The Descent to Water:

Revitalization of the Ashapura Mata Stepwell in India

by
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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

ABSTRACT

This thesis explores the restoration of a historical water architectural typology indigenous to the Indian subcontinent in its pre-colonial past. Stepwells or Vavs are ancient subterranean structures designed with complex engineering and utmost precision to harvest groundwater. As the name suggests, Stepwells or stepped wells are a series of steps that lead down to a water well. They were vital in providing a water source and acted as a communal gathering space.

Stepwells prevailed for centuries and were shut down during colonial rule as the British considered the water in the wells unsanitary and introduced new water harvesting techniques. The wells, once vital for the communities, are deteriorating to a state of disrepair and are now used as dumping grounds. Considering how the stepwells have played a crucial role in shaping the water architecture typology in India, it becomes essential to revive these wells so that their historical and cultural values are preserved for generations to come.

On a parallel tangent, with the growing population and rapid urbanization in India, there has been a significant drop in water tables leading to groundwater depletion. This water crisis issue calls for conservation and effective groundwater management. While the stepwells provided an infrastructure for harvesting groundwater in the past, restoring them would help with groundwater recharge and contribute to reviving the lost heritage.

Along with the restoration of the stepwell as an artifact, this thesis project proposes small-scale, architectural interventions to help with creating a resilient and self-sustaining community around the stepwell and working with and improving both public space and water infrastructure. The revitalization of the Ashapura Mata Stepwell and its surrounding neighbourhood proposes to act as an urban catalyst model for providing restoration strategies for other stepwells in the country.

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DEDICATION

To my parents, for their unconditional love and support.

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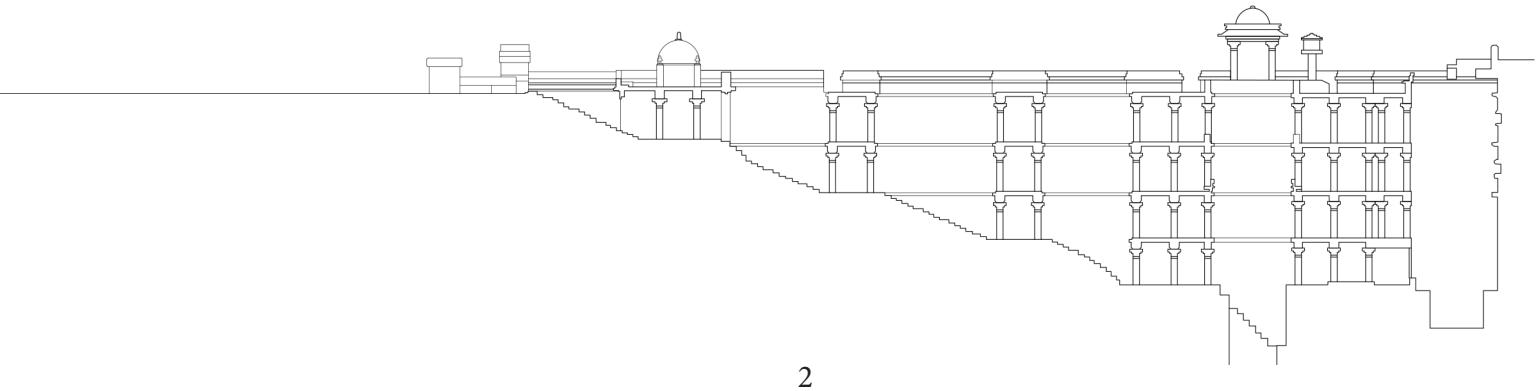
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Part 0

Introduction



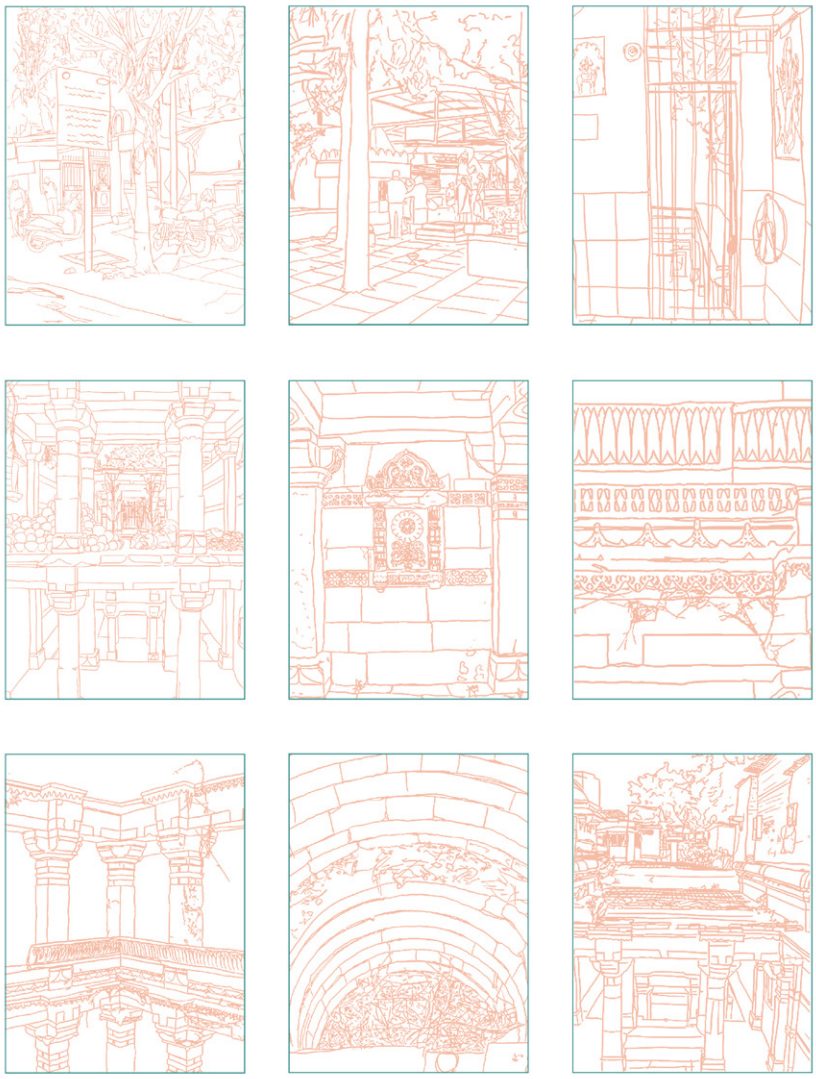


Fig. 0.1 - Introduction to the site. Sequential observational sketches from the walk through from the street to the stepwell. (Read in row format - Top left corner to Bottom right corner)

PREFACE

After months of researching on ***Stepwells***, I finally got to visit one for the first time during my visit to India in 2023. When I landed in the city of Ahmedabad, I went directly to Bapunagar, to visit my thesis site. It was extremely challenging to locate the entrance of the stepwell as it was hidden amidst the bustling community of Ashapura ni Chali. The Ashapura Mata temple stood as a boundary and entry for the stepwell. The vibrant hues of the temple took away the charm of the space.

As I walked further in, I managed to get the first glimpse of the stepwell. It was tucked behind a narrow channel barricaded by a grill gate. The gate that chained the well was the one that opened to a realm of tranquility. As I entered, I was captivated by the beauty of the space. While I descended into the well, I could not help but imagine how the place must have echoed with the joy and laughter of women in the past.

The chaos and noises from the streets completely faded upon reaching the bottom level. Although there was no water in the wells, the walls still breathed fresh air. Beyond this point, I started noticing the deteriorating condition of the stepwell, filled with foliage and barbed wires leaving it in a state of despair.

All of this led me to reflect on the past lives of Stepwells, leaving me to question -

"How can we bring back the life of this historical space and recharge the wells for communal use? How can we, as designers, revive the stepwells to cater to the current society and keep them alive?"



Fig 0.2 - Flatbed displaying the historical, cultural, religious, architectural significance of stepwells in India.


Her Space, Her Story
Exploring the Stepwells of Gujarat
PURNIMA MEHTA BHATT
ZUBAAN ACADEMIC
India's Most Glorious Baolis Are Built By Women For Their Lovers: An Interesting Tale
BOOKS
How India's Extraordinary 'Baolis' Began to Disappear
In The Vanishing Stepwells of India, Victoria Lautman articulates how a traditional water conservation system was foolishly destroyed when the British took the reins.
Looking Down to Plan Ahead
CULTURE INDIA
Can India's ancient stepwells solve its water crisis?
Many Indian cities on the frontlines of climate change and faced with acute water crises are turning to ancient water storage techniques to provide a solution.
WATER
The ancient stepwells helping to curb India's water crisis

INTRODUCTION

Water, a sacred natural element, has played a vital role in the evolution of human civilization. Apart from its daily use, it has displayed various purification powers and holds religious significance in India. The inter-relationship between water and architecture has been particularly prominent in the Indian Subcontinent. Looking at examples of the Great Bath from Indus Valley civilization, ponds in temple complexes, ghats of Varanasi, and stepwells in the western states, it is evident that historically, India established a strong base for water architecture in the country. Among these architectural expressions, Stepwells stand out for their intricate structural and engineering complexity.

Stepwells, also known as ***Baoris, Baolis, Bawadis,*** or ***Vavs***, are ancient subterranean structures designed to store groundwater. As the name suggests, stepwells are characterized by a series of steps descending to the water. Originating from the arid regions of western India, these structures enabled water supply during dry seasons. Each stepwell is unique and possesses a distinct narrative. These indigenous structures hold rich cultural, religious, and architectural significance, dating back to the 3rd century and have undergone a significant evolution.[1] Despite being under the rule of various dynasties such as the Sultanates, the Mughals, Rajputs, and the Marathas in western India, the grandeur and complexity of these wells only increased. Water sourced from these stepwells was used for drinking, washing, and bathing. Apart from providing water to the community, they also served as gathering spaces for women and resting spaces for military troops and travelers.[2] Some communities also used these subterranean structures as ritual spaces, embodying utility, and sacredness.

1 Jain-Neubauer, Jutta. The Stepwells of Gujarat: in Art-Historical Perspective. 1st ed. New Delhi: Abhinav, 1981.
2 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.

The distinctive fractal geometry aids in maintaining a cool temperature during the summer, making the complex structure a truly engineered work of art. Stepwells are also renowned for their remarkable architectural elements, with elaborate sculptural details adorning their walls, cornices, pilasters, pillars, balconies, and niches. Some were considered sacred ritual spaces by Hindus and Muslims, with associated deities and sculptural elements.[3]

Although the stepwells flourished for centuries, their use started to decline during British colonial rule in India. When the British invaded India, they considered the communal wells to be filthy and ordered the shutdown of most of the stepwells in the country.[4] This led to the downfall of these magnificent structures. They brought in Western water technologies, which shifted from wells to hand pumps, and made water available to individual homes through piped infrastructure.[5] The stepwells, once vital for the communities, are now being used as dumping grounds. Most of them are in a completely dilapidated state. Due to their subterranean nature, they no longer fit into the urban landscape.

Ironically, even though India has been introduced to new water techniques, over the years the water tables in the country have depleted due to a significant increase in population, urbanization, and global warming. The natural resources are depleting at a much higher rate than expected. Some of the metropolitan cities in India are projected to run out of groundwater sources by 2030 if restoration measures are not implemented immediately.[6]

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3 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.

4 Lautman, Victoria, and Divay Gupta. The Vanishing Stepwells of India. London; Merrell Publishers Ltd, 2017.

5 Lautman, Victoria, and Divay Gupta. The Vanishing Stepwells of India. London; Merrell Publishers Ltd, 2017.

6 National Institute of Urban Affairs. "Impacts of Changing Climate on Water Resources – Consequences for Indian Cities." C-Cube Blog.

Recently, the government has developed new schemes and policies to restore traditional water-harvesting structures[7]. Although the government is taking active measures to restore stepwells, most of the wells remain unknown to society.

Based on this, it is evident that active restoration measures need to be implemented for the revival of the historical use of these ancient structures. The main objective of the thesis is to propose design solutions to create a catalyst model by reprogramming the functionality of the stepwells to fit into the current urban matrix and enable the recharge of groundwater. This would improve the reachability of the stepwells to society and in turn help with the restoration and maintenance of these structures. It would also build on the cultural and diversity growth of these sites.

For this thesis project, the proposed site of intervention is in the city of Ahmedabad, one of the regions in Gujarat prone to groundwater depletion. The Ashapura Mata Stepwell is currently encroached upon by the local community, with restricted entry, situated in a heavily populated residential colony known as Ashapura Mata ni Chali[8]. Currently, the stepwell is in a dilapidated condition and calls for restoration. Reviving this stepwell would not only provide water for the community during times of crisis but also act as an active communal gathering space. The proposed design interventions allow for flexible programming of the stepwell, creating better accessibility for the public. The project also aims to identify and provide small-scale interventions for the local community around the stepwell to enhance the recharge of groundwater.

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7 Press Information Bureau. "Central Government has formulated National Action Plan for control of air pollution in urban and industrial areas." Accessed 30th April 2024. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1914351.

8 Lesser-known stepwells in and around Ahmedabad and Gandhinagar region. Urban Management Center, February 2018.

METHODOLOGY

This thesis project has three prominent layers that need addressing: the revival of historical value, the groundwater crisis, and existing neighborhood-related issues of the surrounding urban areas. The systematic research methodology provided below helped in identifying the underlying problems and proposing design solutions for the Ashapura Mata Stepwell and the surrounding community.

1. Literature review: Although Stepwells have prevailed for centuries, there is minimal available literature data on Stepwells in India. The literature review undertaken has helped in understanding the historical uses of stepwells along with their religious, cultural, and architectural values. Works like ***Steps to Water: The Ancient Stepwells of India***[9], and ***Stepwells of Gujarat: in Art-Historical Perspective***[10] elaborate on the historical timeline of stepwells in the country. These two books discuss the architectural and spatial significance of stepwells in a broader context, including construction techniques and the decline of these architectural structures in the country. The books also include illustrations of plans and sections of various stepwells, aiding in a spatial comparative study. ***Her Space, Her Story: Exploring the stepwells of Gujarat***[11] specifically explores how stepwells were used as spaces for women, highlighting the vital role women played in their construction and use. This indicates that stepwells can be revived and used as spaces for women's empowerment in the current generation. ***The Vanishing Stepwells of India***[12] provides extensive documentation of existing stepwells in India, showcasing their dilapidated condition through a series of photographs. This literature study helped identify the design site of the intervention and establish drawings to communicate the research study.

9 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.
10 Jain-Neubauer, Jutta. The Stepwells of Gujarat: in Art-Historical Perspective. 1st ed. New Delhi: Abhinav, 1981.
11 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.
12 Lautman, Victoria, and Divay Gupta. The Vanishing Stepwells of India. London; Merrell Publishers Ltd, 2017.

2. Existing site study: Since the site is located in a rural setting, there were no readily available maps for the site. With the use of Google maps and by visiting the site, I was able to create base maps and model out the context of the Ashapura Mata Stepwell. Documenting accurate and purposeful photographs of the site and its neighbouring context, helped with providing raw data for this thesis.

3. Case studies: Upon identifying other restored stepwells in the city of Ahmedabad, I visited Dada Harir Stepwell, Mata Bhavani Stepwell and Adalaj Stepwell to do a comprehensive case study. While these spaces established new roles in the current urban context, they helped me identify areas where they fell short. This further helped with the development of a program brief for the restoration of Ashapura Mata Stepwell.

SUMMARIES

Part 1 explores the historical narrative of stepwells in the Indian Subcontinent. It sets a background context for the interrelationship between water and stepwells. This section elaborates on how these structures work by bringing out the multidimensional characteristics of the subterranean structures. It highlights the historical, cultural, and religious significance of stepwells. The final subsection briefly talks about the decline of historical artifacts.

Part 2 discusses the current state of groundwater and stepwells in India. It highlights the various problems faced by communities and shows the potential threats if immediate actions are not taken. With the help of case studies, the second section investigates understanding the theories of Aldo Rossi, as it sets a base for looking at the site as an urban artifact and proposing relevant strategies.

Part 3 zooms into observing the site at a macro and micro level. The initial study focuses on geographical data and marking out of the stepwells and water sources. The second part of this section explores the critical analysis of the Ashapura Mata stepwell. The analysis highlights the problems at the site and the surrounding local community to develop restoration and groundwater recharge strategies for the site.

Part 4 looks at the various layers of design. The section starts with proposals at a micro level within the stepwells and zooms out into proposing groundwater recharge strategies for the community. The proposed design solutions are intended to make the stepwell accessible to the public and the community and also build on creating a self-sustaining community to recharge groundwater.

Part 1

Water and Stepwells - The Past

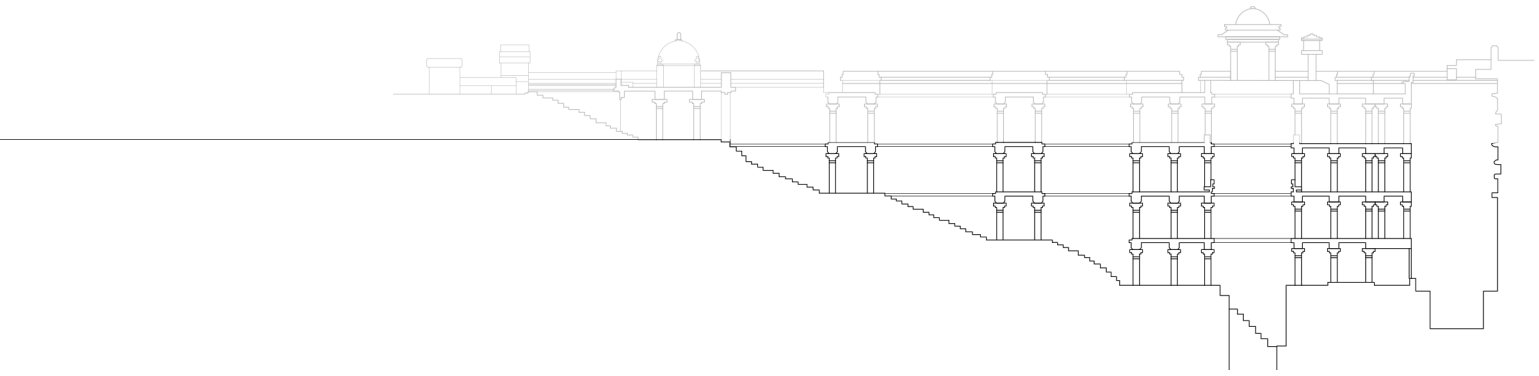




Fig 1.1 - Multiple facets of water.



1.1 Water and the Built Environment

Water is one of the natural resources that plays a crucial role in human survival. It is a multifaceted element with various religious and cultural significances. Due to its flexible form, it is considered feminine in nature. It travels for miles, taking the shape of its course, to provide a source of living. The water we use every day is more than just H2O. From a religious and cultural perspective, water embodies a dual nature of purity and cleanliness. Although the rituals vary from one religion to another, the core principle of a purifying agent remains the same.

Over centuries, this multidimensional nature of water has shaped the cultural history of India. The symbolism of water holds a significant prominence in Hindu mythology. The Sanskrit term, Jeevan, has a dual meaning of water and life, reflecting the inseparable connection between them.[1] Due to the underlying sacred value of water, the rivers in India are personified as Goddesses. The spiritual factor of water led to the establishment of various religious sites in the country. The spiritual role of water has been fading over the years, however in most places, it is just used as an essential resource for everyday livelihoods.

While seventy-one percent of the earth's surface is water, it still remains scarce for everyday human consumption. With the growing concern for climate change and global warming, it becomes essential to protect and conserve this natural element and prevent further contamination and deterioration. Understanding the historical role of human-water interrelationships is crucial in developing solutions to conserve water for future generations.

1 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.

The early traces of the relationship between water and the built environment can be observed in early river civilizations. Nomadic communities settled along rivers to use the water from rivers for crop production as the rivers made the soil fertile for cultivation. Water became an integral part of these civilizations, leading to the construction of dedicated water infrastructures to ensure the transportation of water from one place to another. This phenomenon is evident in structures such as aqueducts during the Roman Empire. The Persians employed similar techniques, and their systems were known as Qanat.[2]

In the Indian subcontinent, water and architectural systems date back to the Indus Valley civilization. The cities of Harappa and Mohenjo-Daro implemented a sophisticated network of wells, sunken cylindrical shafts, and dug-up narrow pits to facilitate water distribution.[3] The arid regions in India predominantly relied on harvesting rainwater and groundwater for everyday water needs. They deployed the construction of Khadin, Johads, Ahar Pynes, Tankas, Kund, Baolis and Vavs. The narratives of these ancient water harvesting techniques showcase the efforts made by communities to source and maintain natural resources.

Another form of early water architecture was observed in the ghats of the Ganges. Ghats are a series of steps that run along the river bridging the city with the river. As mentioned earlier, Hindus bathed in holy rivers for soul cleansing. To maintain this connection, they constructed ghats along rivers to bring the built environment closer to the sacred rivers. This stepped architecture was later observed in the form of stepwells in India. This form of architecture evolved over time and established a significant presence in the western region of India.

