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# **Traditional Dwellings and Settlements**

Working Paper Series

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## **TRADITIONS OF RAIN WATER HARVESTING AND COSMOPOLITANISM. THE CASE OF JAIPUR (RAJASTHAN, INDIA)**

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*Savitri JAL AIS*

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## TRADITIONS OF RAIN WATER HARVESTING AND COSMOPOLITANISM. THE CASE OF JAIPUR (RAJASTHAN, INDIA)



*Did the cosmopolitanism present in the court of Jai Singh II influence the hydraulic structure of Jaipur, this “new city” designed at the beginning of the 18<sup>th</sup> century in the semi-arid region of Rajasthan in India? The essential conditions for the creation of a city is the availability of water, the need for water transcends all borders. This article shows that cosmopolitanism can be seen/is present in the elaborate network of water systems found in the region, and always existed in the form of transfer of technical knowledge. Just as Jai Singh II rooted his capital city on existing traditions while at the same time was open to inventions/ discoveries prevalent in his time for the invention of astronomical measuring bodies, so too, the water system on which the city was built speaks of such exchanges/ cosmopolitanisms.*

### 1. INTRODUCTION

This article questions the relevance of using the term cosmopolitanism regarding the hydraulic heritage of the city of Jaipur in India. In this “new city” designed at the beginning of the 18<sup>th</sup> century in the semi-arid region of Rajasthan, an elaborate network of water systems was planned so as to literally “harvest” water, or in other terms collect and manage rain water for the needs of the city. The water structures that emerged were extremely elaborate and efficient, adapted to a specific landscape, and present at different scales – from domestic wells, step-wells (*baoli, van*), reservoirs, basins (*kund*), to large urban lakes (*talab*). They reflect a hydraulic tradition that is multicultural – Yemenite, Persian, Ottoman, Roman – , embraced and developed in western India, particularly in today’s Rajasthan and Gujarat. They do not speak of one lone discoverer or a solitary genius but of a myriad of connections and know-hows that have come to India from far lands and cultures and developed through many centuries.

These water systems were progressively abandoned during the British colonial era (19<sup>th</sup>-20<sup>th</sup> century) so as to implement new systems with different logics such as dams, pipelines and bore-wells. The layout of these new infrastructures, continued since by the Indian government, seem to have been implemented at the expense of the traditional system. Therefore, is the term cosmopolitanism still appropriate to describe Jaipur's current water system, in the true sense of the word, cosmopolitanism implying the possibility for different cultures and traditions to live and work hand in hand, and integrate one with the other?

Could the revival of these vast and ancient water structures, unused but still visible today in Jaipur's landscape, integrate in the future a more holistic « cosmopolitan » approach? First of all, can their multicultural tradition

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be revived or at least serve as examples in the elaboration of new hydraulic structures as promoted by Anupam Mishra in his book « *Rajasthan Ki Rajat Boonden* » (The radiant raindrops of Rajasthan)<sup>1</sup>, a book read and recited daily in remote villages of Rajasthan in the 1990s as an ode to what has become « local knowledge »?

Secondly, the hydraulic heritage present in the city of Jaipur testifies of wisdom that have been constantly adapted to the specificities of the semi-arid region of Rajasthan and the city of Jaipur. Can they be valorized today and transplanted in other arid or semi-arid regions of the world or are they necessarily linked to a particular culture? Is it possible to sort out those elements and devices that are universal from those that are local, specific to a place?

Thirdly, can the memory of water still act as a major element of public space in Jaipur's urban fabric, water's role extending beyond drinking or domestic use, to a symbolic use? The past is constantly redefined and operationalized for the purpose of future and more appropriate needs. In the wake of global warming we can imagine these structures playing yet other roles in the design of public spaces and in creating islands of freshness within an urban setting.

## **2. THE PREREQUISITE/REQUIREMENT OF WATER FOR A COSMOPOLITAN CITY**

One of the essential conditions for the creation of a city is the availability of water that transcends all borders. The city of Jaipur is better known for its urban layout on a nine squared Mandala (1727)<sup>2</sup> the architecture of its palaces that are of Mughal style<sup>3</sup> and the building of a grand astronomical observatory called Jantar Mantar (1725)<sup>4</sup>, by Jai Singh II (1688-1743), Prince of Amber (Fig. 1 and 2). The fortified city of Amber, nestled on a hillside and located on a strategic defensive position since 966 AD., could no longer reply to the incessant need of water and space for a population that kept growing. The new capital, Jaipur, “the city of victory” in Hindi, was planned to become a commercial platform thanks to its strategical position on the road from Delhi to the ports of Gujarat (Salam, 2011).

