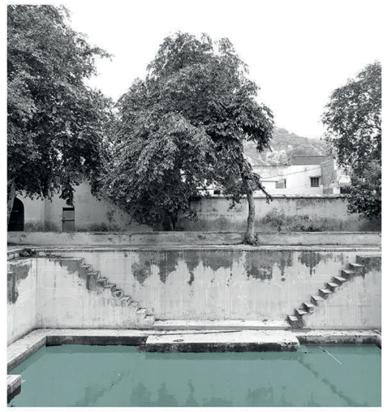


Cheela Bawadi

Atreya bawadi

Sarai bawadi

Bengali Bab ki bawadi



Pashuram Dwar ki bawadi

RECOGNISING HERITAGE VALUES

Illustrations of traditional water systems reveal heritage values to the extent that they are recognised collectively by society, academics, and researchers. These four values can be identified across all projects: site-specificity and integration, sustainability, their role in infrastructure and networks, and identity.

SITE-SPECIFIC AND INTEGRATION VALUES

All projects are site-specific and positioned precisely to optimise the results with minimum possible construction resources. The systems are integrated into the landscape, and the position and size of different traditional water systems are determined by the site's water resources and the function of each system. They usually adhere to the terrain on which they are built, and the terrain and relief are part of the systems that determine their possibilities. In addition, these systems were built using local materials. This causes them to merge and integrate into the environment without abrupt interruptions to the natural continuum.

The Watermills, the greatest possible topographic jump, were sought so that the water would acquire maximum pressure and thus move the horizontal wheel faster, which in turn would transmit the rotation to the stones that ground the grains.

Salt Fields extract salt from the seawater. A combination of volcanic soil, hot climate, and tidal conditions was sought to ensure that the sun could efficiently collect and naturally evaporate seawater, leaving behind crystallised salt. The strategic site-specific placement of these fields maximises salt production with minimal intervention, demonstrating a deep understanding of natural processes. Salt Fields are seamlessly integrated into the intertidal zone, and their layout and size are shaped by the site's water availability and the functional needs of salt production. They follow the terrain's natural contours, utilising tidal flows, evaporation basins, and stones that align with the coastal relief. Built with locally sourced volcanic stones, these salt fields blend harmoniously into their surroundings, maintaining a continuous connection with the natural environment without disrupting its balance.

Water Meadows are human-made irrigation systems built in river valleys to manage the water flow in relatively flat plains. The system uses height difference and a simple architecture: supply channels and ditches, hatches (small sluices), aqueducts, and soil ridges. This allows water to infiltrate, channel into, and divert from the grasslands. This process enriches soil, thereby increasing hay production. Grassland waterworks and constructed ridges form a layout that can be recognised during the dry season. Because of their strategic positioning, they appear to be inundated by adjacent rivers during flood seasons, and infrastructure is built to mitigate flooding.

The steps in the Stepwells of the Nahargarh Fort project shape the hills' topography. This structure harvests thousands of gallons of water annually. The complexity and engineering of this structure are so well established that, in the event of water overflow, the system automatically diverts water towards the city's tanks and wells below, ensuring that every drop is conserved. Similarly, at Jaigarh Fort, the overflow was redirected to Sagar Lake, behind the fort. Additionally, the channels and aqueducts of both forts use natural slopes to direct rainwater into storage tanks, without pumps or machinery.

Heritage values, site-specificity, and landscape integration testify to particular ways of inhabiting and transforming landscapes. They embody generations of accumulated knowledge about local topography, hydrology, materials, and ecological processes, revealing how communities have learned to work with the opportunities and constraints of their landscapes, leaving behind tangible expressions of environmental intelligence.

SUSTAINABLE VALUES

Using natural resources, such as soil and stone, and constructing works with traditional materials and techniques from the landscape, the location itself, and non-contamination, these systems are environmentally friendly and often circular.