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2 News, Posted by AMERICAN. "The History of Water Infrastructure and What We Can Learn from It." American USA News, September 29, 2016.
3 Jansen, M. "Water Supply and Sewage Disposal at Mohenjo-Daro." World Archaeology 21, no. 2 (1989): 177–92. http://www.jstor.org/stable/124907.

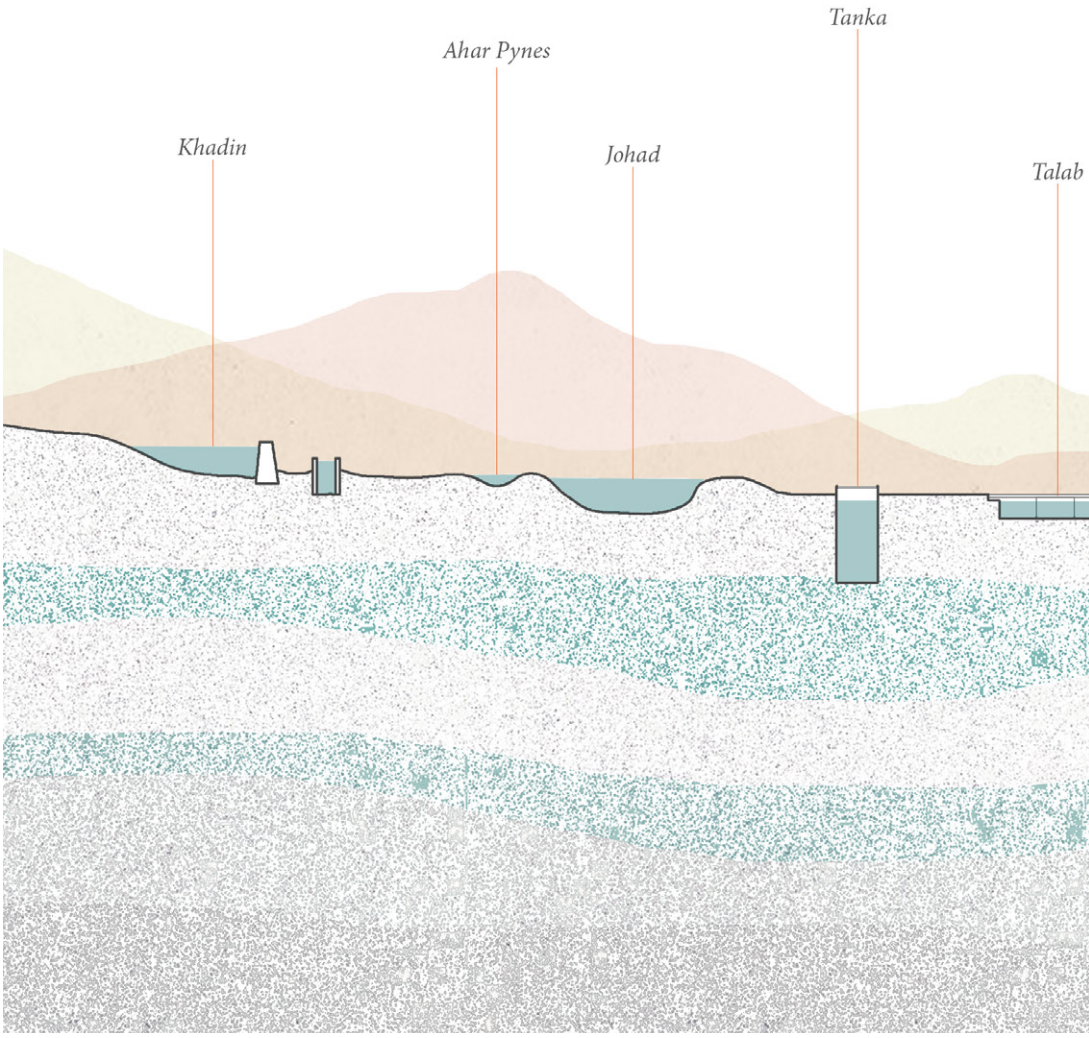


Fig 1.2 - Schematic section showing traditional water harvesting techniques native to the Indian Subcontinent.

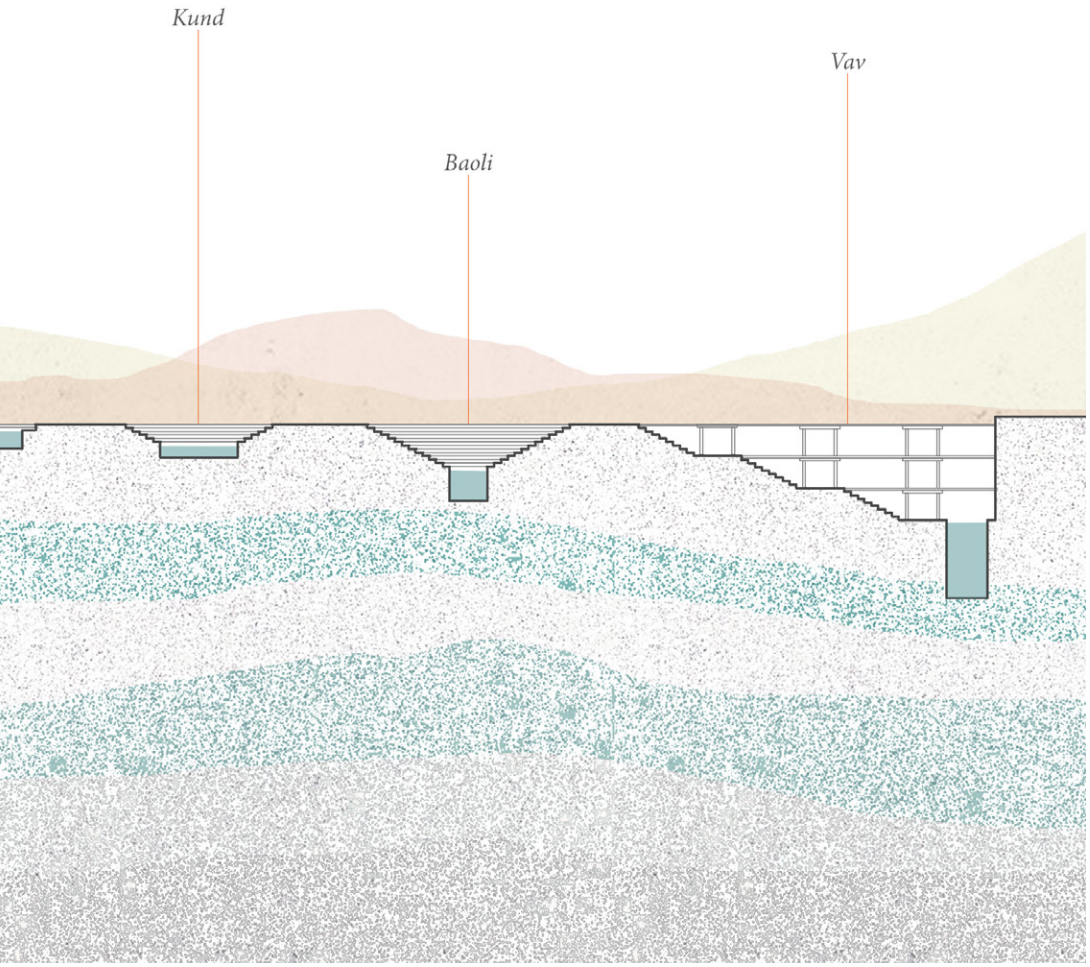

Kund
Baoli
Vav



Fig 1.3 - Illustration of Ghats of Varanasi, India.



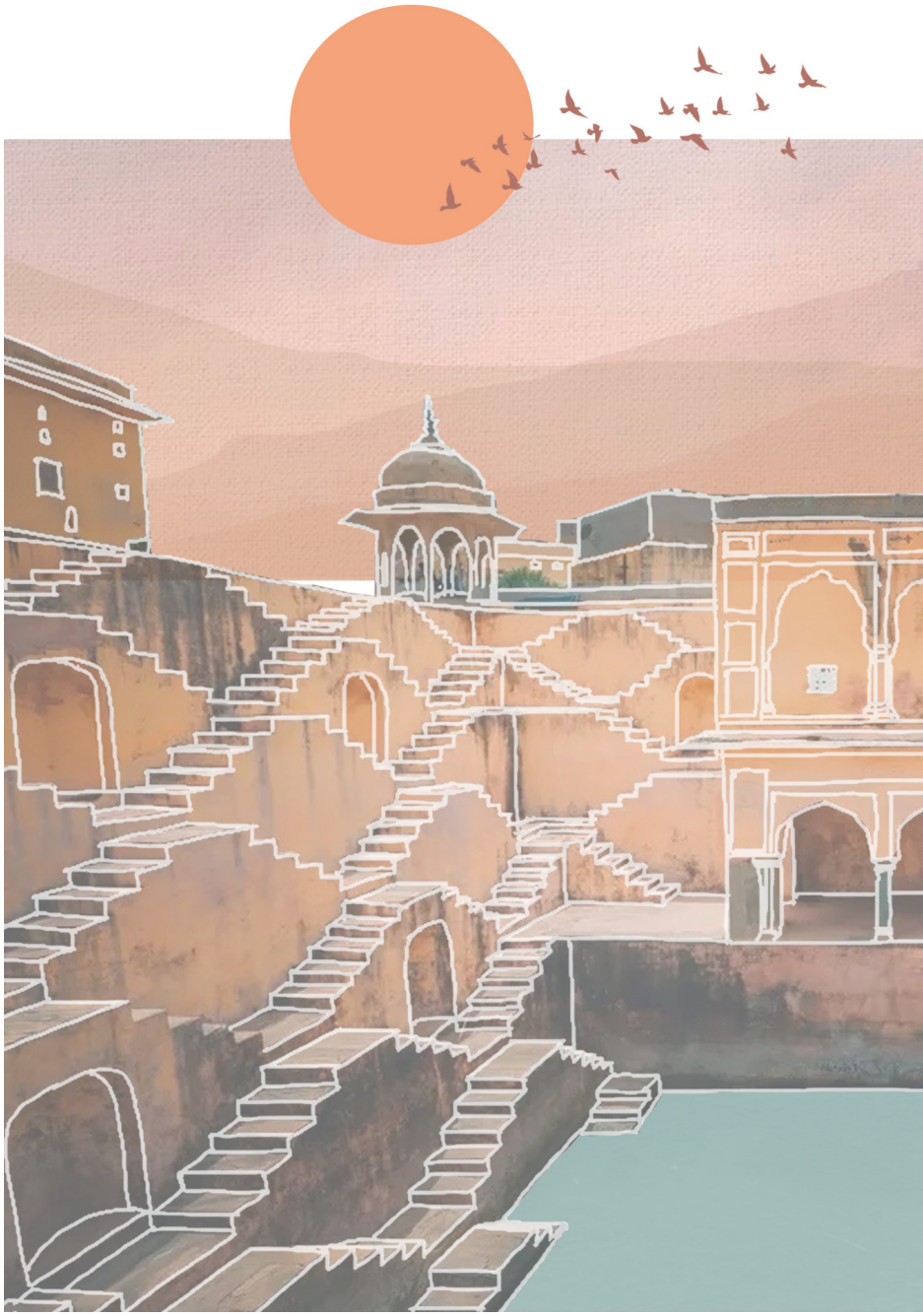


Fig 1.4 - Illustration of Panna Meena Stepwell in Rajasthan, India.





Fig 1.5 - Collage of historical, cultural, religious, architectural aspects of Stepwells in India.

1.2 Stepwell - A Communal Water Harvesting Space

"There are no other wells in the world, that structurally, and decoratively, can compare to the stepwells of Western India, and it was because their builders were content to keep the established traditions to attain such perfection" – John Marshall[4]

As already noted, Stepwells or stepped wells were built in response to curb the water shortage in the western arid regions of India. Due to extreme heat prevailing in these states, the locals mainly depended on sourcing groundwater and harvesting rainwater. Although a conventional well served as a structure for storing and sourcing water, stepwells were primarily built to serve the dual purpose of utilitarian water needs and act as a communal space. It is often remarked that five conventional wells were equivalent to a single stepwell[5].

The water drawn from the stepwells was used for drinking, washing, and bathing. With these daily functions, they were also used as communal gathering spaces for women. They were mostly built along trade routes in the western part of India. These routes were known for the trade of spices, silk, fragrance, cotton, and textiles as resting place for travelers of all types.[6] While historical records indicate that there were over 3000 stepwells of different scales and sizes built in India only about 100 remain today.[7]

4 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.
5 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.
6 Lautman, Victoria, and Divay Gupta. The Vanishing Stepwells of India. London; Merrell Publishers Ltd, 2017.
7 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.

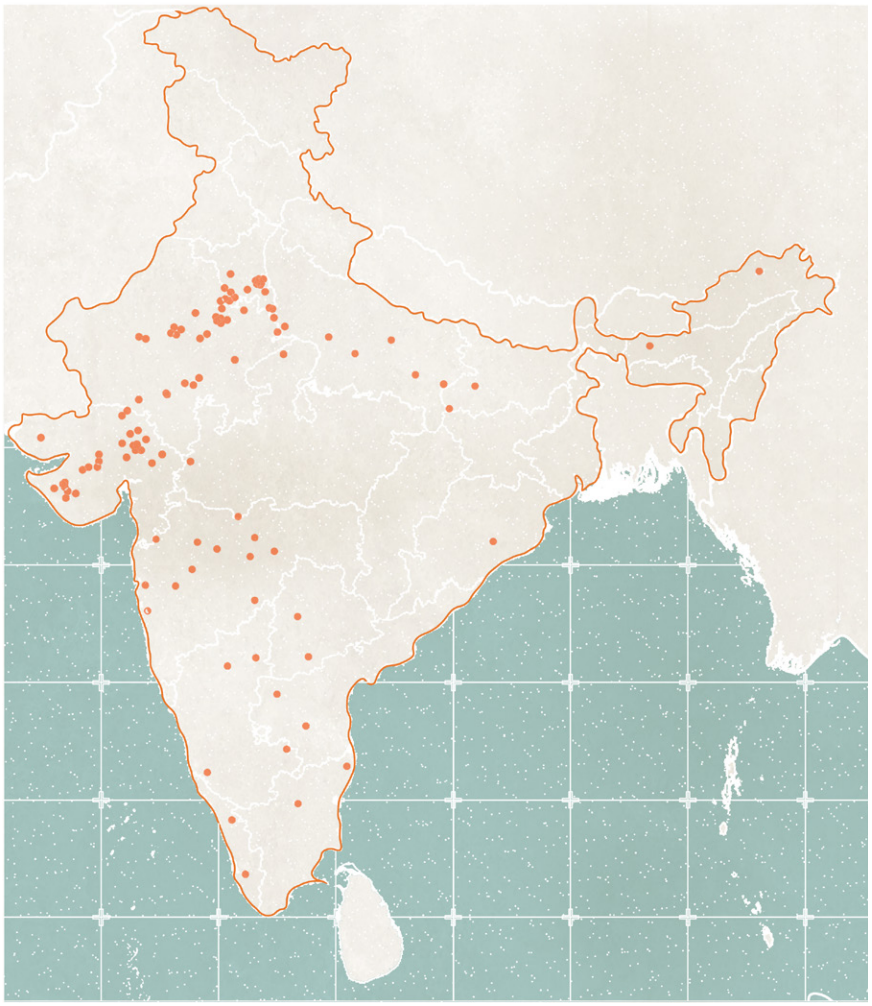


Fig 1.6 - Locations of existing stepwells in India. These stepwells are either in disrepair or are currently being restored.

Special people were assigned to identify the underground water channels also known as aquifers. These locations were dug out to harvest groundwater. The depth of the pits varies from location based on the aquifer. Due to the varying depth, some stepwells involved more complexity in the structure. Through the use of a scaffolding system, stepwells were dug and arranged tier by tier which created different levels. The load-bearing walls transferred the load to a series of columns and beams ensuring structural stability.

The stepwells were built in the western states of Rajasthan and Gujarat. The history of these water harvesting systems dates back to the 7th century and has undergone a significant evolution over time. The oldest stepwell, Adi Kadi ni Vav, was built as a rock-cut cistern in the region of Saurashtra.[8] Over centuries, these rock-cut wells transformed into elaborate stepped wells. Chand Baori, built in the 9th century, displays the complexity of stepwells. Numerous stepwells were built in Gujarat during 924 – 1244 CE under the Solanki rule.[9] The royal families patronized the construction of temples and stepwells. The famous Rani ki Vav, also known as Queen's Stepwell, located in Patan, was built in 1099 AD during the Solanki rule.[10] These stepwells not only served the utilitarian purpose but stood out as architectural marvels reflecting that time's cultural and architectural achievements.

8 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.
9 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.
10 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.

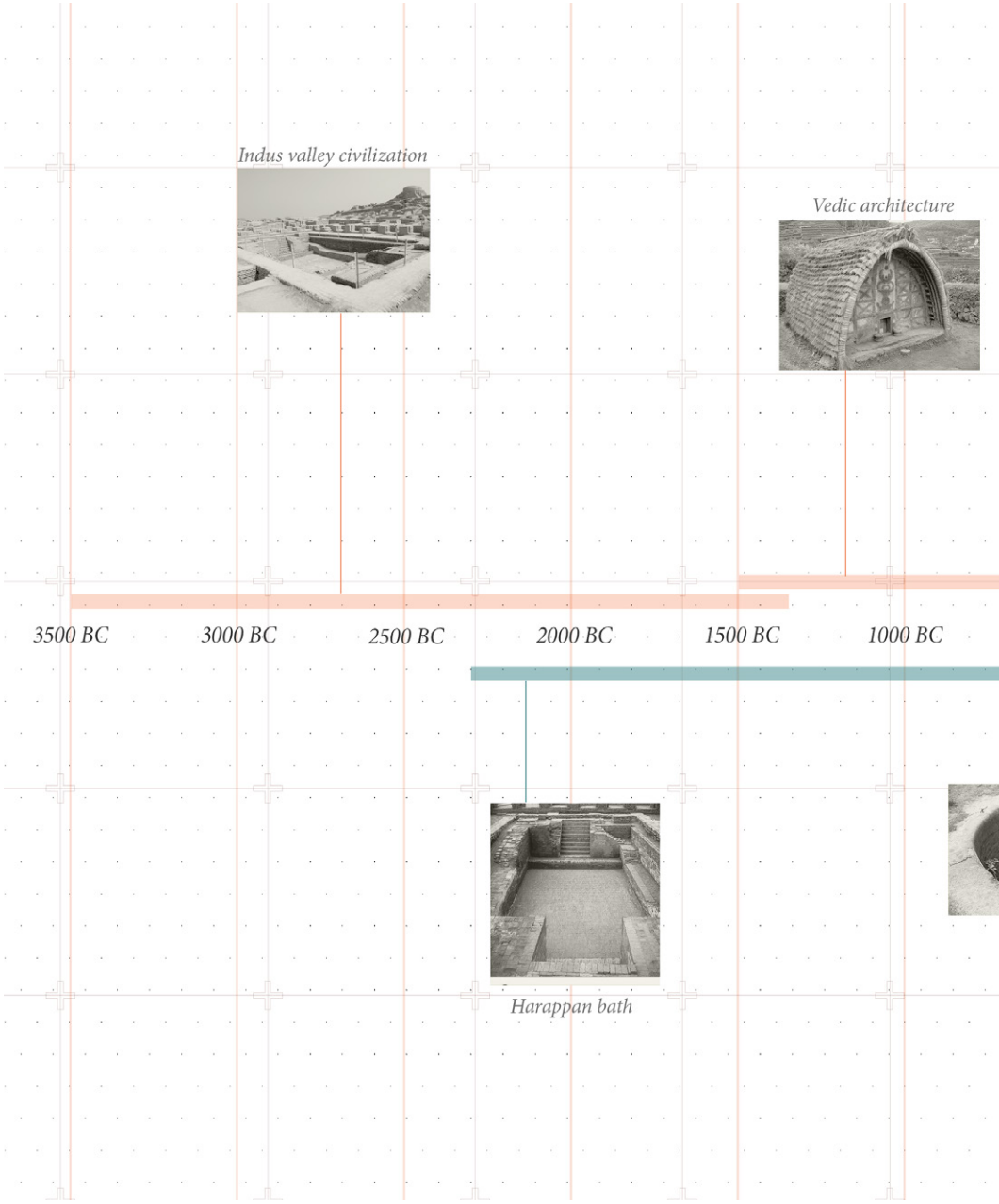
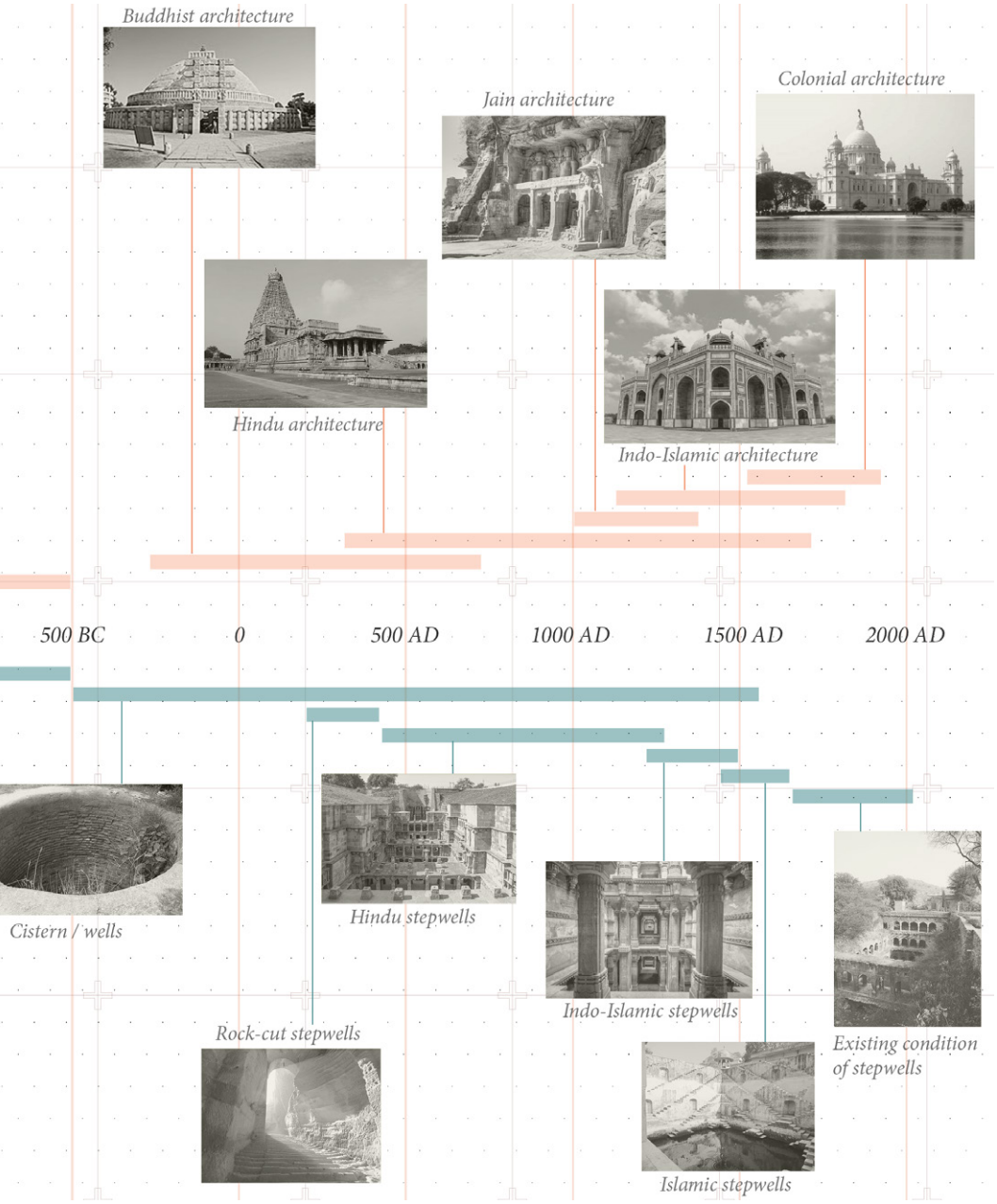