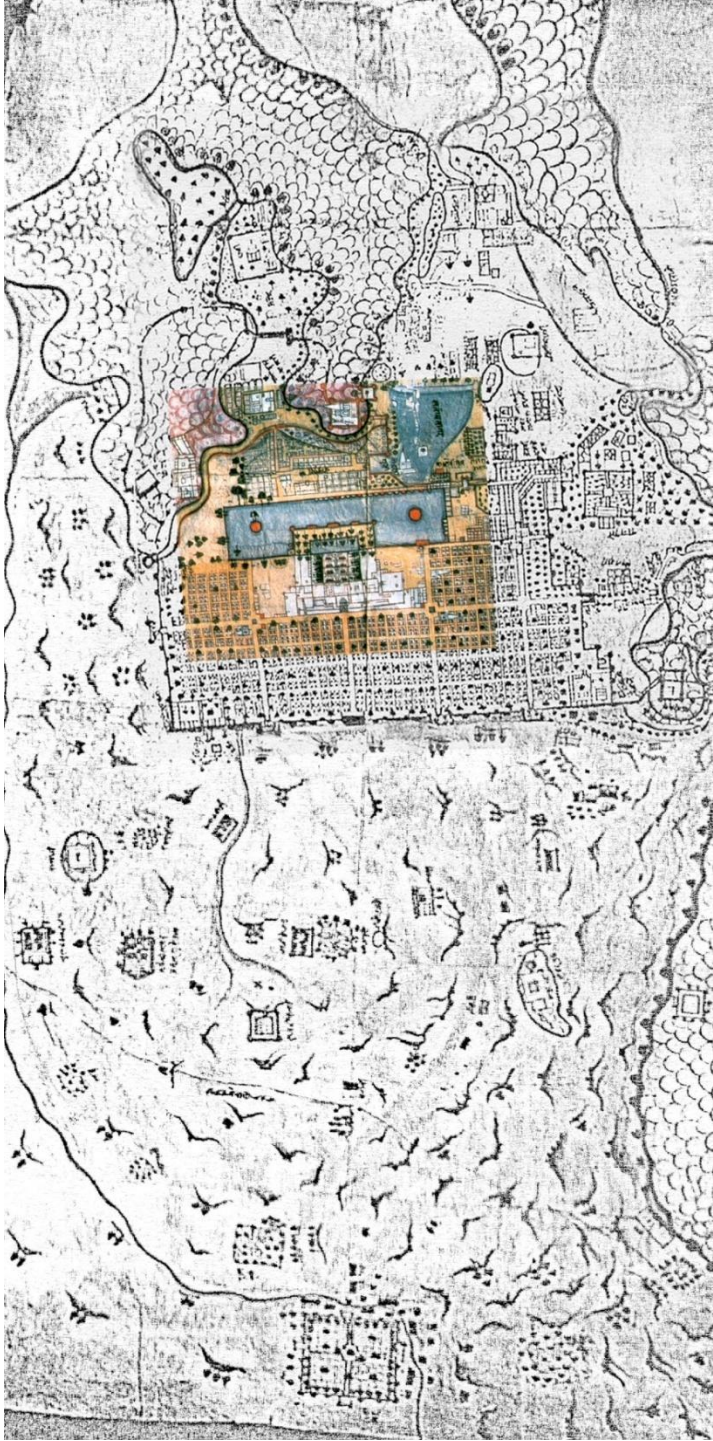


Fig. 1: Plan of the newly built Jaipur city in 1775, and the surrounding water bodies. Jai Singh Museum archives, published in Aman Nath, *Jaipur, the last destination*, 2007, p.58