Watermills participated in and intervened in local water resources to provide energy. The study at the riverbank level allowed us to understand the operation of mills on rivers and streams as open recirculation. Each mill or set of mills does not form a cyclical system and, therefore, a closed system that starts at a geometric point and ends at that point. Instead, these mills are connected at a precise moment to create an artificial but harmless circuit that captures the water and directs it towards the mill mechanisms along a route that ends in the same riverbed of origin, downstream, at another point different from the initial one. Therefore, it is a surface water recirculation system that requires the natural channel itself to complete the technical processes of water use, exploitation, and return. It has been proven that this circular use of water enables different adaptations that make the generic scheme a more complex system; transformations derived from the primary objective of supplying the hydraulic force necessary to carry out the milling of flour, which allows, in turn, to store water in ponds, hydraulic channelling for the irrigation of nearby agricultural lands, or the use of the system by pairs of mills. These actions can be combined to acknowledge the connectivity and collective use of infrastructure, communication, or water in the water recirculation system.

Meanwhile, the production of Salt Fields is sustainable because there is much salt in the sea. Local people harvest edible salt directly from the sea by evaporating seawater with sunlight, fully embodying the rational use of natural resources. New Danzhou immigrants could earn a living by collecting salt-utilised scattered volcanic rocks along the coast to construct dwellings and build monuments, thereby memorialising the birth of new labor within familial units. These stone facilities became symbols of the local salt-harvesting culture.

The sustainable success of Water Meadows is multifaceted. First, positioning the meadows in the Chalkland River valleys provided reliable year-round flow and good subsoil drainage. Second, irrigation systems are regulated through seasonality. This means that land use was based on, and adapted to, water availability. Lastly, they gained popularity despite the expenses to construct and maintain them because of the meadows' regional significance and contribution to the 'sheep and corn economy chain.

In addition to harvesting rainwater, which is a sustainable practice in the region's arid/semi-arid zones, the construction process was also sustainable and circular. The construction of stepwells and forts, like many other structures in the area, uses locally available materials that are durable and suited to an arid climate.

In the case of stepwells, the primary materials were red and yellow sandstone, which were locally quarried and resistant to weathering. Limestone and lime mortar served as binding materials. Another detail was to use Araish plaster (lime-based plaster) on the walls. It is known for its smooth, polished, and water-resistant finish, resembling marble, and offers a reflective surface that keeps interiors cool. This technique is an eco-friendly and sustainable construction method, and some artisans still use it for restoration projects.

Red and pink sandstones are extensively used in the case of forts. Jaipur is known as 'Pink City because of its extensive use of pink sandstone, lime mortar, and plaster. The Jaigarh Fort also housed its foundry, the largest in Asia, for cannon production.

Sustainability as a heritage value should not be understood in terms of its contemporary meaning, which has emerged in response to present and future environmental challenges. Instead, these systems were developed to meet long-term needs for efficiency, productivity, and resource security. In doing so, they embody practical wisdom accumulated through observation, experimentation, and adaptation. Embedded in enduring practices and resource management strategies, this wisdom remains relevant, inspiring more adaptive, circular, and responsible approaches to landscape transformation and governance.

INFRASTRUCTURE AND NETWORK VALUES

Traditional water systems are often embedded within broader infrastructure. Physical structures, such as roads, organise territories, and facilitate trade; many of these systems also form part of agricultural and ecological networks.

Watermills have created many paths or take advantage of existing ones to facilitate the exchange of products and connections between mills in dispersed settlements and villages. Although dates are unknown, analysis of the historical roads through the planimetric surveys of 1873-1874 reveals many roads whose names allude to mills. Therefore, if their creation was not initiated by mills, they were relevant in their use and transit. Similar to communication infrastructure, these lines have shaped mountainous territory.