Fig 1.7 - Evolution of Indian architecture and Stepwells.


Buddhist architecture
Jain architecture
Colonial architecture
Hindu architecture
Indo-Islamic architecture
500 BC
0
500 AD
1000 AD
1500 AD
2000 AD
Cistern / wells
Hindu stepwells
Indo-Islamic stepwells
Existing condition of stepwells
Rock-cut stepwells
Islamic stepwells

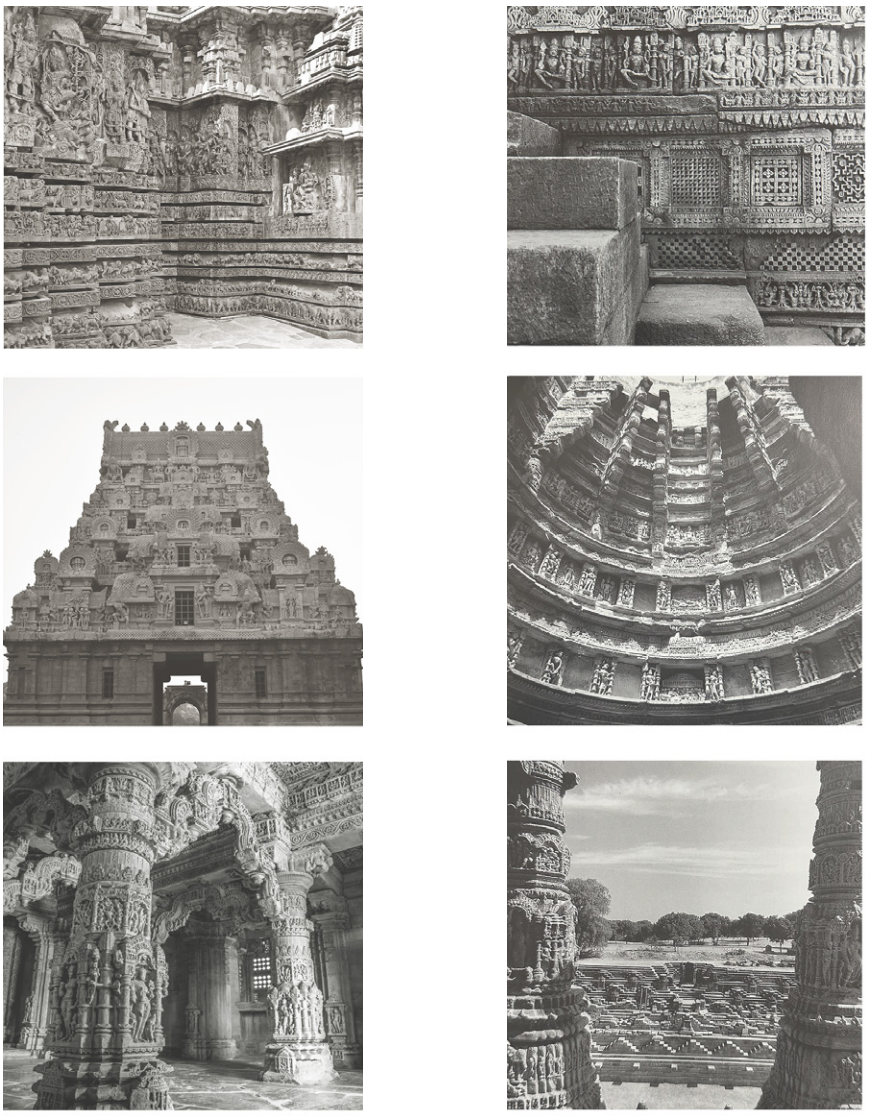
1.3 - An Architectural Artifact

Stepwells held rich cultural, religious, and architectural significance. The water in the wells had spiritual and sacred importance, elevating some stepwells to worship sites among pilgrims. Elaborate sculptural details adorn their walls, cornices, pilasters, pillars, balconies, and niches showcasing the artistry of their time.

Various dynasties ruled over India from early 200 AD until the 19th century. During this period, the rulers commissioned the construction of various worship sites that reflected religious significance of their time. The timeline (see Fig. 1.7) illustrates how Indian architectural styles transformed from the Indus Valley Civilization to the colonial period. The complexity of ornamentation peaked during the Hindu architecture period. The walls and columns were adorned with depictions of Hindu gods and goddesses, displaying the intricacy of the craftsmanship. There was a fusion of elements from Hindu and Islamic architecture, highlighting the sculptural essence of Hindu architecture and the nature-based geometry of Islamic architecture.[11]

While the rulers commissioned the construction of religious worship sites, they also commissioned the construction of stepwells. The stepwells adapted elements from the architectural style of their specific period. The sculptors, also known as Shilpins, who worked on the elaborate motifs of temples, were the same people who built stepwells, carrying the same motifs into these utilitarian structures.[12]

11 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.
12 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.



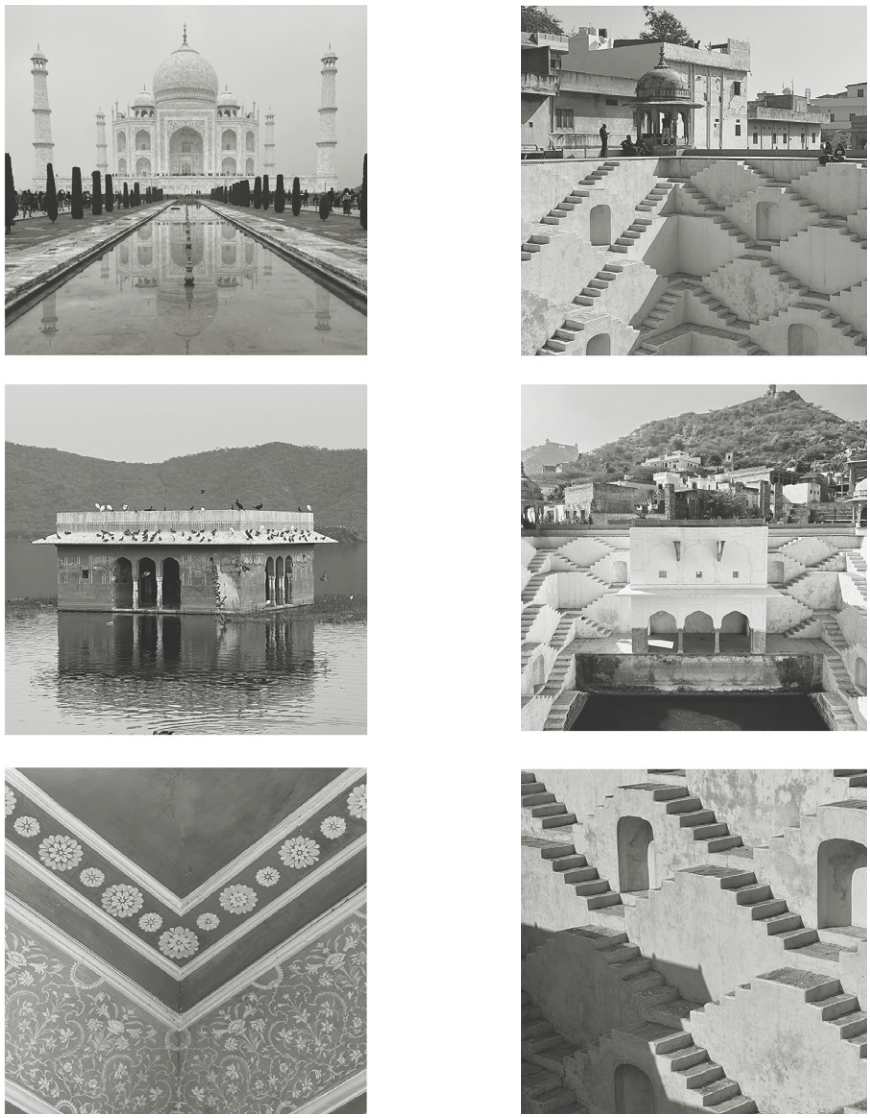
Hindu temple architecture *Stepwells*

Fig 1.8 - Influence of Hindu temple architecture style on Stepwells.



Indo-Islamic architecture *Stepwells*

Fig 1.9 - Influence of fusion (Hindu and Islamic) also known as Indo-Islamic architecture on Stepwells.



Islamic architecture *Stepwells*

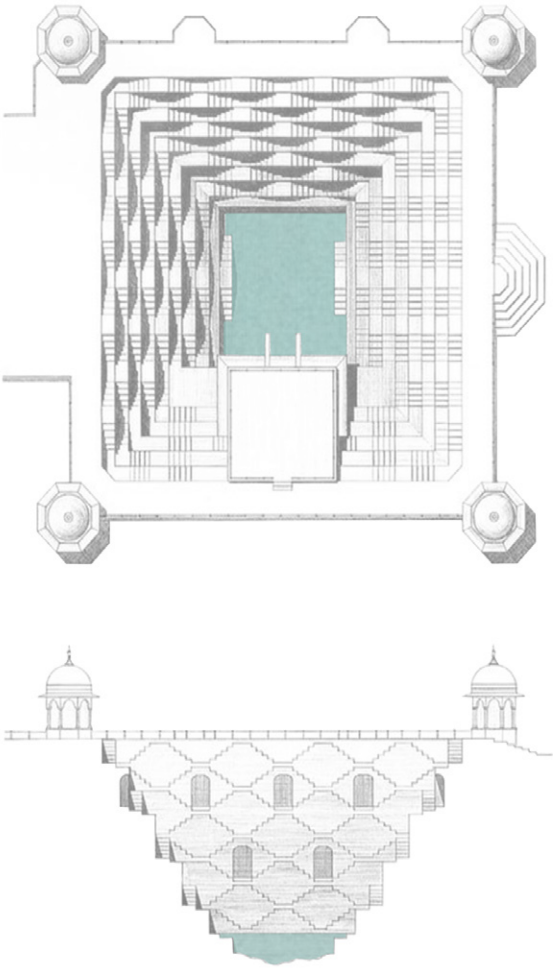
Fig 1.10 - Influence of Islamic architecture style on Stepwells.

Influenced by regional architectural styles, each stepwell exhibited unique features and stood out. When you look at the overall classification of the stepwells in the country, these structures can be categorized into two prominent types based on the architectural form and geographical location. The architectural features and functionality of the wells in Gujarat made them distinct from the ones in Rajasthan.

The stepwells of Rajasthan are commonly known as Baolis, Baoris and Bawadis and were mainly square. These stepwells had a visual appearance resembling stepped ponds or kunds that were included in temple complexes. The open-to-the-sky wells are encircled by steps on three sides or all four sides of the pond. Chand Baori in Abhaneri is the earliest form of stepwell in Rajasthan dating back to 800AD is known to be one of the largest and deepest stepwells in the country.[13] The construction of stepwells had its period of evolution in this region under the reign of the Mughal Empire. A style of Mughal buildings blended into the stepwells which were built as part of the fort complexes. Stone and plaster were the main material used for the construction of the stepwells in this region.[14] The surroundings of the stepwells would typically have pavilions or Chattris built at all four corners.

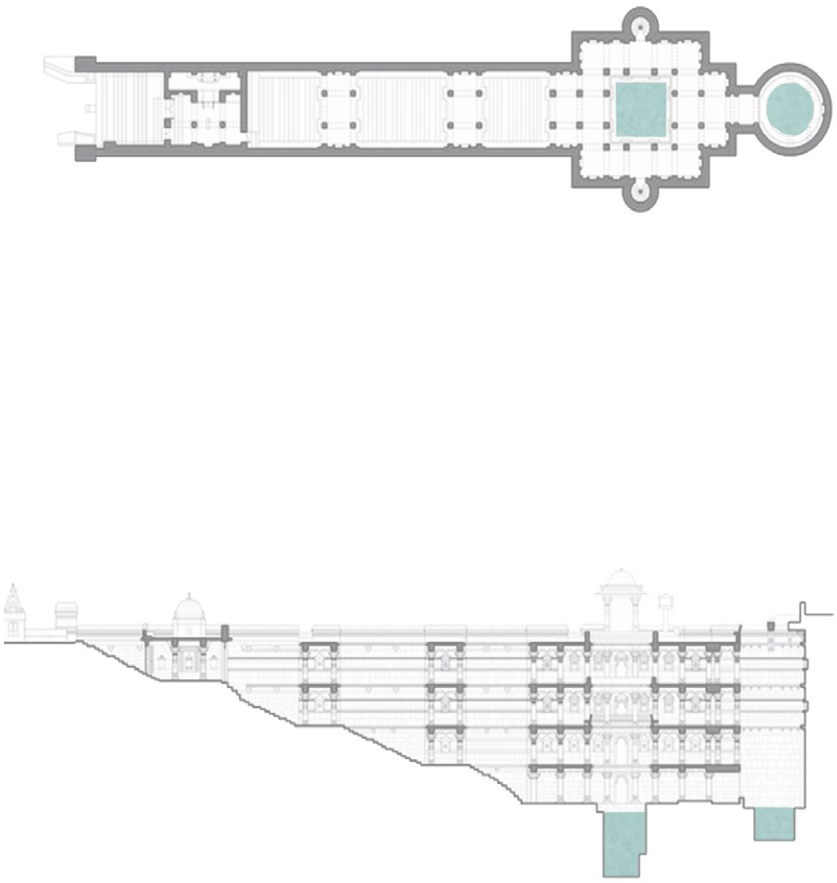
13 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.

14 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.



Chand Baori, Abhaneri

Fig 1.11 - Typical Rajasthani Stepwell, also known as Baoli, Baori or Bawadi.



Ashapura Mata ni Vav, Ahmedabad

Fig 1.12 - Typical Gujarat Stepwell, also known as Vav.

Vavs, Vavdi or Vai are distinct types of stepwells explicitly found in Gujarat. They were constructed as narrow stepped corridors to make it easier for women to go and fetch water from the wells. The stepwells in Gujarat were built in villages and on trade routes to provide a source of water for travelers and military troops and act as resting space.[15] Often travelled at night to avoid the scorching sun and rested in these wells during the day.

The depth of the wells varied based on how deep they had to dig to source groundwater. This depth created levels or pavilions known as kutas inside the stepwells. Vavs also featured intricate stone carvings derived from traditional Hindu temple architecture. Over time, these motifs underwent a significant transition, incorporating Indo-Islamic influences and eventually developing into an Islamic style.

Queen's Stepwell, or Rani ki Vav, in Patan, was built in 1032 AD and stands out as the most impressive and majestic stepwell in Gujarat.[16] This remarkable stepwell has taken architectural features from temple architecture, and the walls are adorned with sculptural motifs of gods, goddesses and celestial nymphs known as apsaras. The well also featured intricate lattice patterns on the walls. Adalaj Vav or Rudabai Vav, Adalaj, built in 1499 AD, displayed a blend of Indo-Islamic architectural style.[17] After the takeover of the Mughal reign over the Western states, the wells ultimately transitioned to an Islamic style of architecture. The walls are adorned with animals, plants, and other natural elements, symbolizing Islamic beliefs. This style can be observed in Dada Harir ni Vav, Ahmedabad, which was built in 1485 AD.[18] Despite the changes in ruling power leading to significant destruction of temples and other religious architecture, stepwells only continued to evolve and became increasingly elaborate.

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15 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.
16 Jain-Neubauer, Jutta. The Stepwells of Gujarat: in Art-Historical Perspective. 1st ed. New Delhi: Abhinav, 1981.
17 Jain-Neubauer, Jutta. The Stepwells of Gujarat: in Art-Historical Perspective. 1st ed. New Delhi: Abhinav, 1981.
18 Jain-Neubauer, Jutta. The Stepwells of Gujarat: in Art-Historical Perspective. 1st ed. New Delhi: Abhinav, 1981.

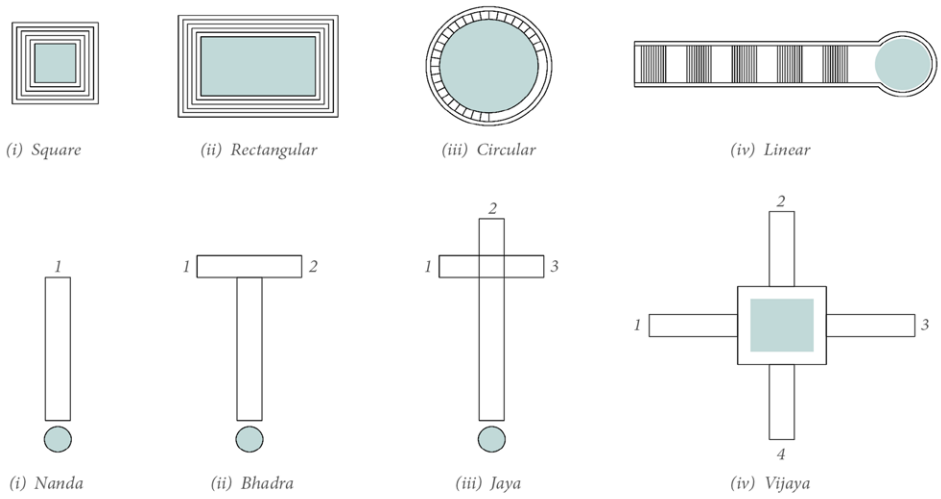


Fig 1.13 - Geometrical classification of Stepwells.

Another prominent aspect of stepwells lies in the geometrical organization of the space. Since they are subterranean, the principles overlapping fractal geometry hold a key significance. The geometrical layout of the space ensures structural stability is intact. Apart from this, the geometry of the wells is aligned in a complex and layered way to prevents evapotranspiration, safeguarding the water stored in the wells.[19] The dynamic layering of these elements ensures the stepwell is cool at all times, harmonizing the function and form of the space.