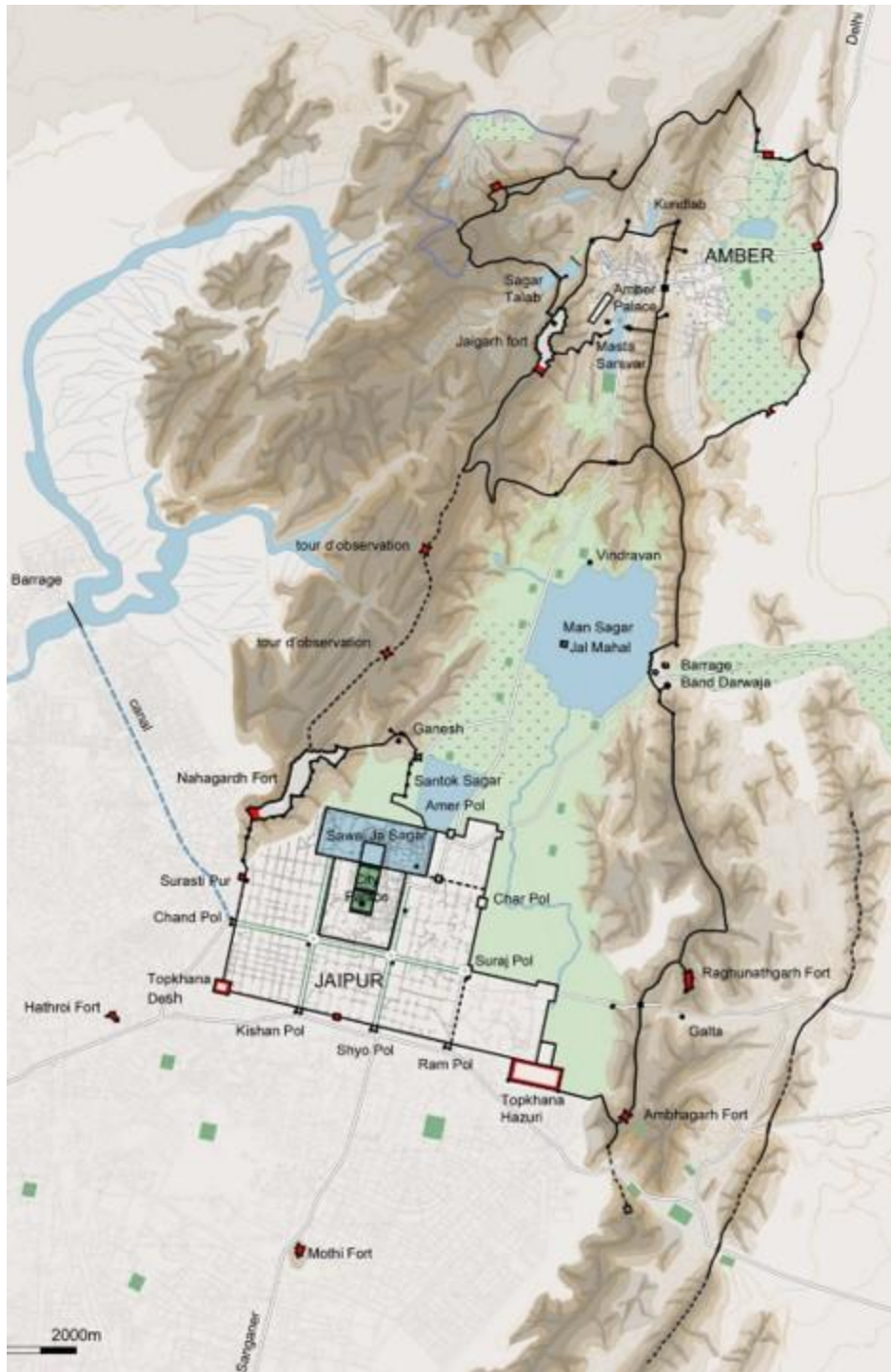


Fig. 2. Map of Jaipur-Amber, Boric, Alain, Cataláa, Françoise, Papillault, Rémi, *Jaipur ville nouvelle du XVIII<sup>e</sup> siècle au Rajasthan*, Thalia, Paris 2007.

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Jaipur is located at the edge of the Thar desert however little is known of the vast hydraulic system on which the city was founded, a very important issue in this semi-arid region where one remembers, the Mughal Emperor Akbar, had to abandon Fatehpur Sikri, the new city he had designed in 1569 for lack of water. One of the reasons for creating Jaipur was because of the increasing demand for space and water. The site chosen at the foot of the Aravalli mountains 11km from Amber, was a flat and dry plain bed of a lake between rivers Amanisha and Dhond. There was good drainage conditions and availability of stone for construction. A stream ran underground into the town enabling public wells to be built at regular intervals and the houses were connected to a sewer covered with large stone slabs, which remind of the Nawabi drains erected by the Mughals in numerous Indian towns.<sup>5</sup> The city was built on agricultural land and it is presumed that the numerous wells and water structures present for irrigation purposes were conserved, extended and developed so as to sustain the requirements for this new city. The region was already well versed in this particular architecture specialized in the collection, channeling and storage of rainwater. It had developed in its history a skillful water management network/system adapted to arid zones.

So as to understand these water structures and the general traditional management of water systems in India it is essential to understand the specificities of the country's monsoon regime, where great quantities of water have to be managed in short periods of time. This is particularly true in Rajasthan, the driest states of India, which has an annual rainfall of just 100 mm in the western to 650 mm in the south-eastern part of the state. In the city of Jaipur, 91% of the annual precipitation (492mm) occurs during the two monsoon months of July and August, and the maximum amount of rain recorded in an hour can amount to 75mm<sup>6</sup>. In these extreme climatic conditions, a sophisticated network of rainwater harvesting was planned, spanning the territorial, urban and architectural scale, so as to collect, store and distribute water. This system allowed the collection and storage of water so as to provide for an initial population of 150,000 inhabitants<sup>7</sup>.

Rain water was harvested on fortified ridges to supply defending forts, on the slopes of the surrounding hills that directed rain water towards natural and artificial lakes designed with dams and reservoirs and in the ground so as recharge the city's various watersheds. At the bottom of each catchment areas, wells, step-wells (*baoli*) and basins (*kund*) were built to provide water for irrigation, domestic and ritual uses. The city of Jaipur is representative of all these different water harvesting techniques, some through direct rainwater collection, from the top of hills to the plains, and others collecting water indirectly through percolation of ground water. The various elements of this water harvesting system that captures, stores and distributes monsoon water are: dams and lakes, basins and reservoirs, wells and stepped wells. Dams are used to retain water in basins formed by the site's natural topography, to form lakes (*talab*), which make it possible to store water while feeding part of the water table. Canals (*nali*), collect rainwater during the monsoon season and channel it to lakes, cisterns and reservoirs (*tanka*) or basins and tiered ponds (*kund*). Finally, wells (*kua*), are architectural

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structures providing access to water, and are supplied by groundwater. Step wells (*baoli*), are like simple wells, but with a system of steps to provide access to water.