Salt Fields are more than just a production system; they are the foundation of the salt village's identity and collective memory. From the earliest days of settlement, salt production has been the core of village life, shaping the village's landscape and cultural traditions. Ancestral halls were built beside these salt fields, and structures such as stone towers emerged over time, marking the community's historical relationship with salt production. Apart from their economic and cultural significance, salt fields also play a crucial ecological role. Their unique structure creates favorable conditions for mangrove growth, stabilising the coastline and intertidal zone. For a coastal village, this natural buffer is essential to protect against erosion and to maintain the delicate balance of the marine ecosystem. The fields persist through the villagers' daily use and maintenance, crystallising generations of labor and tradition into a living cultural heritage that sustains the village's existence.

The Water Meadows were part of the more prominent English agricultural 'Sheep-Corn system' in which sheep would graze the pasture of the meadows during the day and be moved to arable land during the evening to enrich the soil with dung and urine so that the water meadows were naturally fertilised by water and arable land by sheep. This method of production was invented during the French Revolution and the Napoleonic Wars, when self-sufficiency was necessary, and it remained a part of England's rural history.

The forts of Jaipur were primarily part of a triangular defense network: Jaigrah, a military stronghold protecting the cities of Amer and Jaipur, and Nahargarh, a strategic lookout and protection from the northwest. Built at high elevations, they provided visual coverage of trade routes, valleys, and potential enemy approaches, creating a network that combined governance, defense, water security, and economic management. Water, human resources, and materials were shared across forts. If one fort falls short or has shortages, others can support it through tunnels and strategic outposts.

The infrastructure and network values of stepwells are fascinating and often underappreciated. They were not just utilitarian water storage spaces but rather part of a more extensive integrated infrastructure network that supported sustainable urban planning, agriculture, and community life. While the primary function is harvesting and storing water for year-round use, many stepwells have overflow systems that channel excess water into tanks, farms, and other stepwells. The design features multilevel construction with descending staircases and platforms that allow access to water at various depths, as the water table fluctuates. A single stepwell can store thousands of litres of water, which is crucial during periods of drought. They are often embedded within the city's urban grid, located near temples, palaces, markets, and community centres. They are part of a distributed water network of the city, forming a chain of water structures, such as a catchment hierarchy strategically placed to serve different neighborhoods, many of which are connected to irrigation channels to support agriculture. While scientific aquifer mapping is not known, traditional builders intuitively understand the hydrology. They designed these structures with a deep awareness of underground water behavior, thus forming a living breathing groundwater network.

Across the examples presented, infrastructure and networks organised relationships between settlements, productive landscapes, and their surroundings into coherent territorial systems. As heritage, they preserve the spatial logic through which water coordinates production, ecological functions, and everyday life.

IDENTITY VALUES

Beyond their physical and functional qualities, traditional water systems also embody a fundamental intangible value: they reflect the identity of communities that create, maintain, and rely on them. Rooted in local knowledge, practices, and traditions, they are an inherent part of the regional culture and identity.

Watermills reveal fundamental ways of living and working in this rural environment, which is why they are essential in defining the identity of the Sierra de Cádiz. Nevertheless, the profound socio-economic transformations of the 20th century altered the functionality of the rural territory, leading to the abandonment of certain artisanal practices, such as milling, which culturally characterised the society of the Sierra de Cádiz. This led to the disuse of water mills, which remained in ruins as relics of a bygone era. Their persistence in the territory and their delicate state of conservation imply a triple approach: study them to extract the wisdom they contain, protect them to prevent their disappearance, and reactivate them to become a living network of the place.

Salt Field production has been handed over from one generation to another. The unique lifestyle and agricultural activities are integrated with the environment, forming a distinctive cultural landscape and earning these villages the nickname 'salt villages. ' Salt fields in Danzhou reflect an ancient attitude of adapting to uncertain futures, while prioritising human survival and quality of life. These salt fields are essential to the local village's identity and culture. Local villagers have also begun to develop tourism to maintain a unique landscape formed by salt fields.