Stepwells are typically designed in various shapes and sizes based on geographical locations and reachability to groundwater. Whether linear, circular, square, or rectangular, each design holds an underlying geometric narrative. The circular stepwells displayed the spiral geometrical through the arrangement of the steps, while the square and rectangular ones increased their complexity with increasing corners.[20] The form of linear stepwells adapts, and transforms based on the number of entry and exit points. These points were determined by the size of the well shaft.[21]

The factual geometry and precise angle of steps create perspective illusions within the space. This adds a layer of depth and improves the sophistication to the space. The architectural elements and levels within the stepwells are usually repetitive creating a sense of rhythm and continuity. Even though the step size in Baolis is standard, the staggered layering creates an illusion of scaled-down steps.[22]

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19 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.

20 Parmara, Samirsinh P., and Debi Prasad Mishra. "Fractal Geometry in Water Conservation Structures: Step Wells and Tanks in India." Indian Journal of History of Science 55, no. 2 (September 2, 2020). https://doi.org/10.16943/ijhs/2020/v55i2/154675.

21 Parmara, Samirsinh P., and Debi Prasad Mishra. "Fractal Geometry in Water Conservation Structures: Step Wells and Tanks in India." Indian Journal of History of Science 55, no. 2 (September 2, 2020). https://doi.org/10.16943/ijhs/2020/v55i2/154675.

22 Parmara, Samirsinh P., and Debi Prasad Mishra. "Fractal Geometry in Water Conservation Structures: Step Wells and Tanks in India." Indian Journal of History of Science 55, no. 2 (September 2, 2020). https://doi.org/10.16943/ijhs/2020/v55i2/154675.

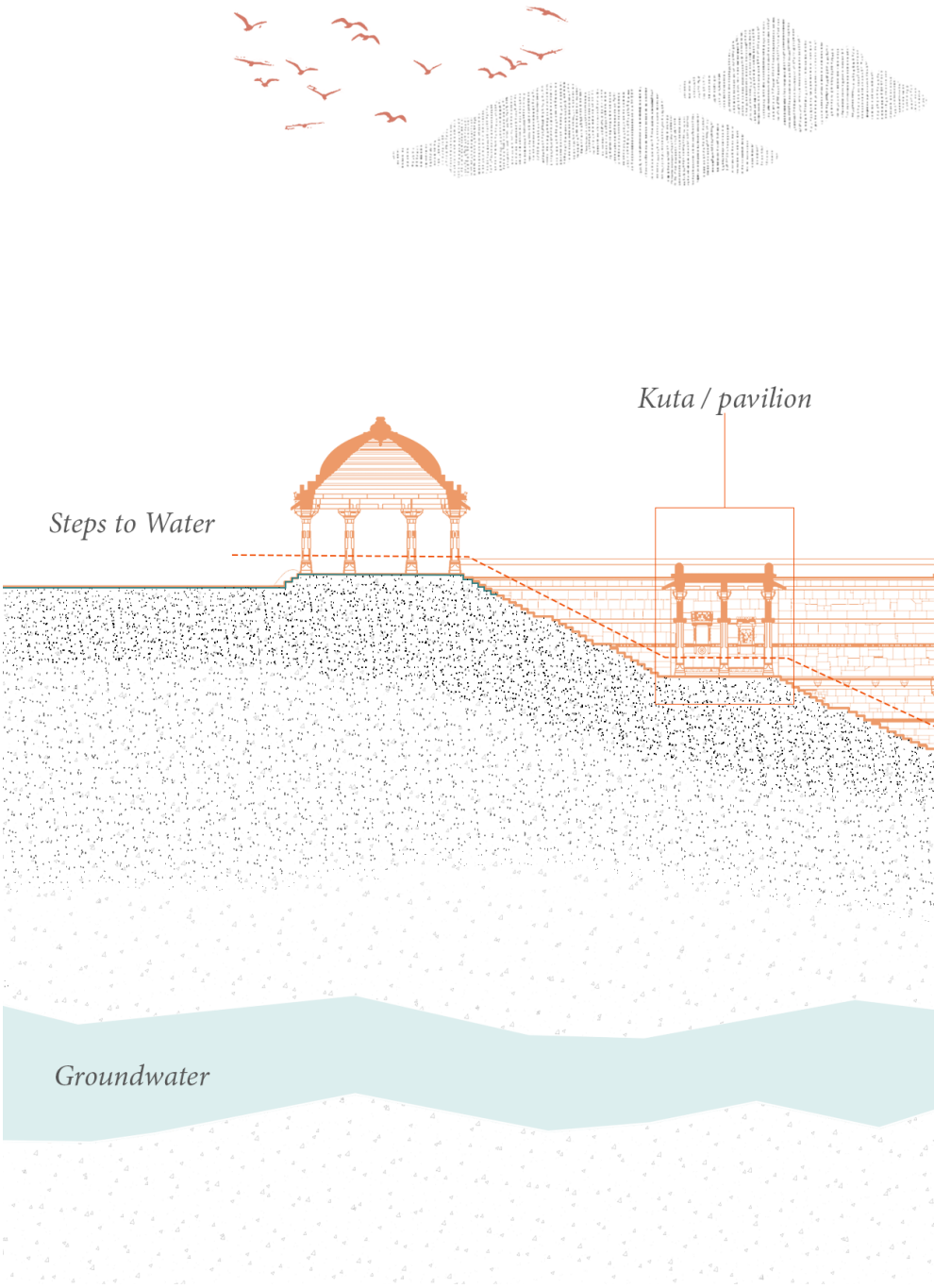


Fig 1.14 - Spatial characteristics of a Stepwell.

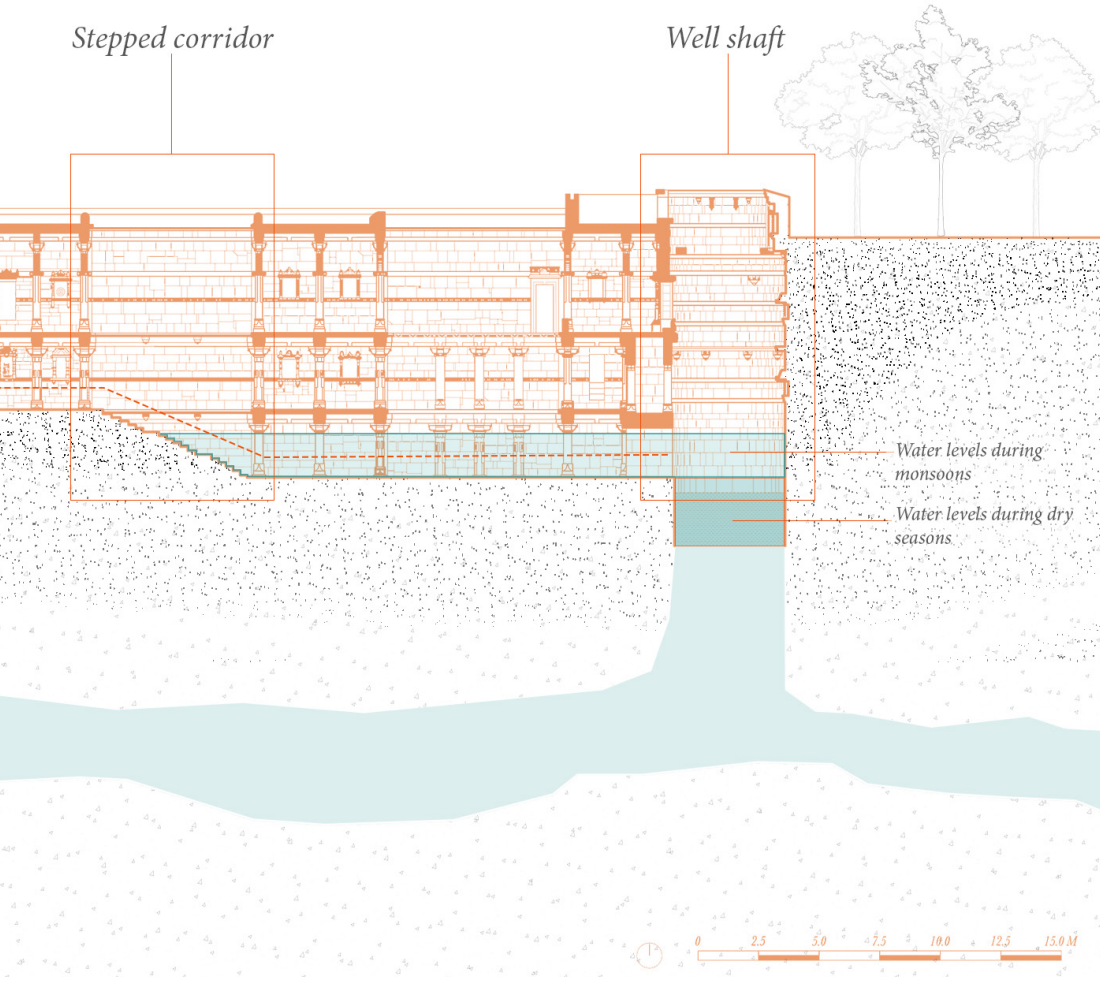

Stepped corridor
Well shaft
Water levels during monsoons
Water levels during dry seasons
0
2.5
5.0
7.5
10.0
12.5
15.0 M



Fig 1.15 - Schematic diagram of a women's route to a Stepwell.

1.5 Stepwells as a Space for Women

Water is often considered feminine and holds profound religious and cultural symbolism in India. Most of the rivers in the country are regarded as sacred and are associated with Hindu goddesses. "Women are identified as carriers of water"[23], both internally and externally. They carry life in the essence of water within the womb and are traditionally known for fetching water from wells for everyday use, as they are bound to the domestic sphere of fertility and nurturing. It is important to recognize this intimate connection between women and water, as it has played a pivotal role in the history of stepwells.

Traditionally, society often considered women to be associated with the private realm as they are typically confined to the domestic sphere, while men belonged to the public realm. Due to the domestic responsibilities placed upon women, they were the ones tasked with fetching water from these wells, making stepwells a rare publicly prominent space among women. For a long time, there was no dedicated space for women to gather. However, with the prevalence of magnificent stepwells in the western states of India, they became communal gathering spaces for women.[24] These spaces enabled them to escape the social limitations imposed by patriarchal society.

During pre-historic times, married women were obligated to cover their faces with a saree veil called the *purdah* to prevent them from being seen by the opposite sex. Stepwells provided freedom from the *purdah* system due to the privacy created by their compelling subterranean nature. Historically, in this gender-focused society, stepwells nurtured women and allowed them to express their emotions freely. While some shared their sorrows between the walls of these wells, others found solace in laughter.[25] Due to the water-sourcing pattern established during dusk and dawn, stepwells became predominantly women's gathering spaces.

23 Quoted by Autumn Petlier at Water Water Day, University of Waterloo, 2024
24 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.
25 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.



Fig 1.16 - Historical role of women in India

Apart from the spatial significance, the interrelationship between women and water also extends to religion and spirituality. The water in most stepwells is considered sacred and is believed to possess fertility and purifying abilities. Due to the nature of stepwells, women often worshipped local female deities inside these spaces. They performed rituals honouring the deity and the water inside the stepwell and gave food and flower offerings to the goddesses, also known as devis or matas, to seek blessings.[26] This religious and spiritual significance of the stepwells continues to prevail in some of the stepwells even today.

As women increasingly used the stepwells for the above reasons, they became the primary patrons in constructing some stepwells in Gujarat and Rajasthan. It is believed that gifting water and quenching thirst was a way to attain immortality.[27] Twenty-five percent of the stepwells were commissioned by women. Additionally, it is also identified that the stepwells commissioned by women resulted in more extraordinary delicacy and intricacy in the artwork adorning their interiors. This can be observed in Queen's Stepwell at Patan, Rudabai Vav at Adalaj and Dada Harir Vav in Ahmedabad. As the stepwells were associated with local deities, they showcased feminine artwork on the walls and columns of the wells.

This highlights the significant role played by women, not only in the architecture but also in the functioning and establishment of religious significance associated with the stepwells.

26 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.
27 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.

1.6 Decline of Stepwells

Stepwells prevailed for centuries across the western states of India, serving as vital water sources and communal gathering spaces. The traditional water harvesting systems were indigenous to the early historic periods of India's history. The royal families mainly focused on building communal and religious infrastructure. During the eighteenth century, when the British East India Company invaded India, their focus shifted to constructing new infrastructure such as roads, railways, bridges, and highways. Additionally, the British built civic buildings and influenced the architectural style of Indian structures. Traces of British influence on Indian architecture persist even today. Most local water sources during this period were communal gathering places. However, the British perceived water from these wells as filthy, unclean, and unfit for human consumption.[28] Coming from the western countries, they believed Indians were ignorant and unhygienic about their local water sources and assumed that this ignorance could have been the cause of diseases spread in the country.[29] Consequently, this perception led to a decline in the use of stepwells and their water, despite their importance to the local community.

Most of the stepwells were sealed and closed, eventually leading them to crumble to the ground. This prompted the introduction of new hydraulic engineering in the country. The states of Gujarat and Rajasthan were significantly affected by severe water crises due to the prevailing climatic conditions. With the introduction of new water systems, it became relatively easier to source water from tanks and piped taps. However, despite having enough water supply, many found it difficult to transition from the taste of fresh groundwater to piped water.[30]

28 Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.
29 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.
30 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.

While the British primarily focused on improving infrastructure, they completely overlooked the fact that they were losing out on an essential public space amidst the shutdown of the stepwells. The new modern water techniques led to the stepwells falling into disrepair, or being used for other types of activities, rather than utilitarian purposes.[31] Due to the closure of the wells, the locals were unable to meet the demands of water ritual spaces. The echoes and laughter of women in these subterranean structures were lost forever.

With the expansion of rural and urban areas, the original traces of the wells were lost. They ceased to function as resting spaces for travelers. The use of stepwells as water providers transformed into mere dumping grounds. The wells, which were once inhabited by humans, are now inhabited by plants and other species. The surrounding communities absorbed the stepwells into their households and transformed them into places for drying laundry and extended storage spaces. As villagers relied on piped infrastructure, they stopped cleaning the wells, making the water unfit for human consumption. The communities that once used the space and were responsible for preserving it started neglecting these wells. The stepwells declined in the 20th century as water tables fell, leading to the shutting down of numerous wells.[32] This ancient method was completely abandoned and forgotten.

31 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.
32 Lautman, Victoria, and Divay Gupta. The Vanishing Stepwells of India. London; Merrell Publishers Ltd, 2017.

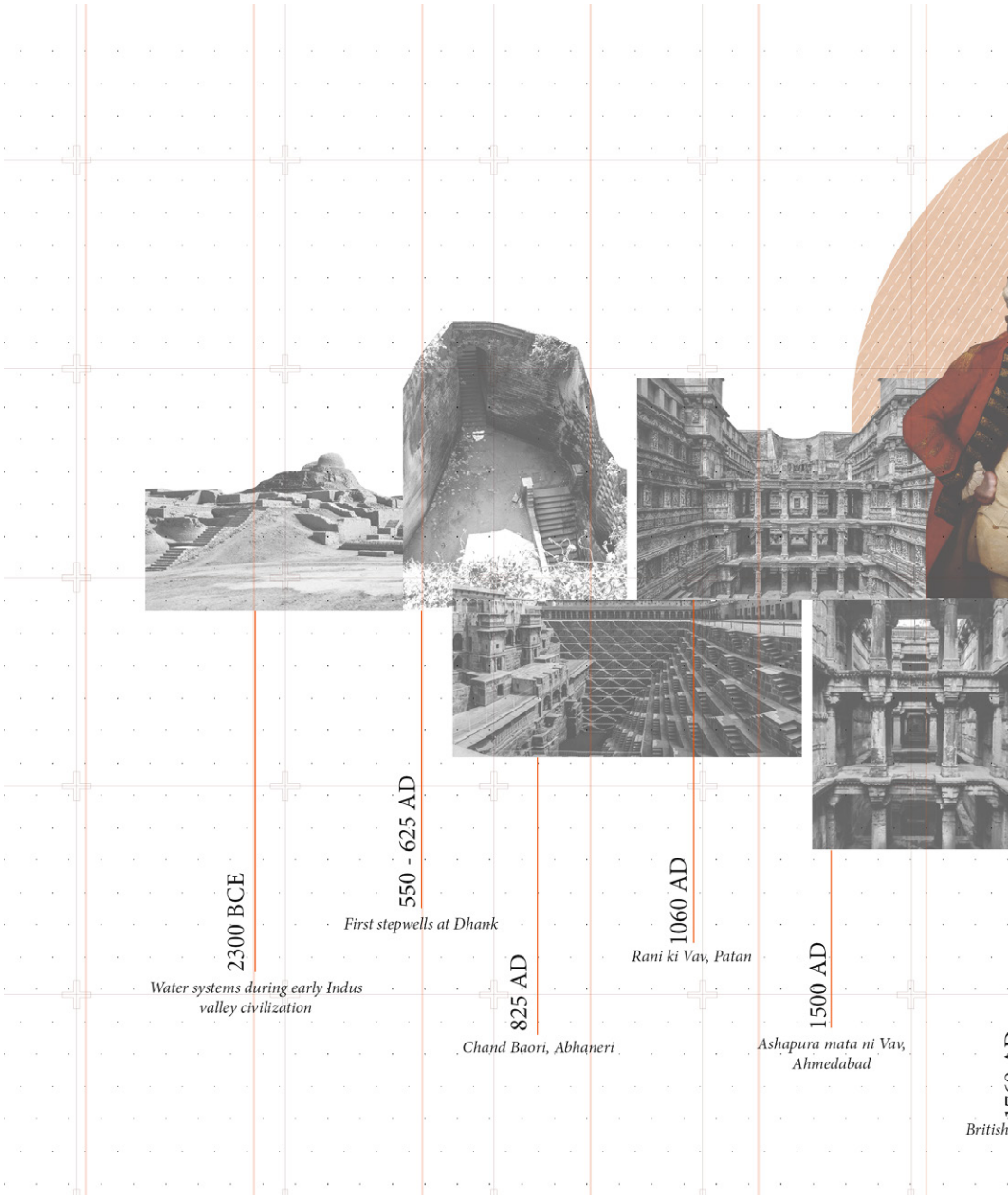


Fig 1.17 - Timeline highlighting the decline of Stepwells.