Rain water was thus harvested on fortified ridges to supply defending forts, on the slopes of the surrounding hills that directed rain water towards natural and artificial lakes designed with dams and reservoirs and in the ground so as recharge the city's various watersheds. At the bottom of each catchment areas wells, step-wells (*baoli*) and basins (*kund*) were built to provide water for agricultural and domestic uses.

### 3. THE ROLE OF JAIPUR'S TRADITIONAL WATER SYSTEM

The city's choice of location is intimately linked to the topography, which creates a natural water reservoir that is able to capture drops of rain water. The hills surrounding the city form a natural watershed with drainage channels that, over time, have been carefully designed to collect water through canals, known as *nala*, cut into the rock, which lead the water to the urban lakes. The canals usually follow the contour lines. An ingenious system of counter-slopes on the canals enables sand and dust to be filtered by gravity from the first run-offs. Remains of these canals are still present today.

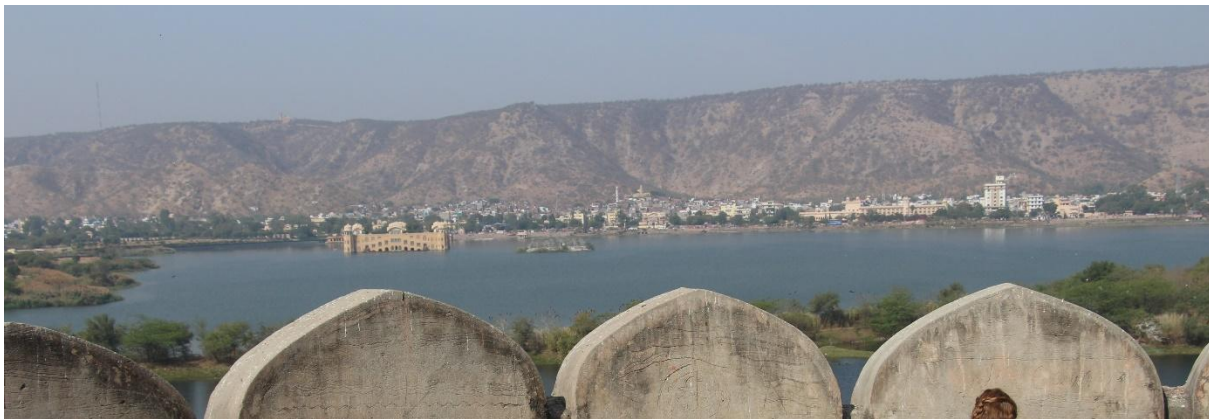


Fig. 3: The Man Sagar lake and the city of Jaipur behind, photography Savitri Jalais, 2018.

The city thus is flanked on one side by the Aravalli hills that drain the water into the city and the Man Sagar Lake that used to receive this run-off. This used to prevent floods during the rainy period and provide water all through the year to the ground water that fed the numerous wells. The Man Sagar lake is an artificial lake or reservoir built by Raja Man Singh in 1610, by damming the Dravyavati river between the hills of Khilagarh and the mountainous regions of Nahargarh (Fig. 3). In the middle he constructed a palace that seems to float in the water and was used for court gatherings. The lake lies to the north of the city on the road that leads to Amber. It covers 95 hectares and has become today, the recipient of wastewater from the city of Jaipur. The two major canals that drain the surrounding hills of Nahargarh and the city of Jaipur are the Brahmpuri and the Nagtalai *nala*, which bring untreated sewage, in addition to runoff from unpaved streets to this lake, the largest surrounding the city. The depth can vary from 60 centimetres to 5 metres, the span is shrinking due to



primary function of a *baoli* which is to capture a maximum quantity water, which depends on the level of the surrounding groundwater level. The key is to locate the water table at its highest and to ensure its constant recharge thanks to the infiltration of precipitation that feeds the ground water table. They were initially located on the outskirts of the city, in agricultural land or in gardens. When the city of Jaipur was built, some of them were incorporated within the urban fabric. It was subsequently difficult to construct such monumental structures inside the city and so simple wells (*kua*) were constructed instead.