The water meadows were gradually abandoned in the mid-19th century, when farming became mechanised and artificial fertilisers were introduced. Generally, water meadows are poorly protected; it is estimated that only 4% of individuals and trusts are 'well preserved,' whereas 40% have been destroyed since 1998. The Harnham Water Meadows are protected for their archaeological remains and status as a Site of Special Scientific Interest (SSSI) due to their vast diversity. (Historic England, 2018)

The identity value of historic structures, such as Jaigarh Fort, Nahargarh Fort, and the Stepwells of Jaipur, extend beyond their physical and functional roles. They symbolise regional pride, cultural continuity, architectural ingenuity, and environmental intelligence. The Jaigarh Fort, also known as the Fort of Victory, embodies the military prowess of the region's kings. It protected the cities and was never conquered, giving it an aura of invincibility and pride. Home to the enormous cannon, the foundry and armory in the fort, along with its advanced rainwater harvesting system, reflects self-reliance and craftsmanship, adding to the identity of eco-conscious foresight and blending defense with sustainability.

On the other hand, the Nahargarh fort formed the northern defense ring and showcased refined palace architecture with the Indo-European flair. Now a space for art galleries, films, and public events, it has become a living cultural landmark that connects the past with the present. Its identity lies in being a protector-turned storyteller.

Apart from being a water source, the stepwells served as community nodes—places of gathering, rituals, trade, and daily chores, such as washing and fetching water. In some cases, they also serve as subterranean temples, abounding in carved images of the region's male and female deities. Some were designed with ornate pavilions, reflecting their importance to public life. In desert cultures, access to water = power; thus, stepwells reinforce social equity when shared among communities. It was considered highly meritorious to commission a stepwell as an act of philanthropy, or in the memory of a loved one. Some of them are still used in colorful festivals and sacred rituals.

These examples demonstrate that the identity value of traditional water systems lies in their continuing capacity to sustain meaning, memory, and cultural practices across generations. They connect communities to their landscapes through shared histories that continue to shape their local and regional identities.

CONTEMPORANEITY

While differing in geography, function, and cultural context, the selected traditional water systems revealed a remarkably consistent set of heritage values. Their heritage significance lies not only in their physical structures but also in the knowledge, relationships, and practices they embody. Together, these values demonstrate that traditional water systems are best understood as cultural landscapes where environmental, social, productive, and cultural dimensions have co-evolved over time.

Collectively, these values deepen our understanding of what these systems represent in the past, what they may contribute to the future, and what can be sustained if the traditional water systems and infrastructures that connect them remain in place.

Their relevance becomes even more evident today, as many interventions have drifted from their environments and functional programs, becoming speculative, decontextualised, or disproportionate, and treating place as a neutral support devoid of intrinsic qualities. These tendencies and reactions have renewed interest in values that reconnect design with place, in pursuit of more sustainable, adaptable, and context-responsive architectures and systems. Undeniably, traditional water systems are significant in the presence of collective memory, culture, and ways of life, which still offer valuable lessons for contemporary society. They are a source of knowledge about traditional building techniques, use of locally adapted materials, natural resource management, and strategies for integrating interventions within the territory. Drawing these systems in their territory is a fundamental methodological tool for revealing these qualities.

However, the lessons that these constructions offer should not be limited to their environmental performance, which dominates much of today's discourse. More comprehensively, they reveal the complex and dynamic cultural, social, economic, architectural, and environmental relationships that have evolved. From this perspective, traditional water systems offer enduring lessons extending beyond their material forms. As Paul Oliver recalls, vernacular architecture, in general, is 'the root of our culture and what gives it meaning.'

Recognising traditional water systems as heritage resources with architectural and territorial significance also means acknowledging the ways of life that they embody. As such, they demand protection and preservation. Even without reference to climate change, their value to contemporary society is undeniable, and they continue to reveal knowledge that warrants greater attention from public institutions, helping ensure their legacy endures.