1769 AD

invade India

early 1800s

Western water techniques brought to India

1800s

Tapped water provided to houses

1850 - 1900

Fall of stepwells

2023

Existing condition of stepwells

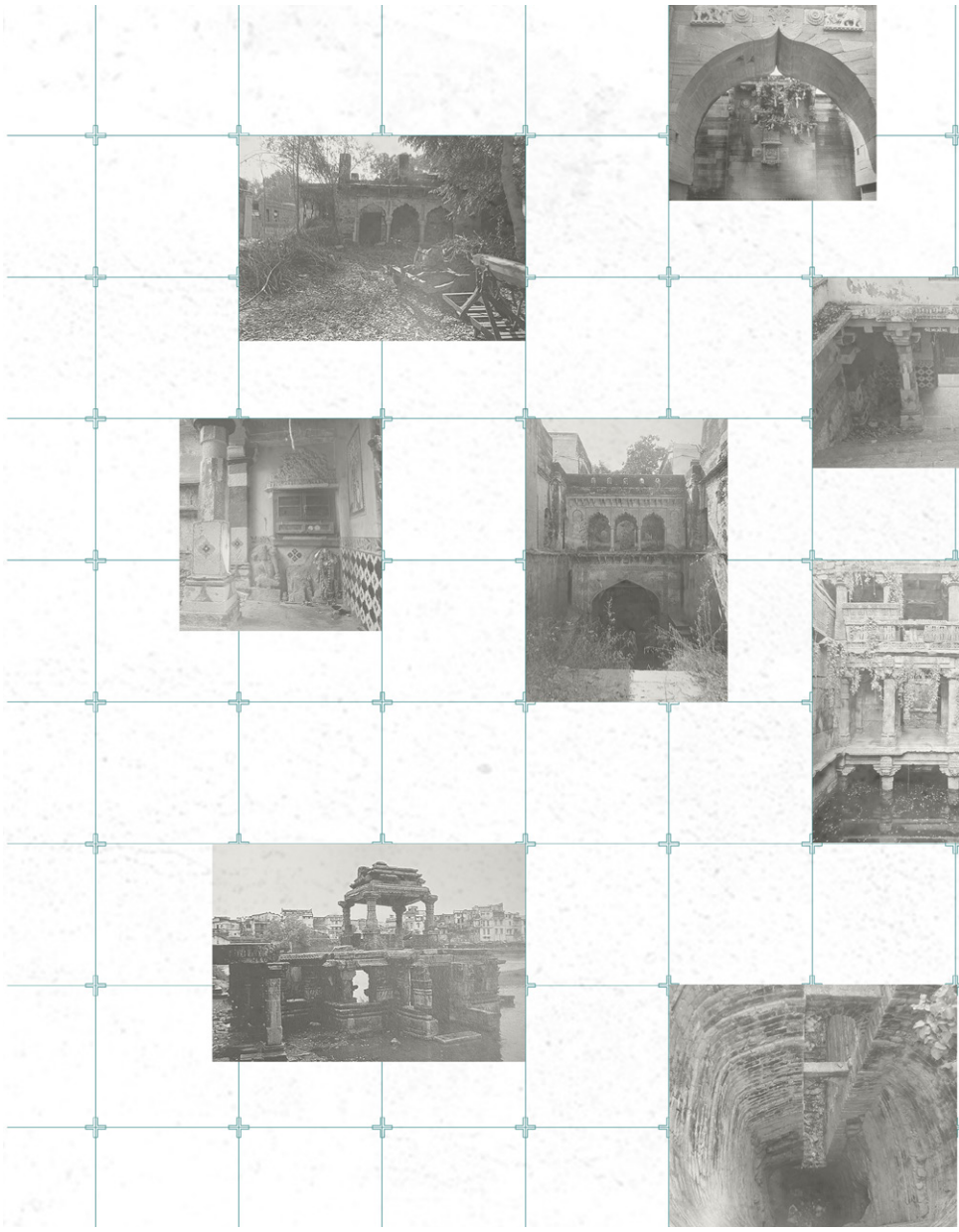
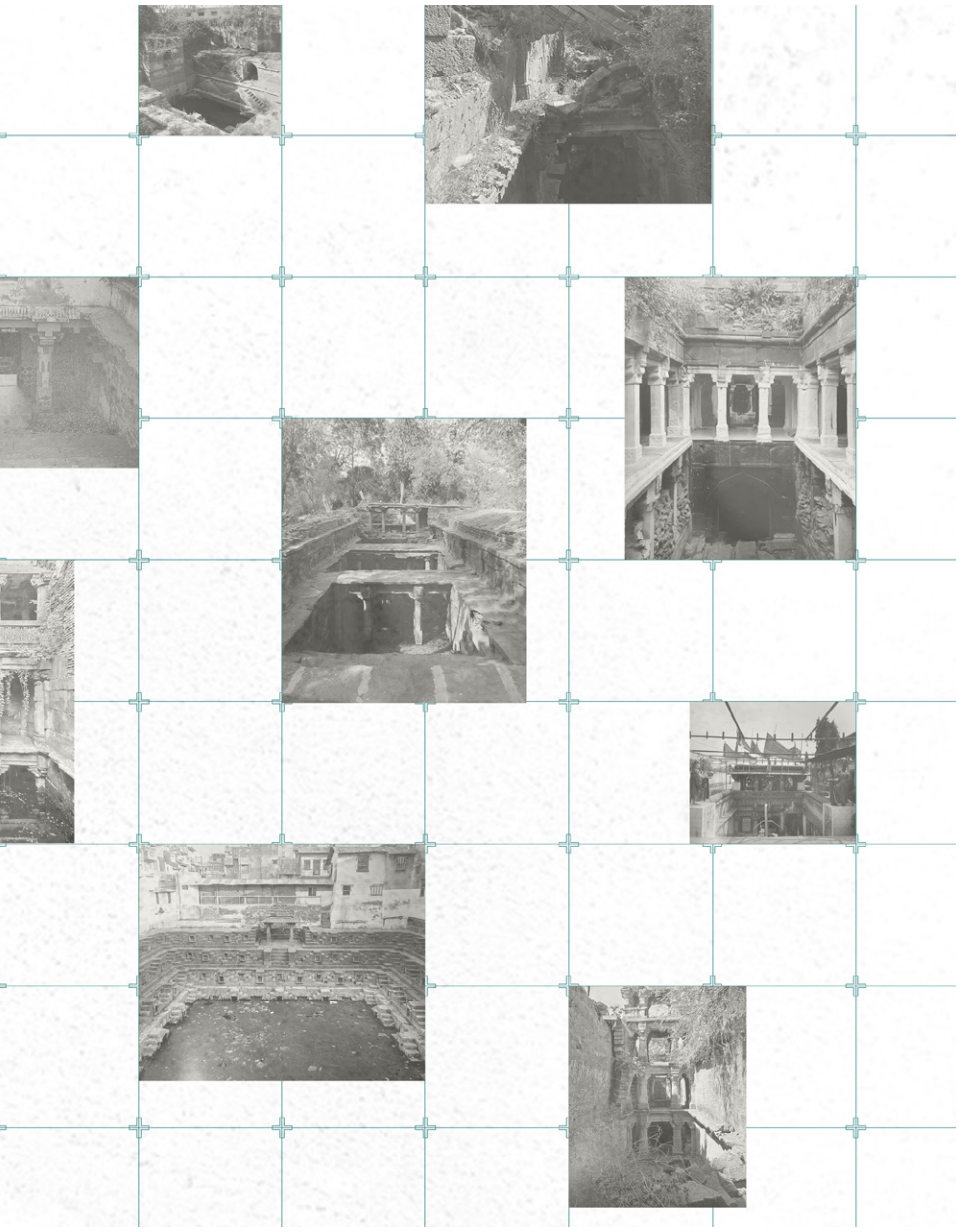
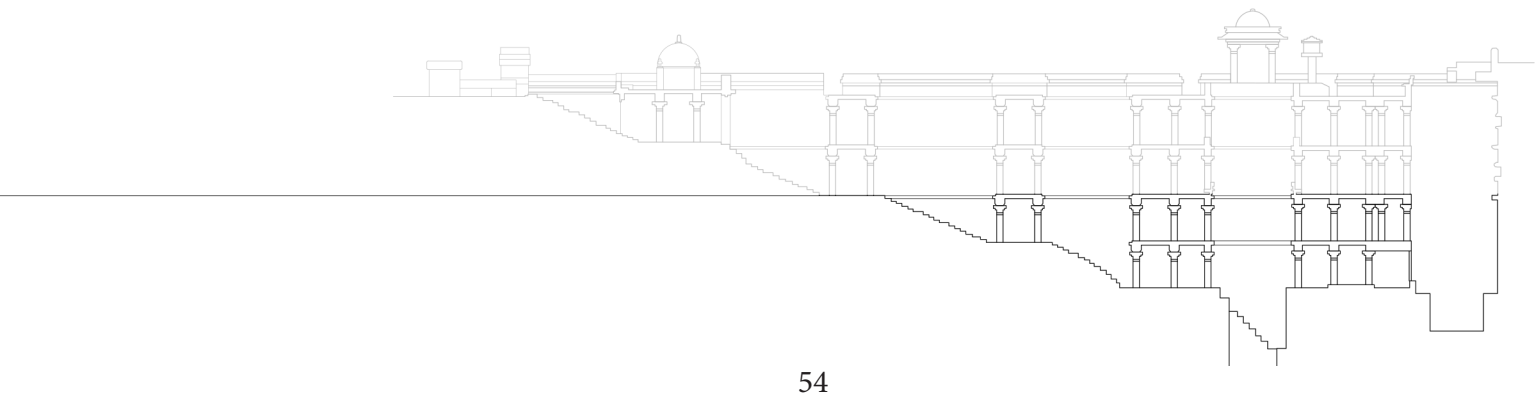


Fig 1.18 - Existing condition of Stepwells.



Part 2

Water and Stepwells - The Present



2.1 - Groundwater Depletion in India

In the recent demographics, India has surpassed China to become the country with the largest population in the world. Currently, there are over ten metropolitan cities with a population of over seven million and this is expected to increase rapidly by 2030.[1]

Rural migration to urban areas for education and employment has led to rapid urbanization. Cities are growing at an exponential rate, the demand for natural resources is increasing. One of the resources which is under stress and in need of urgent action is water. India, which is known through history for its traditional water harvesting techniques is currently going through severe water stress. Based on the projection for 2050, over thirty cities in India are to face extreme water shortages.[2] Over the last decade, the groundwater tables have drastically dropped, and if this were to continue, the depletion rate is said to triple from 2041 to 2080.[3]

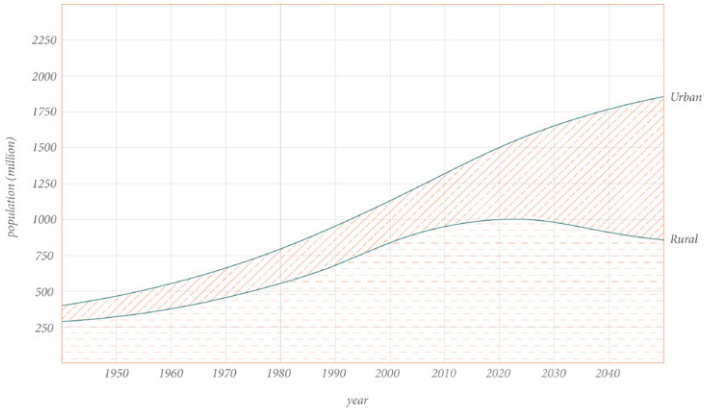


Fig 2.1 - Urban and Rural population growth in India.

1 Urbanet. "Urbanisation in India: Infographics." Urbanet, January 2, 2024. www.urbanet.info/urbanisation-in-india-infographics/.

2 "Bengaluru Is Not Alone, Other Indian Cities Too Could Soon Face Water Crisis." Times of India, March 27, 2024. www.indiatimes.com/news/india/bengaluru-is-not-alone-other-indian-cities-too-could-soon-face-water-crisis-630882.html.

3 Bhattarai, Nishan, David B. Lobell, Balwinder-Singh, Ram Fishman, William P. Kustas, Yadu Pokhrel, and Meha Jain. "Warming Temperatures Exacerbate Groundwater Depletion Rates in India." Science Advances 9, no. 35 (September 2023). https://doi.org/10.1126/sciadv.adi1401.

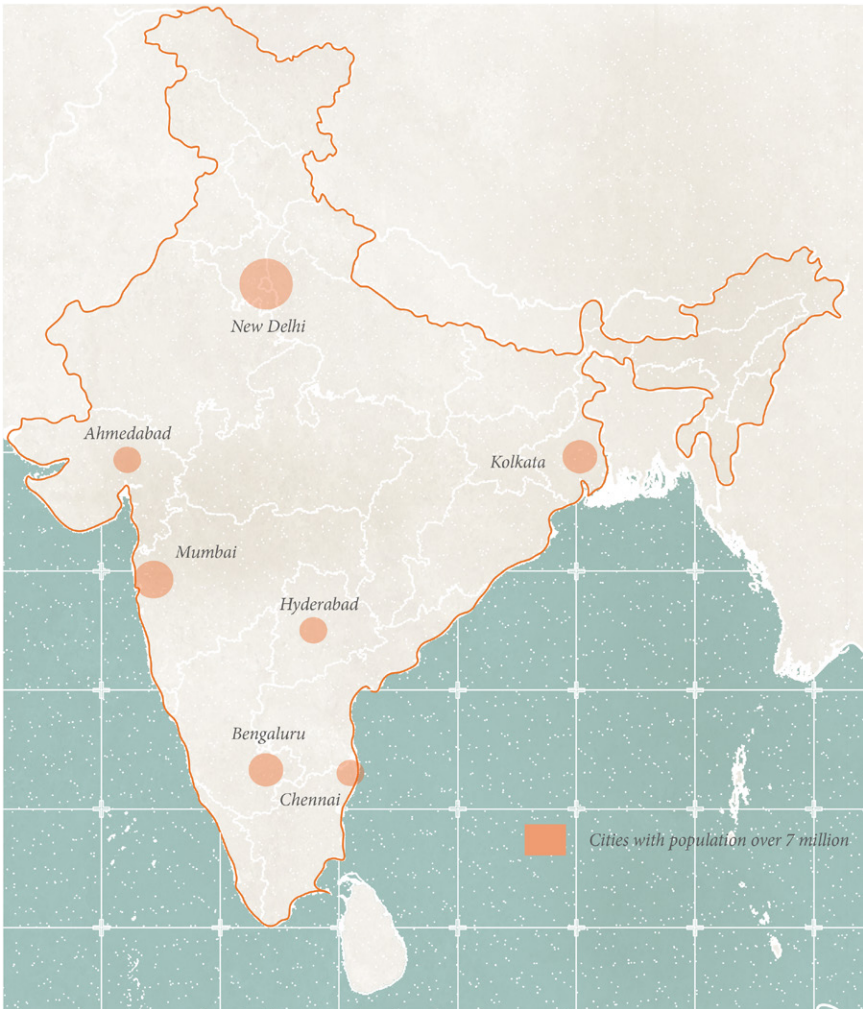


Fig 2.2 - India cities with population over 7 million in 2015.

Water is one of the most essential commodities we need for survival. The water we drink is also required for irrigation, cooking, bathing and washing. While this natural resource has a multi-functional purpose, it is currently being exhausted. Globally, a person typically needs 20L of water per day to fulfill their basic needs.[4] Unfortunately, due to climate change and poor water management, the water that we use is not meeting the per capita requirement. While India has a population of over 1.4 billion people, it only utilizes 4% of world's water, making it clear that the country is eventually going to exhaust its resources.[5]

The growing population and water demand in India is causing over-exploitation of water resources leading to a drop in water tables. Over the years, the decrease in water tables has doubled in cities like Delhi, Bengaluru, and Ahmedabad.[6] While the availability of groundwater is decreasing, there has been a rise in the use of surface water like monsoon rains. It is important to ensure that surface water cannot be completely reliable due to the unpredictable weather patterns caused by climate change.

Leakage of pipes and inadequate infrastructure have furhtermore caused immense water loss, which could have been conserved and used to meet the demands of urban population. Due to poor water management, many households still lack access to piped water supply.[7] The country , to mitigate the impact of impending scarcity needs to reinforce strict water management policies to ensure that water conservation strategies are implemented.

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4 "How Much Water Is Needed in Emergencies." WHO WEDC. Accessed March 2024. https://cdn.who.int/media/docs/default-source/wash-documents/who-tn-09-how-much-water-is-needed.pdf.

5 Pandey, Pooran Chandra. "India Has 16% of the Global Population but Only 4% of Total Water Resources, Resulting in Water Scarcity in Many Regions." Climate Scorecard, September 13, 2023. https://www.climatescorecard.org/2023/09/india-has-16-of-the-global-population-but-only-4-of-total-water-resources-resulting-in-water-scarcity-in-many-regions/.

6 Padhmanaban, Vishnu, and Prachi Srivatsava. "Which Indian City Will Run out of Water First?" Mint, August 4, 2019. www.livemint.com/news/india/which-indian-city-will-run-out-of-water-first-1564920315004.html.

7 Padhmanaban, Vishnu, and Prachi Srivatsava. "Which Indian City Will Run out of Water First?" Mint, August 4, 2019. www.livemint.com/news/india/which-indian-city-will-run-out-of-water-first-1564920315004.html.

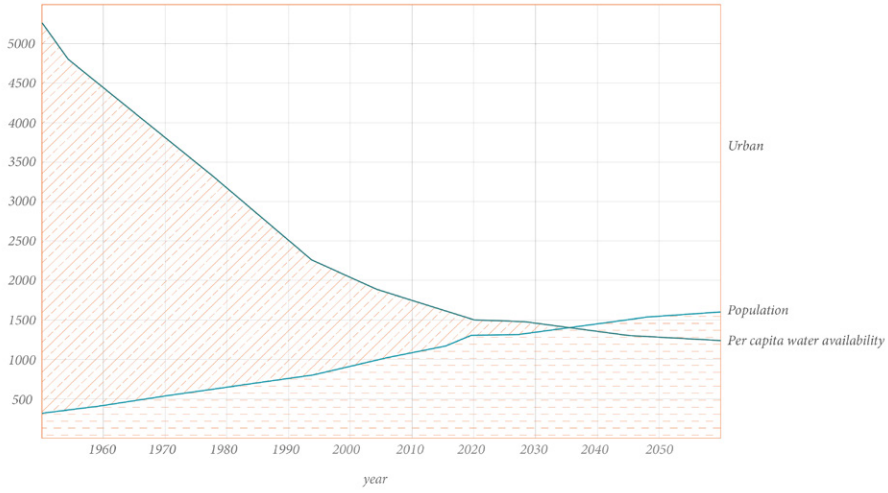


Fig 2.3 - Decreasing per capita water availability rates.

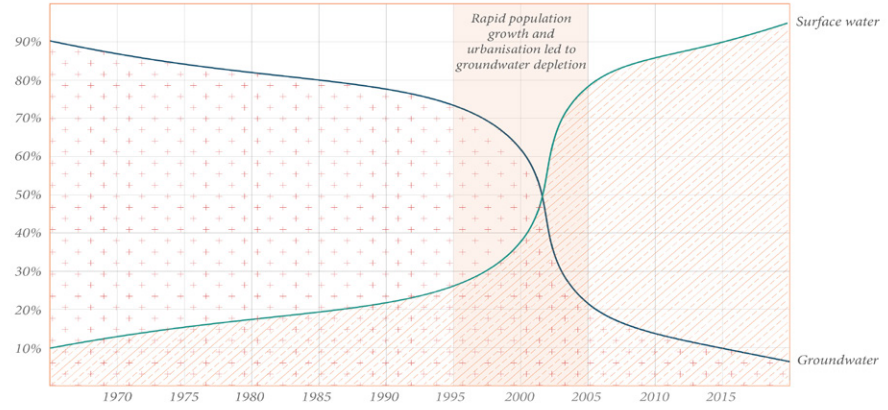
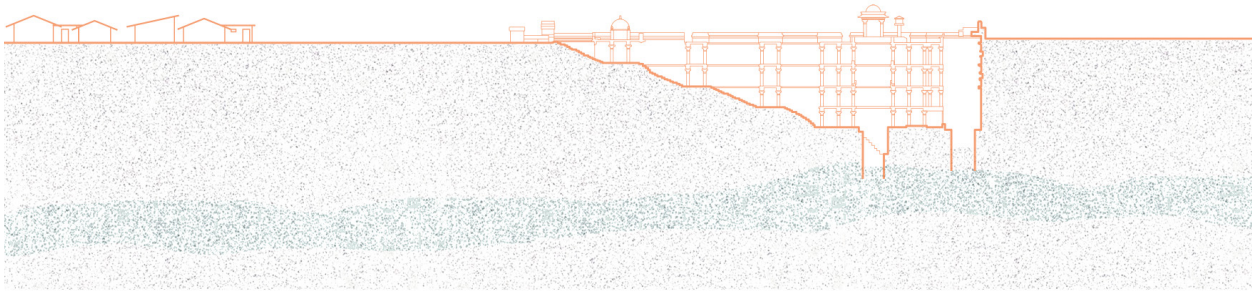
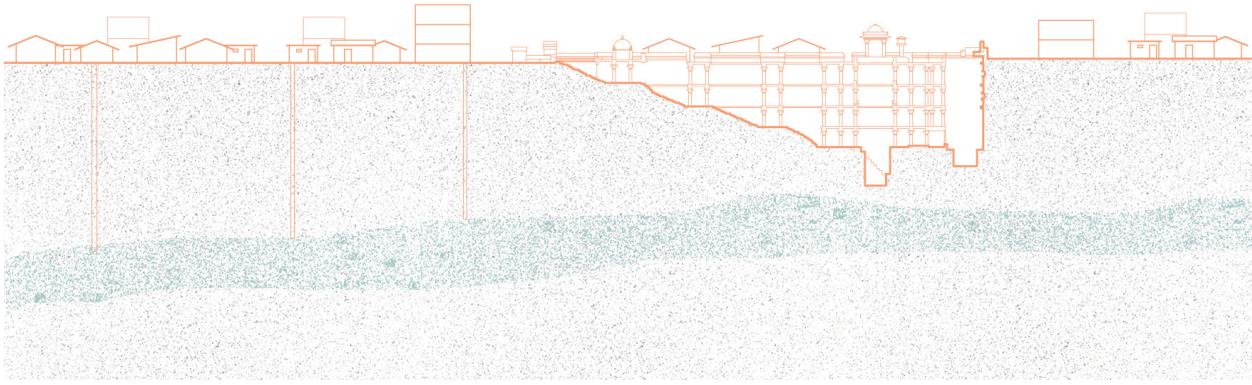
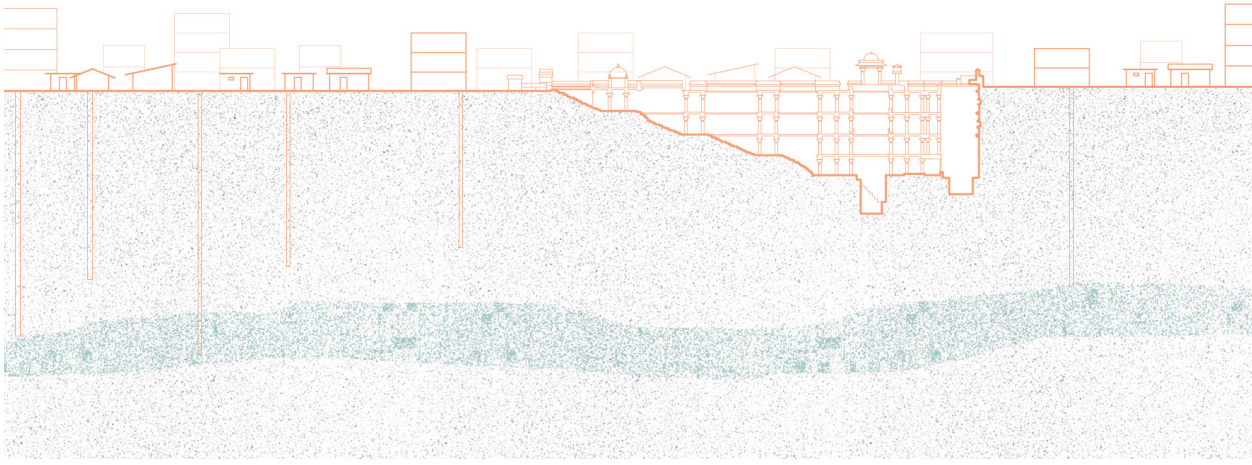


Fig 2.4 - Groundwater depletion and surface water usability rate.