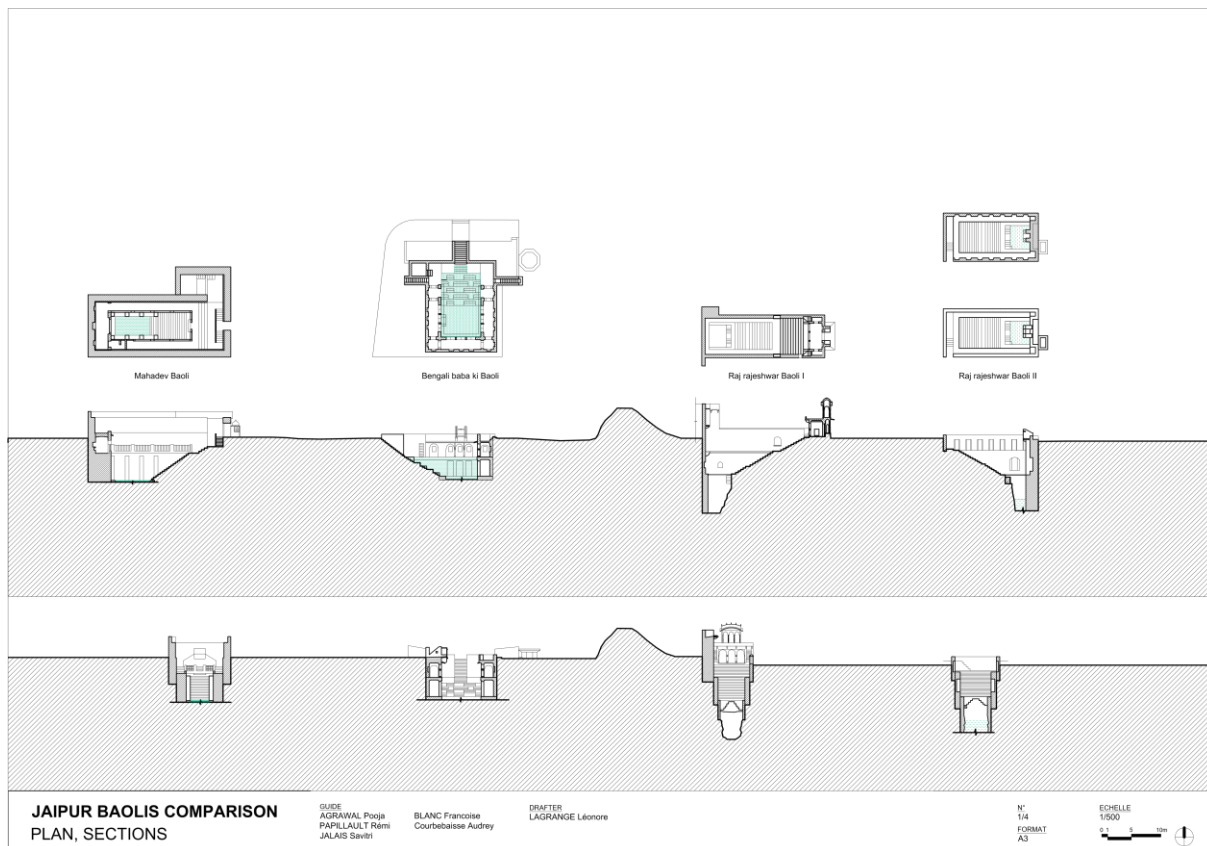


Fig.

5: *Baoli* vary in size, form and orientation, measure drawing L onore Lagrange, 2018

*Baoli* are composed of a reservoir and a flight of stairs that link the ground/street level to the water level. They are often rectangular, narrow and linear in shape. In section, it forms a triangle, composed of a horizontal line at ground level, a vertical line that sinks deep into the earth and a slanted line following the diagonal of the stairs. The system of groundwater capture is a vertical well, or a simple square pit which goes down to the water table. In his book, *The Iconography of water*, Frederic W. Bunce explains that classic wells could be dug where the water table was relatively close to the ground. Where the groundwater table was more than 6 or 7m below ground level, a *baoli* was built, not only to provide access to water, but also to provide a cool respite from the scorching heat of the dry season. During the monsoons, the tank can also collect rain-water, like a cistern<sup>8</sup>. However, it is more efficient in capturing water from the ground, the *baoli* gets filled up proportionally to the rise in groundwater level. Actually, the reservoir being of a big size, the volume of water

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that percolates in a *baoli* is much greater than that of a well. This is reflected in a popular saying “*panch kuva barabar ek va*”, one *baoli* is equivalent to five wells. The dimensions of *baoli* are varied (Fig. 5). With time, they embellished, and these wells ended up resembling underground buildings and palaces. These various forms and sizes can be explained by geological conditions: deeper the water table, longer will the *baoli* need to be so as to respect a comfortable descent. The water needed for a certain community can also influence the size of the *baoli*, as it is clear that the larger a *baoli*, the greater its water capacity will be. Each *baoli* has above its rim and around its perimeter a system to draw water from the well/reservoir.

The cases we have seen above depicts the simplest way to access water: by digging a well, whose function is to capture groundwater. The location of a well depends therefore on the presence of a groundwater and its level of water. As a result, wells are frequently found in plains and valleys, and are non-existent on slopes and ridges. Furthermore, those wells dug in built-up area are exposed to the risk of water pollution.

In a city like Jaipur, where forts are built on the mountain ridges, it was important to find other ways to provide pure and abundant water, whatever the context and morphology of the land. Devises were thus designed to harvest water directly, to capture and conserve it, even on slopes, ridges or in densely built-up areas. Such is the function of the traditional water reservoirs, called *kund*, *tanka* or sometimes *jhalara*, artificially constructed basins of various shapes and sizes. The oldest example of a reservoir with steps can be found in the Uperkot caves in Junagadh, dating from the 4th century. They take the form of a pit, the walls of which are generally made up of steps with a more or less steep slope to allow access to the water level. They generally collect run-off water, and are often used for religious and ritual purposes, enabling ablutions and baths, but some are also purely utilitarian, simply supplying water to a site. Anupam Mishra poetically describes these structures:

“The principle is simple: to hold back the drops of rainwater, and store it in a perfectly clean place. Ponds or small basins, *kund* or *kundi*, reservoirs or *tanka*, the names and forms may vary, the function remains unchanged: to immobilize and store for tomorrow the drops that have fallen today”.