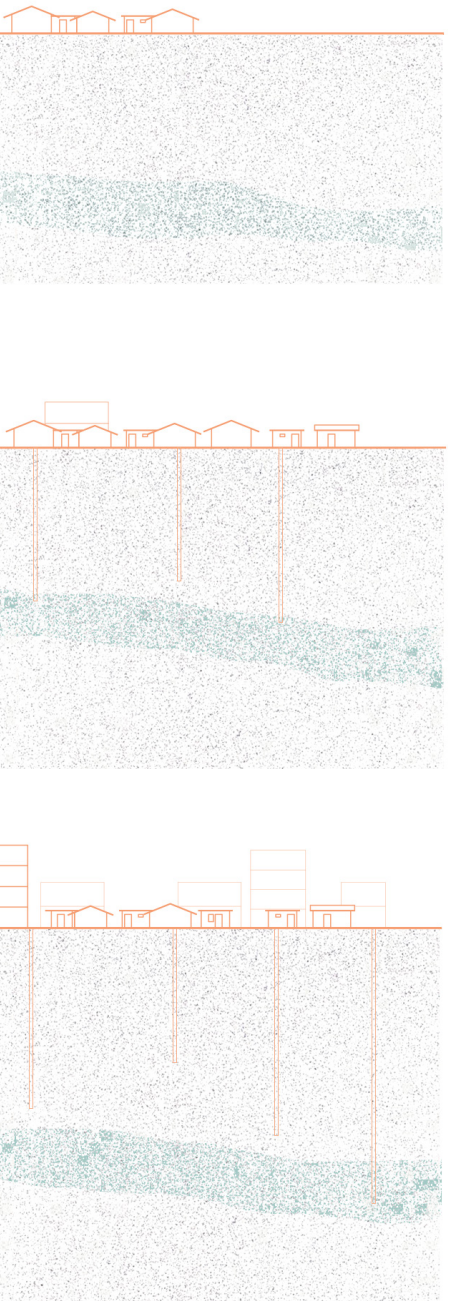


Fig 2.5 - Excessive drilling of groundwater leading to over-exploitation of resources.





Fig 2.6 - Sources of Water.

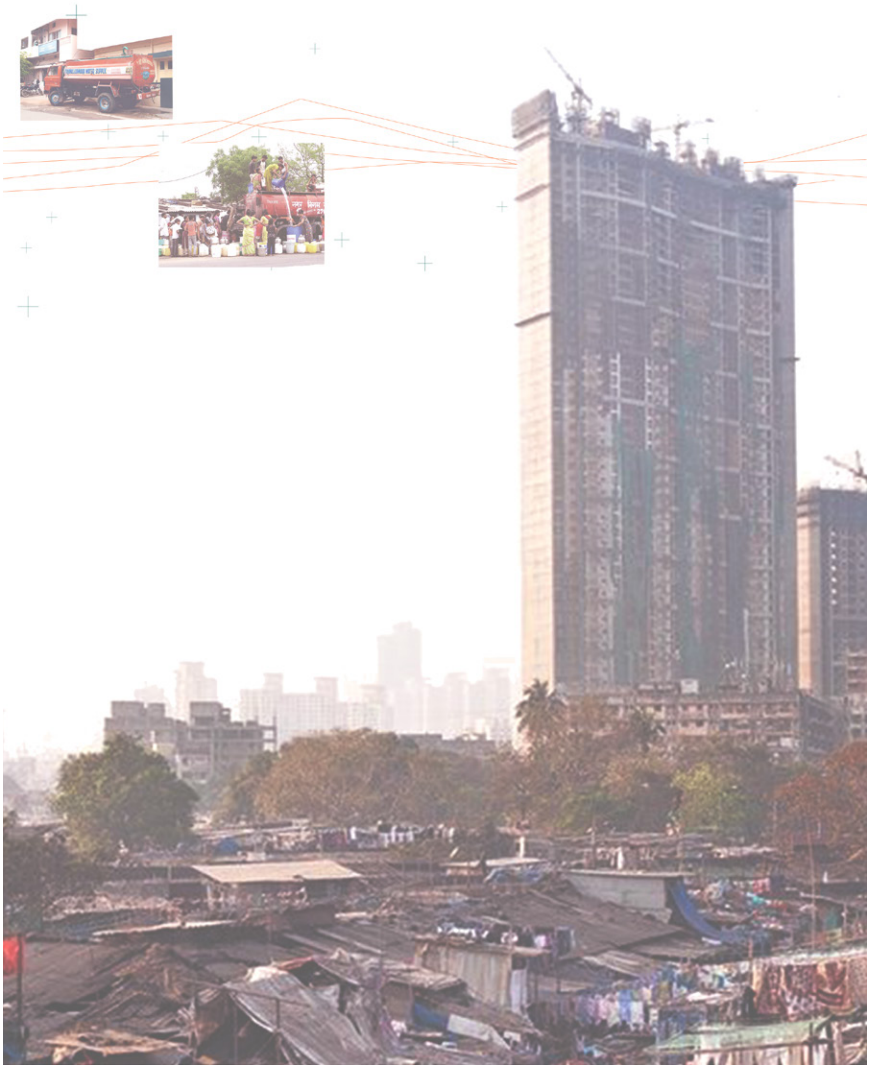


Fig 2.7 - Tankers becoming sources of water in urban cities.

During colonial rule, in the 19th and 20th centuries, India transitioned from traditional water harvesting methods to western engineered methods of water supply techniques. The British introduced piped infrastructure and made water available for most households.[8] And post-colonial India continued to use these methods, centralizing the water supply systems. Due to these centralized systems, water is not distributed equally. There is no value and care provided for the water at the local neighbourhoods or district levels. The water quality has deteriorated due to delayed or low maintenance.[9] When, before British colonial government, water systems were decentralized, the community households around the stepwells were the prime caretakers of the infrastructure and water ensuring water sustainability within the community.[10] This is not observed today in the case of the current centralized urban water systems in India.

With the introduction of new techniques, and growing demand for water, the cities have been extensively drilling even deeper borewells for sourcing groundwater, leading to over-exploitation of that groundwater.[11] The stepwells which once supplied groundwater for the community, do not serve their purpose anymore due to the decline in the water tables that fed them. As groundwater is over-exploited and diminishing in cities, private companies have started sourcing water from rural areas.[12] During extreme dry seasons, water tankers from rural areas often become the only source of water. If this reduction of water tables and ad hoc approaches using water tables were to continue, India is expected to face critical water scarcity by 2050.[13]

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8 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.

9 X, Science. "Pollution Risks Worsening Global Water Scarcity: Study." Phys.org, February 6, 2024. https://phys.org/news/2024-02-pollution-worsening-global-scarcity.html.

10 Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.

11 Parmar, Jignesh. "AMC Plans to Drill More Borewells sans CGWB Nod amid Groundwater Crisis." Times of India, August 1, 2023. https://timesofindia.indiatimes.com/city/ahmedabad/amc-plans-to-drill-more-borewells-sans-cgwb-nod-amid-groundwater-crisis/articleshow/102294757.cms.

12 Singh, Ram Kinkar. "Shortage of Tankers Add to Delhi's Water Woes amid Heatwave Conditions." India Today, 2024. www.indiatoday.in/cities/delhi/story/delhi-water-crisis-shortage-tanker-heatwave-summer-2554459-2024-06-17.

13 "Bengaluru Is Not Alone, Other Indian Cities Too Could Soon Face Water Crisis." Times of India, March 27, 2024. www.indiatimes.com/news/india/bengaluru-is-not-alone-other-indian-cities-too-could-soon-face-water-crisis-630882.html.

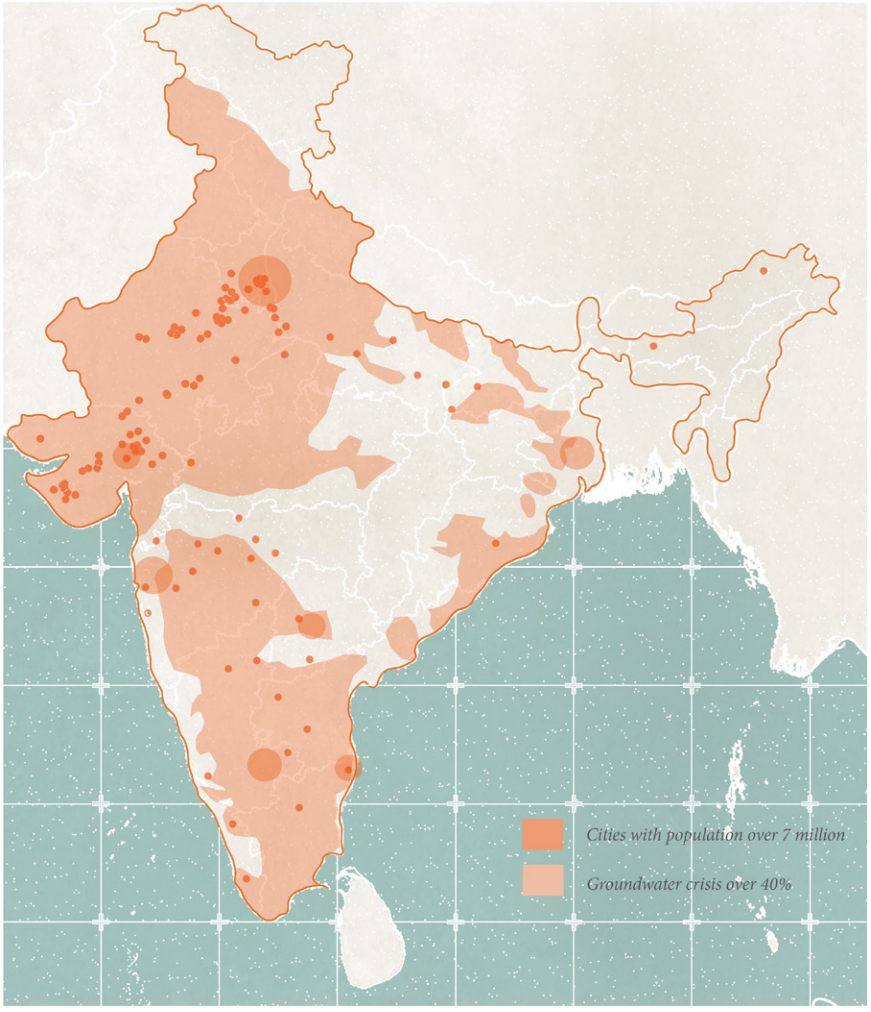


Fig 2.8 - Water stressed regions with location of existing stepwells.

Fig. 2.8 shows the groundwater-stressed regions in India. While the southern and western states are the most affected regions, these are also the ones with ancient stepwells. Gujarat is one of the most water-stressed regions, with Ahmedabad having the third deepest groundwater tables in the country.[14] It is important to note that the city has over 35 existing stepwells within a 100km proximity.[15] If the city's abundance of stepwells provided a source of water in the past, then it is evident that the underlying aquifers had and might have a high potential to provide groundwater. With the depletion of water tables, it becomes essential to restore stepwells to help with curbing groundwater depletion in the country.

Restoring traditional water harvesting systems would improve the sustainability of the surrounding communities. With the historical shift from traditional water harvesting methods to centralized systems, rainwater is going to waste. Reviving these ancient techniques would not only be a part of a solution to tackle climate change problems, but also help with creating a better social and cultural environment. Restoring these subterranean structures will enable the collection of stormwater runoff and store the water for dry seasons all as a part of a larger system of mitigating drought. There are many proposals for restoring these wells in the country.

In 2022, as a part of the Jal Shakti mission, the Government of Gujarat proposed the revival of stepwells.[16] The main goal of the scheme is to restore the ancient structure and ensure that the wells are maintained to provide a water source for the local community.[17] This scheme will contribute to the restoration of ancient community-led water harvesting practices.

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14 Tandon, Aakansha. "Groundwater Level in Ahmedabad Is Third Deepest across the Country, Rajya Sabha Told." Republic , August 2, 2021. https://www.republicworld.com/india/groundwater-level-in-ahmedabad-is-third-deepest-across-the-country-rajya-sabha-told/?amp=1.

15 Lesser-known stepwells in and around Ahmedabad and Gandhinagar region. Urban Management Center, February 2018.

16 "Stepwells of India (Jal Mandir)." Press Information Bureau, 2022. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2022/jun/doc202262267001.pdf.

17 "Stepwells of India (Jal Mandir)." Press Information Bureau, 2022. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2022/jun/doc202262267001.pdf.

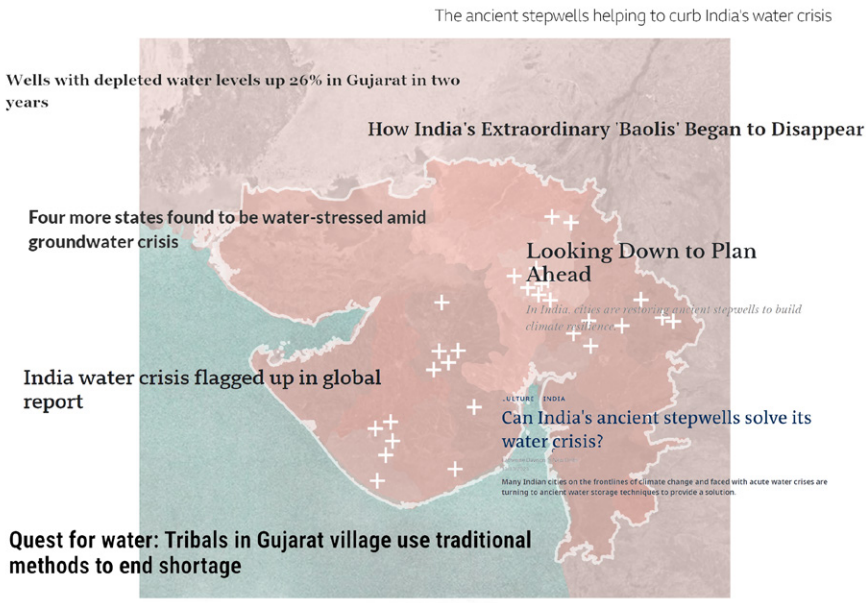


Fig 2.9 - Stepwells as a solution for groundwater depletion.

Apart from the restoration of stepwells, the Government of India has deployed a scheme to build modern and traditional systems to harvest rainwater[18]. The government has allocated a budget as part of this mission to ensure potential measures are taken to prevent further depletion in groundwater tables.

Although the government is currently taking measures to restore stepwells and conserve rainwater, it becomes essential to ensure the restoration is done in a manner to support the local community. The restoration schemes require meticulous planning and design interventions to support sustainability management. This makes it crucial to evaluate the strategies and principles for the restoration of stepwells in the country.

18 *"Policy for Rainwater Harvesting." Press Information Bureau, 2023. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1914351.*

2.2 - Restoration of Stepwells

Stepwells have played a significant role in the evolution of utilitarian architecture in India. The narratives of these wells have drastically transformed in relation to the historical and geographical aspects of their various sites. The stepwells, which were once built on trade routes far from settlements, have now been absorbed by cities. Growing populations have led to expansion of cities, with the stepwells becoming urban artifacts. Italian architect and urban theorist, Aldo Rossi's idea of the city and central identity - creating the role of the urban artifact sets a theoretical framework for the restoration and preservation of stepwells for this thesis research.

Aldo Rossi's theory on the city as a man-made object, which is developed by and around various long lasting urban artifacts, can be reflected in the evolution of stepwells in the post-colonial period. The form of the city always indicates the temporal narratives of the past. An urban artifact is determined based on its historical value and form.[19] Rossi states that the individuality of a structure comes from its richness and history.[20] In the case of stepwells, the structural complexity, scale and elaborate motifs have led them to be recognized by the government and are being preserved as a historical artifacts. Some of the wells restored by the Archaeological Survey of India played a prominent role in the narratives of the historical past of stepwells.

Most of the smaller stepwells still remain unrecognized and are currently in disrepair. While some of the stepwells are restored, they do not serve their original purpose. The primary use of the structure has evolved to adapt to the modern society. The four themes in Rossi's idea of urban artifacts, individuality, locus, design and memory can be integrated into this project for the restoration of stepwells in the country. The wells once displayed a social, cultural and spiritual character creating layers of individuality and memory and still do so.

19 Vogt, Adolf Max. Aldo Rossi: The Architecture of the City. New York: Society of Architectural Historians, 1983.
20 Vogt, Adolf Max. Aldo Rossi: The Architecture of the City. New York: Society of Architectural Historians, 1983.



Fig 2.10 - Dilapidated state of stepwell.



Fig 2.11 - Restored stepwell as a tourist site.

The permanence of the stepwells is typically determined by the existing geography and urban morphology of the city that has grown around it for centuries. The existing context of a stepwell determines its functionality for restoration purposes.

According to Rossi's theory, permanence can be either pathological or propelling.[21] It is important to understand these two categories as they establish basic principles for the functioning of stepwells in the current context and ensure successful restoration and management.

21 Vogt, Adolf Max. Aldo Rossi: The Architecture of the City. New York: Society of Architectural Historians, 1983.

A building or site is characterized by pathological permanence when its form and physical attributes remain unchanged.[22] The urban form isolates these buildings or sites or tends to grow around them, disregarding their historical significance. Due to urbanization, the primary purpose of stepwells as communal water harvesting spaces has not evolved as that use has been abandoned. These sites are now outdated and anachronistic.[23] When observing the urban morphology of these sites, one can witness the growth of the city disregarding the presence of the stepwell. The historical prominence of the stepwells is fading amidst the urban growth of the city, leading to the erosion of their social, cultural, and spiritual value. These structures require restoration and adaptation through new programming in the stepwells.

Propelling permanence emphasizes the preservation of the form from the past.[24] This built form allows individuals to connect with the historical past of the city. The physical attributes are restored to maintain the continuity of memory. Some of the restored stepwells serve as urban landmarks and preserve cultural heritage within the expanding urban fabric. They instill a sense of individuality, memory, and continuity. The surrounding context of a restored stepwell narrates the stories of the past and plays a significant role in the urban form. These structures become major tourist attractions and landmarks within the urban fabric. The developments around the stepwell support its functioning. The following case studies of restored stepwells in the city of Ahmedabad serve as examples of propelling permanence in the city.

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22 Vogt, Adolf Max. Aldo Rossi: The Architecture of the City. New York: Society of Architectural Historians, 1983.
23 Vogt, Adolf Max. Aldo Rossi: The Architecture of the City. New York: Society of Architectural Historians, 1983.
24 Vogt, Adolf Max. Aldo Rossi: The Architecture of the City. New York: Society of Architectural Historians, 1983.

Case study - 1

Adalaj ni Vav/ Rudabai Stepwell

Location - Adalaj, Gujarat

Built - 1485

Context - Stepwell complex

Status - Restored

Primary use - Tourism

No. of storey - 5

Depth from ground - 24

Horizontal length - 67.4m

Adalaj Vav is located on the outskirts of the City of Ahmedabad. The stepwell is one of the most prominent stepwells which displays a blend of Hindu and Islamic Architecture. It resonates with Aldo Rossi's theory of propelling permanence. The stepwell has been restored and protected by the Archaeological Survey of India and attracts many tourists year-round. The surrounding context is developed to amplify the significance of the urban artifact. The land adjoining the stepwell is landscaped to create a tourism complex for the stepwell and has infrastructure to cater to the tourists.



Fig 2.12 -Context map of Adalaj ni Vav.

Case study - 2

Dada Harir ni Vav

Location - Ahmedabad, Gujarat

Built - 1499

Context - Historical mosque complex

Status - Restored

Primary use - Tourism

No. of storey - 5

Depth from ground - 32

Horizontal length - 64m

Dada Harir ni Vav is another example of Indo-Islamic architecture. This stepwell is located in a historical mosque complex in the metropolitan city of Ahmedabad. Though the stepwell and its surrounding complex stand out as an artifact of propelling permanence, the well relatively gets minimal tourists compared to Adalaj ni Vav. The stepwell delivers a propelling story from the past through its intricate architectural elements.



Fig 2.13 -Context map of Dada Harir ni Vav

Case study - 3

Mata Bhavani Vav

Location - Ahmedabad, Gujarat
Built - 1866
Context - Residential
Status - Restored
Primary use - Temple
No. of storey - 4
Depth from ground - 17
Horizontal length - 45m

Taking its name from the local deity that resides within, Mata Bhavani ni Vav is a restored structure currently being used as a temple. It is situated amidst the bustling residential community in Asarwa, Ahmedabad. The locals act as the primary users and caretakers of the stepwell, using it continuously as a site of worship. While the structure remains intact, modifications and signage additions have been made by the locals to ensure that the stepwell functions effectively as a temple.



Fig 2.14 -Context map of Mata Bhavani Vav



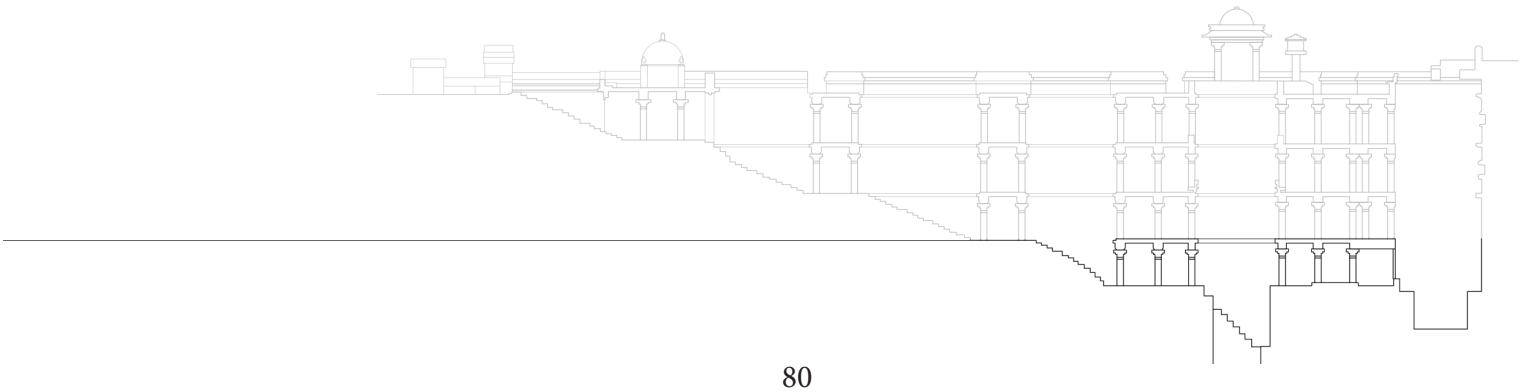
Fig 2.15 - Ashapura Mata Stepwell, Ahmedabad

The above-mentioned case studies provide a structural framework for restoring other stepwells in the country. While Adalaj ni Vav and Dada Harir ni Vav have been revived to serve as tourist spots, Mata Bhavani Vav is used solely as a temple. It is evident that the urban context acts as an inevitable determinant for the programming of the stepwells, hence their propelling role in the city's development.

Analyzing stepwells based on their individuality and historical memory draws out restoration strategies for the site. While the government is taking measures to restore the traditional water harvesting systems, it becomes crucial to ensure they are revived for the benefit of the local communities. The wells need to be restored in a way that the local community imbibes the historical culture of the past and becomes the prime caretaker of the wells. This promotes the maintenance and regular functioning of the stepwells. Some of the critical components considered for selecting the site are the historical past, the existing condition of the stepwells, aquifer depths, the surrounding urban context and the interrelationship between the stepwells and the local community.

Part 3

A Site with Potential



3.1 - The City of Ahmedabad

Ahmedabad also known as Amdavad, is in the western state of Gujarat, India. With a population of over 8 million and a projected population of 11 million by 2030, it stands among the top fast-growing metropolitan cities.[1] The city is known for its rich cultural heritage, being home to over 25 stepwells.[2] Apart from stepwells, the traditional architecture displays a blend of Hindu and Islamic architectural styles making it Asia's first World Heritage City in 2017.[3] The city also displays influences of Indo-Saracenic architecture style, a mixture of Hindu and Persian architecture. The modern architecture of the city carries the essence of traditional architectural style. The city has numerous historical sites, protected by the Archaeological Survey of India and the state conservation bodies.

Historically, Ahmedabad relied on groundwater for everyday water use which has now transitioned to surface water due to the undergoing water crisis. It sits on an Alluvial confined aquifer which ranges from a depth of 20 to 50 meters. The range of the depth varies seasonally. As the city receives 755mm of rainfall annually, it becomes crucial to harvest rainwater during monsoons.

1 Urbanet. "Urbanisation in India: Infographics." Urbanet, January 2, 2024. www.urbanet.info/urbanisation-in-india-infographics/.
2 Lesser-known stepwells in and around Ahmedabad and Gandhinagar region. Urban Management Center, February 2018.
3 Hossain, Md Toukir. "Why Is Ahmedabad Considered a UNESCO World Heritage Centre." RTF | Rethinking The Future, April 3, 2023. https://www.re-thinkingthefuture.com/city-and-architecture/a8659-why-is-ahmedabad-considered-a-unesco-world-heritage-centre/.

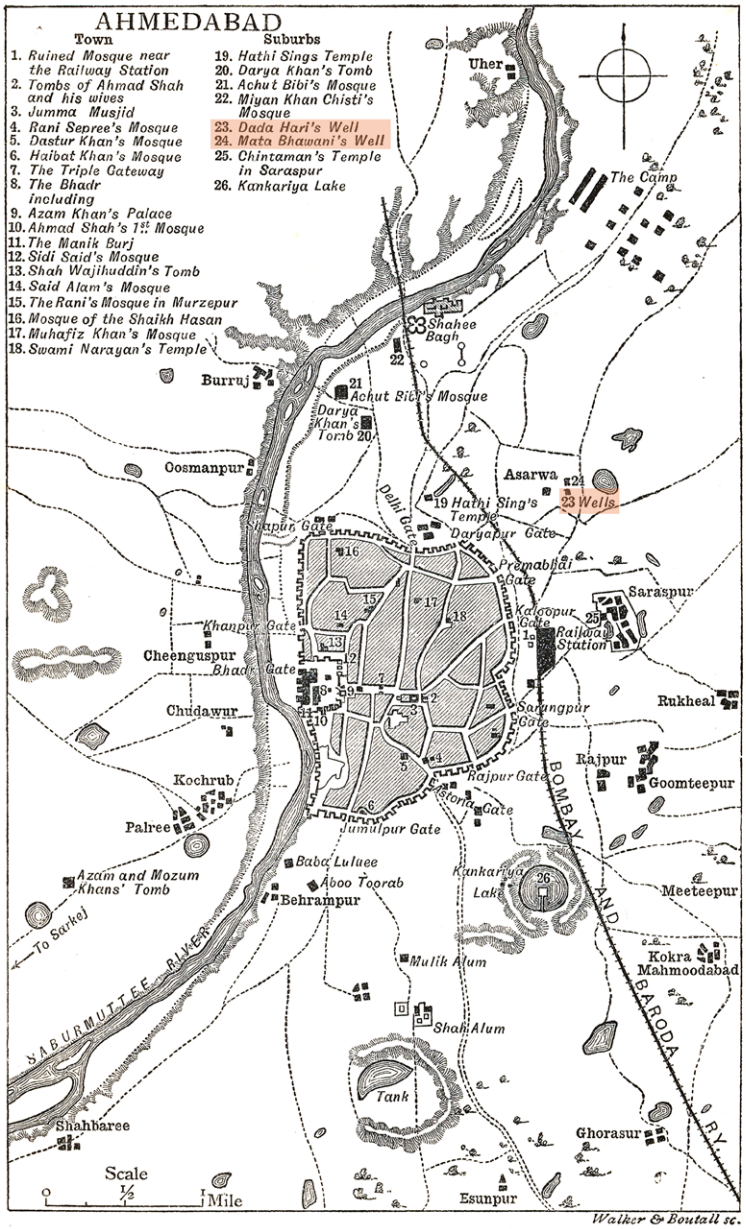


Fig 3.1 - Historical landmark map of Ahmedabad highlighting stepwells.

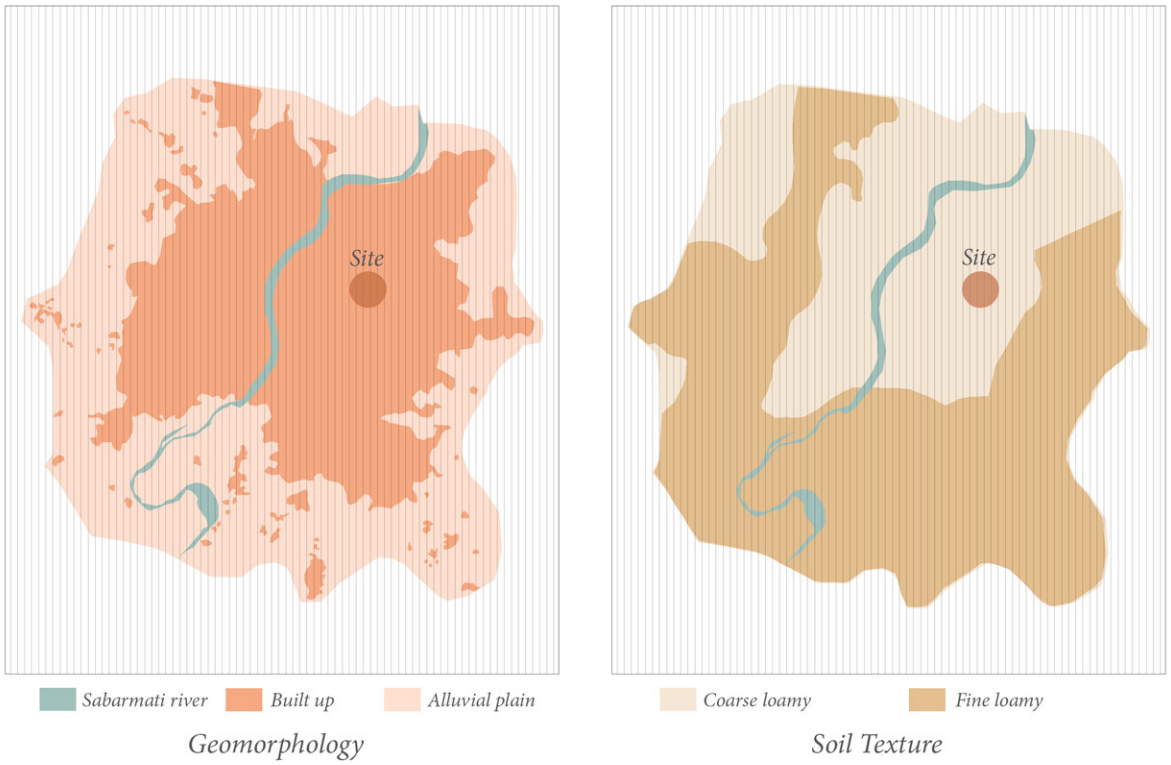
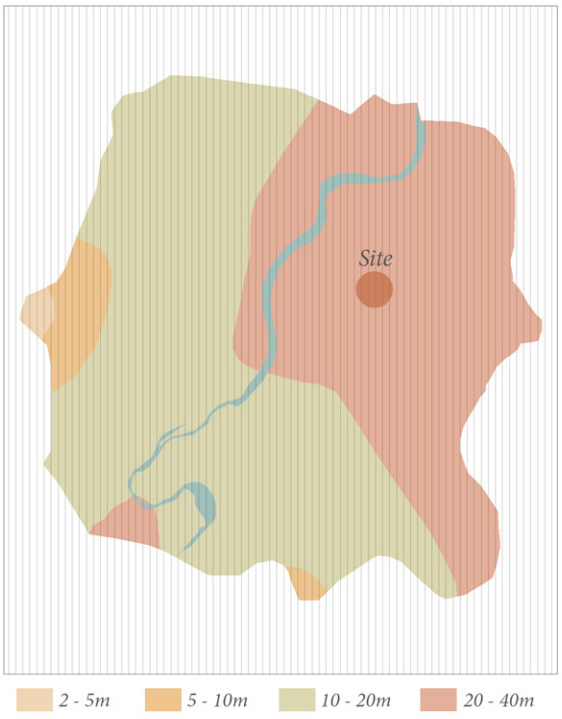
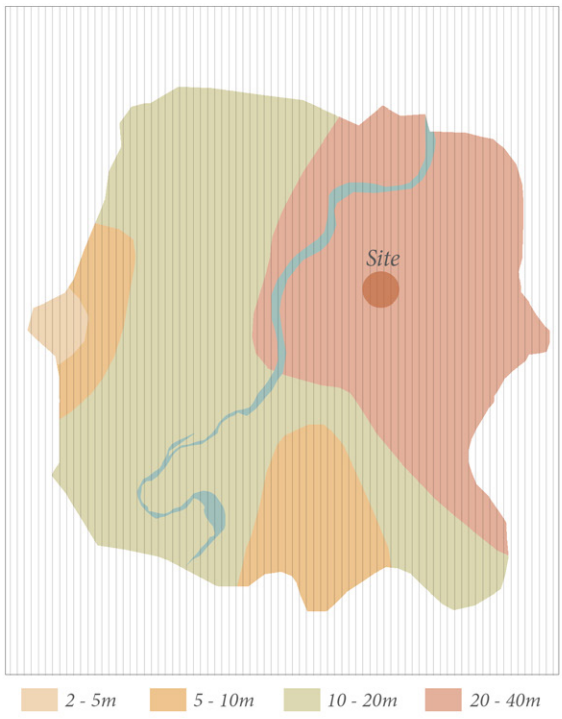


Fig 3.2 - Geographical data of Ahmedabad City.



Pre Monsoon Depth to Water Level Map- Unconfined Aquifer



Post Monsoon Depth to Water Level Map- Unconfined Aquifer

There are over twenty-three stepwells within the city. While some of the stepwells such as Dada Harir ni Vav, Mata Bhavani Vav and Jeethabhai Vav are protected by the Archaeological Survey of India, the remaining stepwells are unprotected[4]. From Fig. 3.3, it is evident that most of the stepwells were built right outside the walled city on the eastern side of the river. As there are many stepwells in the city, proposing a restoration plan for one stepwell can function as a demonstration model for other sites. After carefully examining the existing condition, historical value, and surrounding context of all the unprotected stepwells, Ashapura Mata Stepwells seemed the best fit for the scope of this project.

4 Lesser-known stepwells in and around Ahmedabad and Gandhinagar region. Urban Management Center, February 2018.



Fig 3.3 - Lesser known stepwells in the city of Ahmedabad.

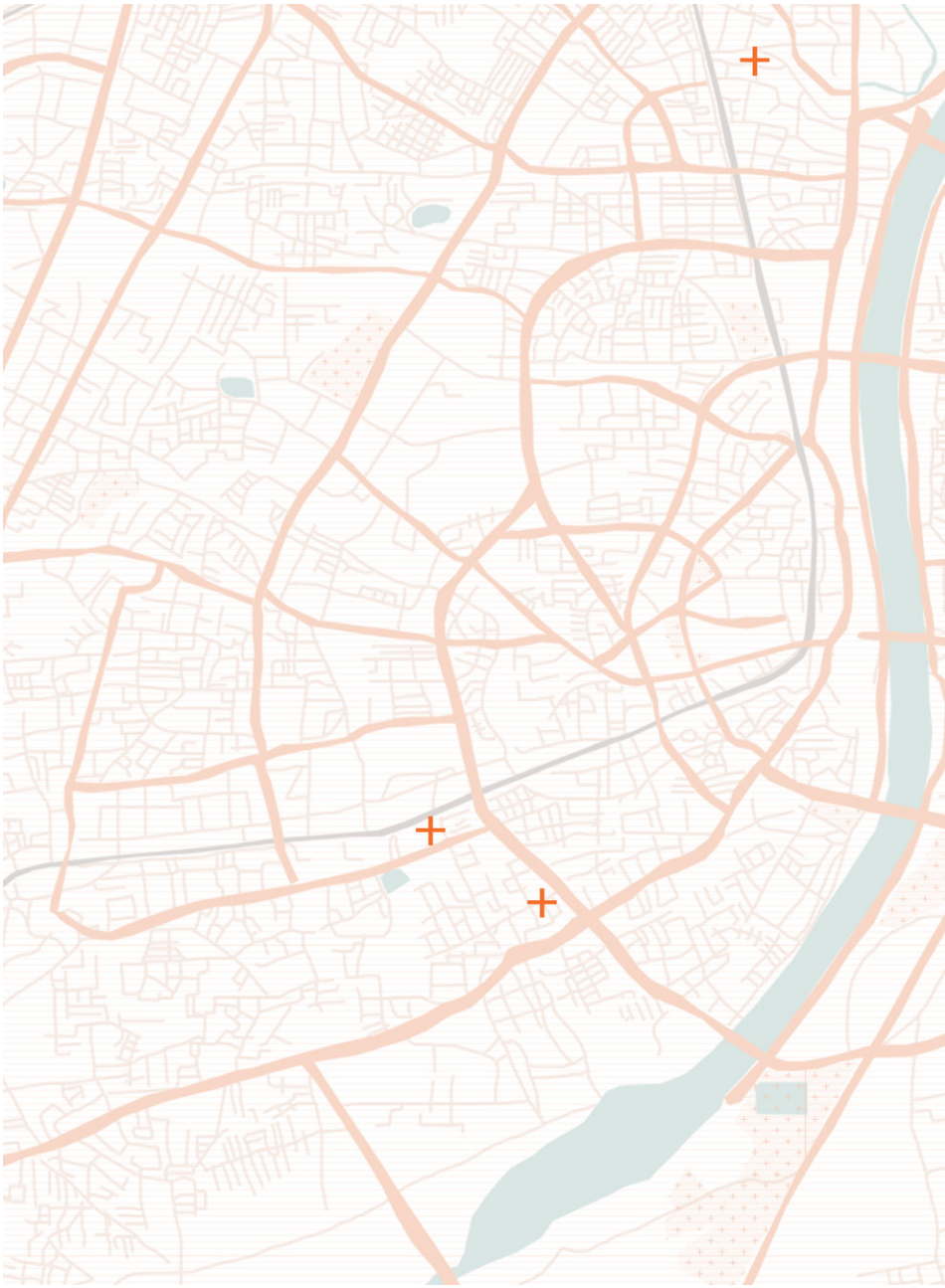
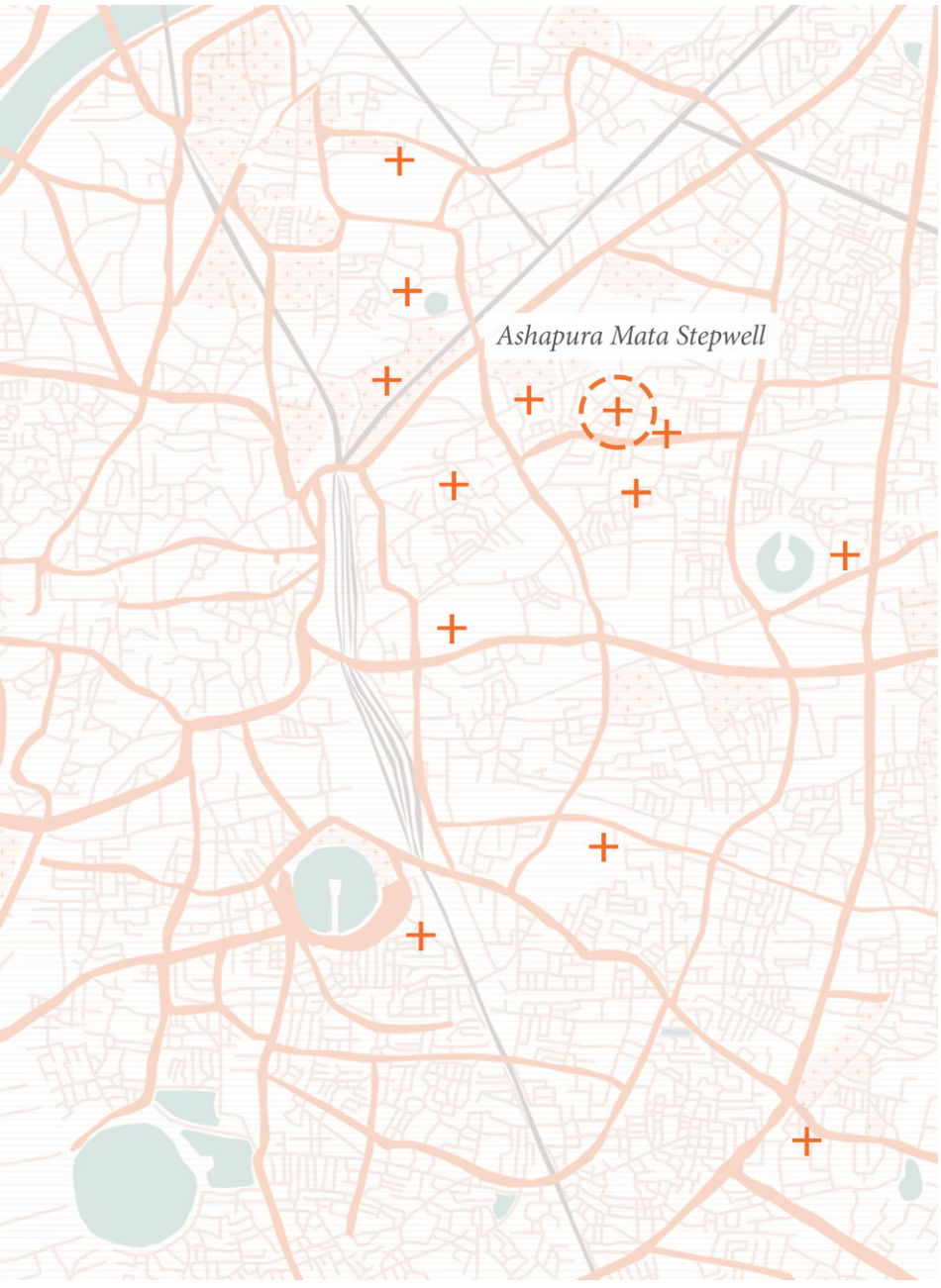


Fig 3.4 - Stepwells around the site.