The reservoirs in Jaipur are located at various points: on hill crests, on a slope between two steep hillsides, in valleys, in the depression leading to a lake or on the plain, and in different contexts: in forts, associated with temples, within gardens, in isolated wild places or in the heart of the city surrounded by buildings.

On top of the Jaigarh Fort water is collected on the ridges around the fortified walls during the monsoon season. Loops have been built to encircle the ridge and retain rainwater. This 4km-long system is made up of three successive loops that enable to collect more water, control its flow speed and remove impurities through sedimentation. The first loop begins at the highest point of the hills, 4km south-west of the fort. An

aqueduct connects it to the second loop at a slightly lower altitude, and so on to the third and final loop. This loop ends in a large, reinforced canal that carries all the water collected in the fort through an underground tunnel equipped with a metal grate that allows the water to pass through the fortified wall, free of the heaviest sediment. Once inside the fort, the tunnel splits into two channels. One directs the first, less pure rainwater into the pit to water the animals, while the other takes the clean water to three tanks, called *tanka*<sup>10</sup>. These were used for domestic purposes by the royal family and the general public. While the tank in Jaigarh fort was covered the one designed at the Nahargarh fort is open to the sky. Morna Livingston describes it:

“Because its pool was excavated and its irregular side walls shaped into stairs, Nahargarh resembles a quarry, almost an amphitheater around the water. Its well is designed so that monsoon water falling on the slopes is channeled through a shell-like spiral to feed its pool. As monsoon rains often carry a heavy burden of sediment, the twisting spiral encourages silt or stone to settle where it can easily be removed”<sup>11</sup>. (Fig. 6a and 6b).

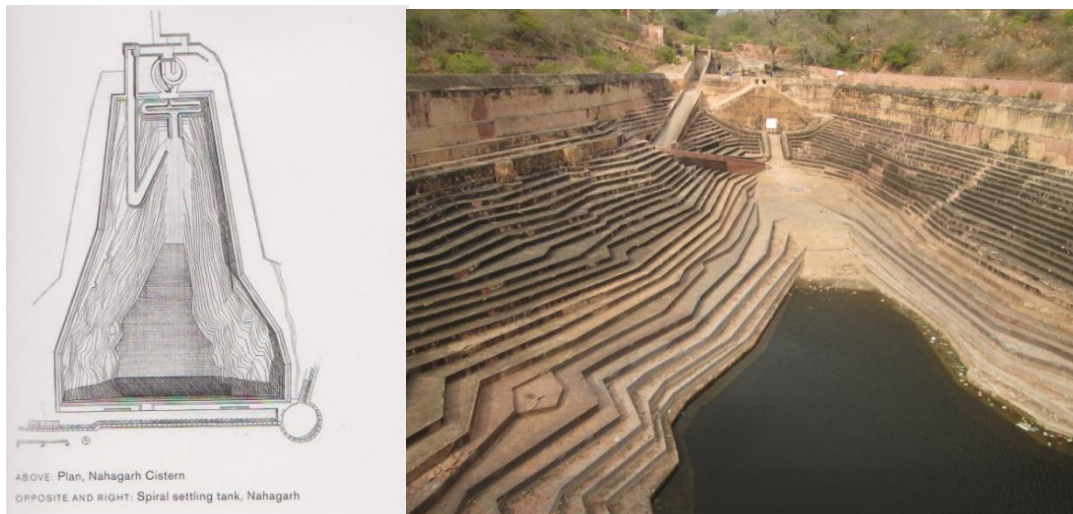


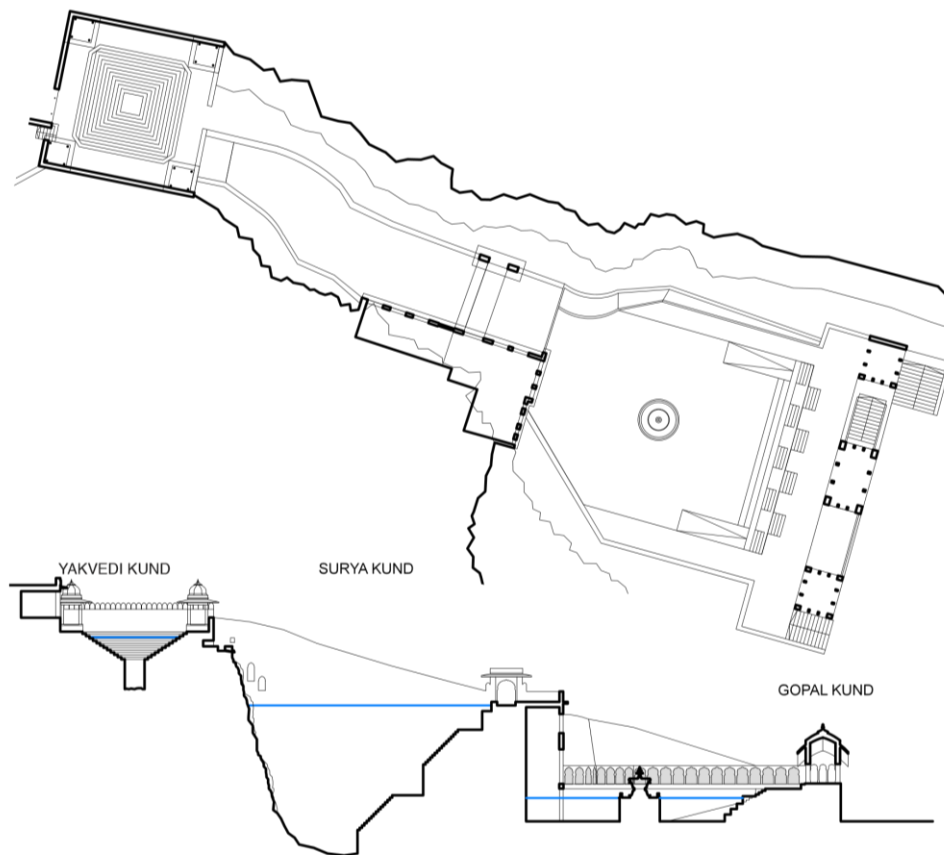
Fig. 6a: Nahargarh cistern, drawing Morna Livingston, *Steps to water : the ancient stepwells of India*, Princeton Architectural Press, New York, 2002, p. 129

Fig. 6b: Nahargarh cistern, photography Savitri Jalais, 2018

Four reservoir- *kund* are situated at the heart of the city, like the Tal Katora reservoir, in a dense urban environment where the presence of water has a cooling effect in a city with an arid climate. A vast majority of them make the most of existing natural conditions that facilitate water harvesting. Some use the slope of a hill as a basin wall so as to simplify and reduce costs in construction. The reservoirs have certain common characteristics and present also a significant diversity in terms of their size (width, length, depth) and a great architectural diversity.

The differences can be extreme when the smallest reservoir, the Kadamb Kund of the Galta Ji complex, which measures fifteen meters wide, is compared to Tal Katora, the largest in the city, which measures two

hundred and fifty meters on each side. This difference in dimensions can be seen with the depth of each reservoir: shallowest reservoir, the Saraswati Kund measures three meters deep, and the Surya Kund measures more than sixteen meters deep. These variations in size can be explained by different factors. First, water requirements can influence the size of the reservoir. Indeed, it is clear that the larger a tank, the greater its water capacity will be. This is for example the case for the tanks of Jaigarh Fort, which has the covered *tanka* with the largest storage capacity in the country. However, the morphology of the territory can also determine the size and depth of a reservoir, like for example the Surya Kund, which has an almost vertical natural slope of the hill constituting one of the walls of the reservoir (Fig. 7). Depending on the origin of the water, the morphology of the territory of establishment, the needs of the population, we observe various techniques for capturing and transporting water.



Plan et coupe du parcours des trois réservoirs principaux de *Galta Ji*



Fig. 7: Galataji temple and water complex, measure drawing Claire Joulia, 2018

Most of the reservoirs are surrounded by a wall whose height often varies from one to two meters. This wall is often pierced with one or more small openings connected to the channels which supply the water tank. It is generally also provided with one or more larger openings which serve as entrances for men or animals. This

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wall is built directly around the tank to protect the water it contains from impurities that could be carried inside by the wind.

“Water and humidity damage buildings to the point that, if they are not regularly maintained and repaired, they quickly fall into disrepair. While disused temples from the first centuries CE may survive in ruined rubble, the pits of neglected water structures fill with soil and waste and easily disappear underground»<sup>12</sup>.

Today, even if some reservoirs have retained their former functions and uses, most are welcoming new ones or, on the contrary, are completely abandoned. Often the *kund* associated with temples and therefore having a religious and non-functional value have not undergone any modification of their functions and uses. Indeed, the Panna Menna ka Kund, the Yakvedi Kund, the Surya Kund and the Gopal Kund, are still used only for religious rituals such as ablutions or bathing of men and women. Some tanks are fortunate to have recently been restored and cleaned by different organizations, so that they can still perform their function properly. This was the case of the Panna Meena ka Kund in 2015 , the Kadamb Kund in 2016, and the Vidyadarh Kund in 2019.

#### **4. TODAY'S HERITAGE IN CONTEMPORARY CONTEXT**

Today, the city has a population of 3,9 million living in an area of 484.64 km<sup>2</sup>, and forecasts predict that by 2035 it will have more than 6.5 million inhabitants. How can the expansion and densification of this city be planned in such a way as to consider the management of water, the environment, energy and transport, while at the same time respecting the specific historical character of the city and its traditions? At the time of its creation, numerous wells and basins, large reservoirs and water circuits were built across an entire territory to supply the city with water. With the introduction of a public water distribution network at the end of the 19th and beginning of the 20th centuries, this system was gradually abandoned, even though its architecture, often very imposing, persisted in the landscape (Fig. 8).



Fig.

8: Talkatora lake within the extended, densely built city, photography Savitri Jalais, 2018

These water structures mark today the physical landscape of the city, they are often part of the city's animated public spaces and their maintenance or revival may or may not be related to the original water use for which they were initially built. Some on the contrary are today not only abandoned but their historical geographies overlaid by urban developments that do not always consider their flows and patterns<sup>13</sup>. In this context, questioning their present role as vectors of nature in an urban context – the cooling effect of water, a haven of peace, gathering places and playgrounds – can be propitious in today's dense and polluted metropolis.

In face of Jaipur's rapid urbanization and the increasing demand for water, a new water system has not only replaced the old system but created the conditions for its extinction : pipes and channels draw water from sources that extend well beyond the city limits and water is currently supplied by the Bisalpur dam situated 120km south of Jaipur. The approach is utilitarian and to use the words of Fulton 2001<sup>14</sup>, this new water management views water as a fuel for the urban "growth machine", tapping in the process the natural resources of other secondary towns and cities and transforming a whole territory into a desert. Furthermore, this water supply being insufficient, it is constantly supplemented by a large number of water pumps, which

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considerably deplete the ground water level. Gradually, an entire system is today abandoned while its architecture is still very much present in the Jaipur landscape, its water level reduced and greatly polluted.

The study of the potentials of these historical water systems, often designed in a monumental scale, opens new perspectives. Can they be reclaimed, conserved, revitalized so as to form part of a local, equitable and sustainable approach to water, offering a significant quantity of water to the city, as well as public spaces? And most importantly, can these structures re-enter the cultural imagination and be part of a living heritage that fosters “a sense of culture as a capacity to aspire”?<sup>15</sup>.

## NOTES AND REFERENCES

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<sup>1</sup> Read Anupam Mishra's *Radiant Raindrops of Rajasthan*, translated by Ms. Maya Jani, Research Foundation for Science Technology and Ecology, 1995

<sup>2</sup> Numerous books and articles have been published on the city of Jaipur, based on to the Vastushastras geometric framework of a mandala. The urban plan was based on a square formed Mandala, grid system with nine districts reserved for trade and crafts, separated by wide avenues intersecting at right angles.

<sup>3</sup> Palaces built in the new city but also in Amber during Jai Singh II's first years in power were constructed in the Mughal style for the aristocracy and his court (Borie, 2007)

<sup>4</sup> For further reading refer to Andreas Volwahn, *Cosmic architecture in India, The Astronomical Monuments of Maharaja Jai Singh II*, Prestel-Mapin, 2001 and Raina Dhruv, “Circulation and Cosmopolitanism in 18th Century Jaipur. The Workshop of Jyotishis, Nujumi and Jesuit Astronomers” in C. Lefevre, I. Zupanov and J. Flores (dir.) *Cosmopolitismes en Asie du Sud, Sources, itinéraires, langues (XVI<sup>e</sup>-XVIII<sup>e</sup> siècle)*, Purushartha 33, Paris, 2015

<sup>5</sup> For example, in Benares, there was an extensive system of underground drains dating back to the 16th century, called Nawabi drains, intended mainly for rainwater. Rectangular in shape and irregularly inclined, they were made of rough bricks and stones (from 1 to 6 feet wide and 1 to 9 feet high), extended on different levels under the center of the paved roadway and were connected to the courtyards of the houses. See Savitri Jalais, *Les ghat de Bénarès. Variations architecturales d'une rive sacrée*, Genève, MétisPresses, 2022

<sup>6</sup> See Rainfall profile of Jaipur: [http://amssdelhi.gov.in/RESEARCH\\_FILES/JAIPUR\\_RF\\_PROFILE.pdf](http://amssdelhi.gov.in/RESEARCH_FILES/JAIPUR_RF_PROFILE.pdf)

<sup>7</sup> A. Borie, F. Cataláa, R. Papillault, *Jaipur ville nouvelle du xviii<sup>e</sup> siècle au Rajasthan*, Paris, Thalia, 2007.

<sup>8</sup> Victoria Lautman, *The Vanishing Stepwells of India*. Merrell Publishers Ltd, 2017

<sup>9</sup> *Radiant Raindrops of Rajasthan*, translated by Ms. Maya Jani, Research Foundation for Science Technology and Ecology, 1995.

<sup>10</sup> For a thorough analysis see the article of Pr. Rajendra Singh Khangarot, “Jaigarh in Amber: techniques of Water Harvesting”, in Jutta Jain-Neubauer, *Water Design, Environment and histories*, Marg, 2016, pp.48-57

<sup>11</sup> Livingston, M., *Steps to water : the ancient stepwells of India*, Princeton Architectural Presss, New York, 2002, p.129

<sup>12</sup> Julia A. B. Hegewald, *Water architecture in the South Asia, A Study of Types, Developments and Meanings*, 2001, Introduction, p. 4

<sup>13</sup> James L. Wescoat Jr. has conducted a study on this subject in the city of Delhi, see “Barapulla nallah and its tributaries, waterscape architecture in Sultanate and Mughal Delhi » in Jutta Jain Neubauer , 2016.

<sup>14</sup> W. Fulton, *The Reluctant Metropolis: The Politics of Urban Growth in Los Angeles*, JHU Press, 2001.

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<sup>15</sup> A. Appadurai, 2004, *The Capacity to Aspire: Culture and the Terms of Recognition*, in V. Rao & M. Walton (eds.) *Culture and Public Action*, Palo Alto, Stanford University Press, pp. 59-84.

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