Ashapura Mata Stepwell

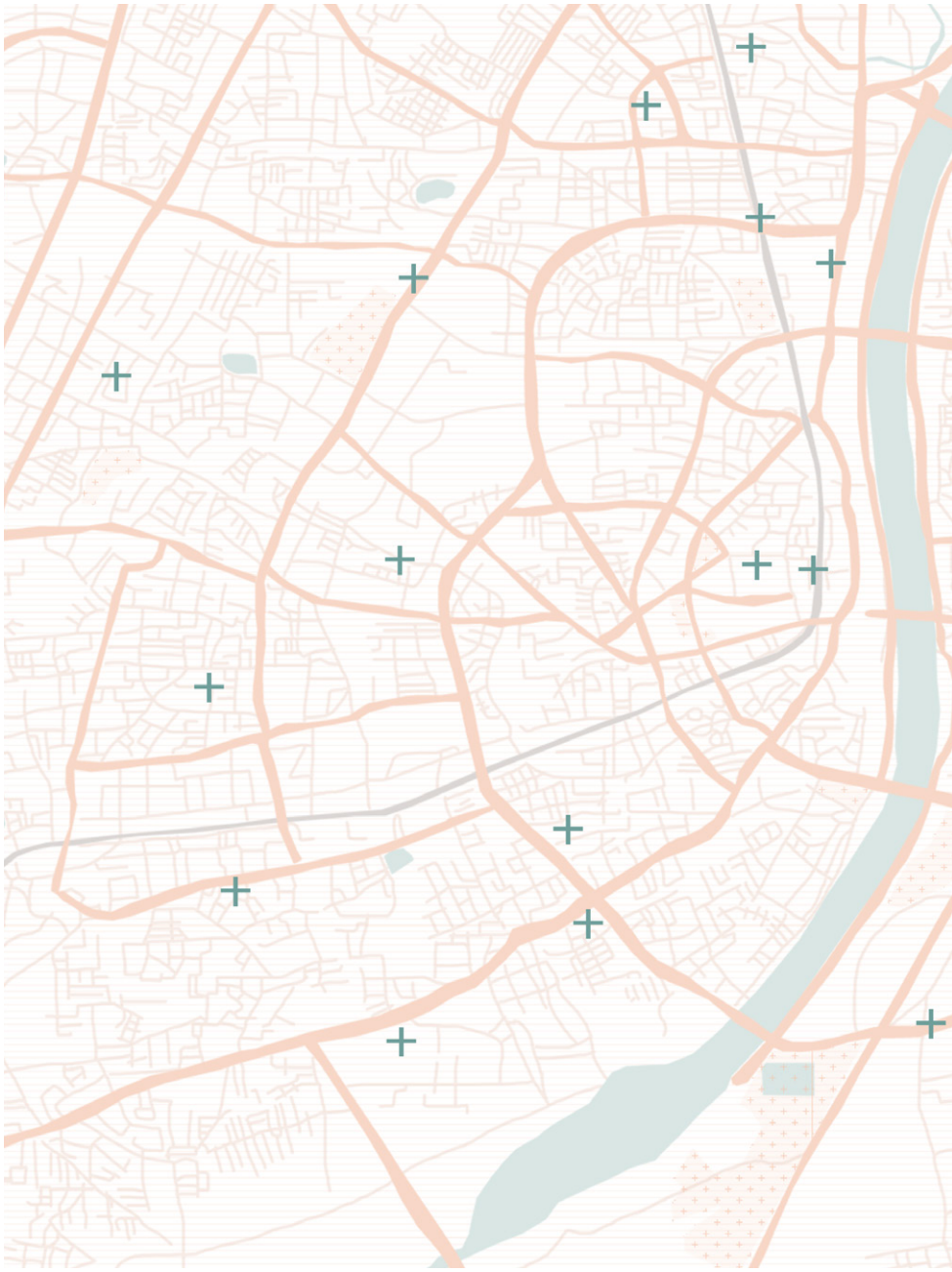
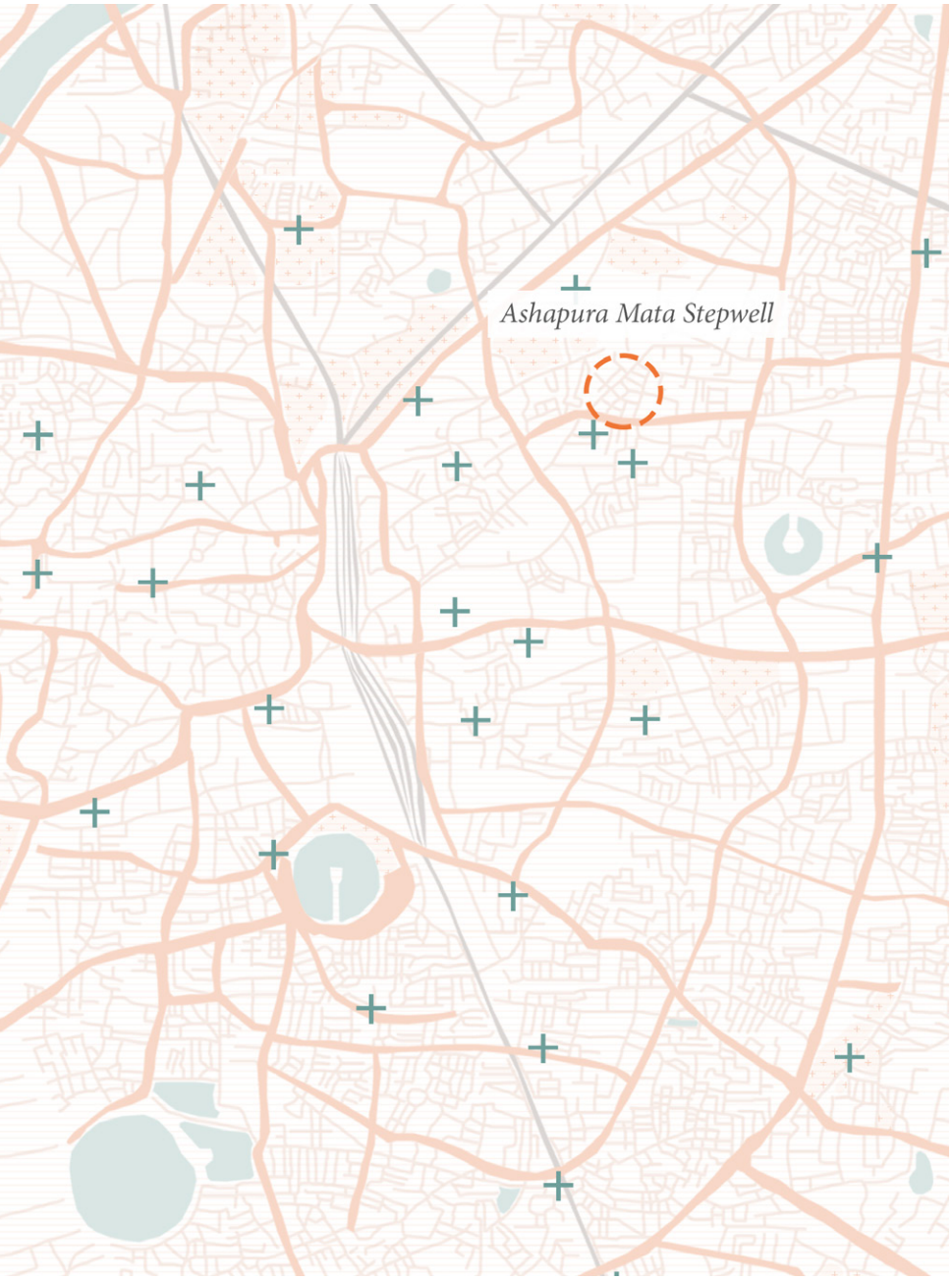


Fig 3.5 - Location of municipal water supply points in the city.


Ashapura Mata Stepwell

3.2 - Site and Context

The Ashapura Mata Stepwell is located on the eastern side of the Sabarmati River, in Bapunagar, Ahmedabad. The site primarily consists of the historical stepwell, the temple and the residential neighbourhood. The proposed design site is 1.43 hectares with a high density of residential units. Towards the main street are mixed-use buildings with commercial on the first level and residential on top. Amidst these buildings lies the temple complex. It houses storage rooms, shrines, trees, restrooms, cattle shed and the temple. The temple is seated on the first pavilion of the stepwell which restricts the flow of public into the space. The local community has encroached on the stepwell and transformed the materiality of the temple. The natural stone is now covered in tiles and paints.

The urban morphology of the site indicates the organic growth of the residential community around the stepwell. This urban growth is strikingly different from the surrounding context. The houses share a common wall with the historical stepwell.

Due to the high density of the residential units, the internal street network is significantly narrow. All the streets within the site are paved making it a pedestrian zone. The narrow lanes only allow the movement of bicycles and motorbikes within the site. The site has three large open spaces out of which two are left empty. These are the spaces with the most vegetation within the site. Based on observations, the residential units within the site can be broadly categorized into two types, houses with sloped corrugated roof structures and houses with flat roofs.



Fig 3.6 - Ashapura Mata Stepwell

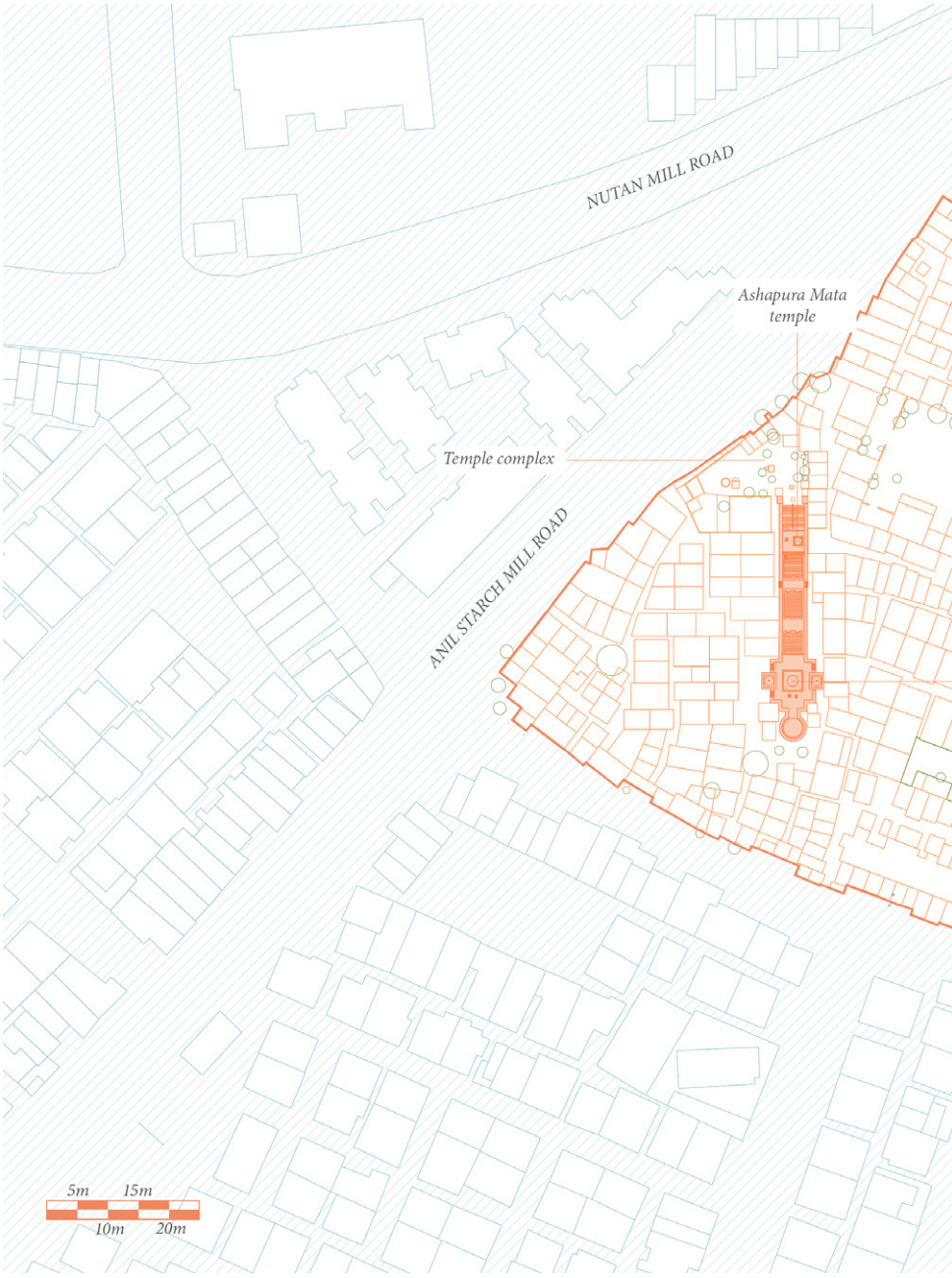
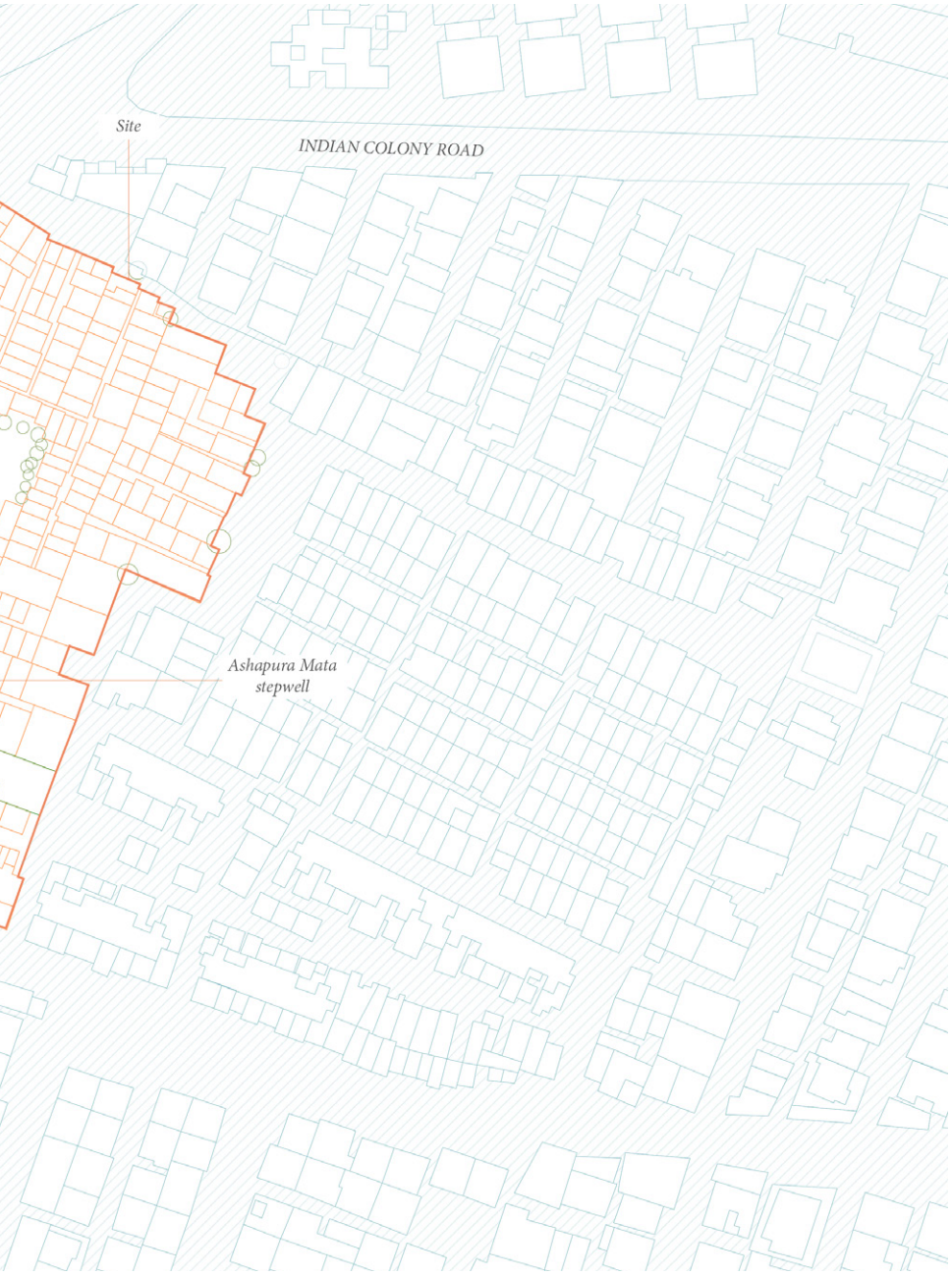


Fig 3.7 - The neighbourhood around Ashapura Mata Stepwell.


Site
INDIAN COLONY ROAD
Ashapura Mata
stepwell

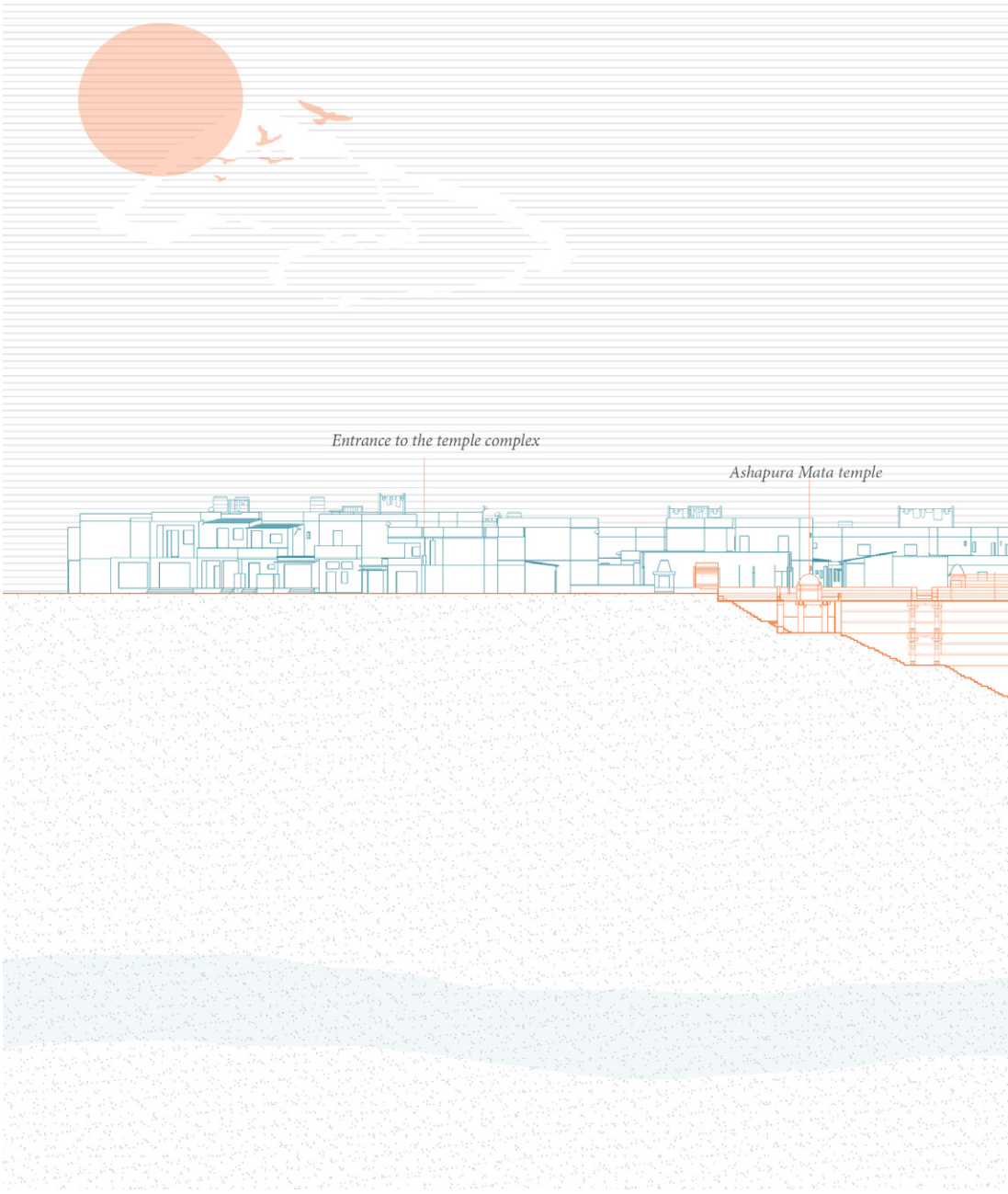


Fig 3.8 - Section cutting through the stepwell and the residential neighbourhood.

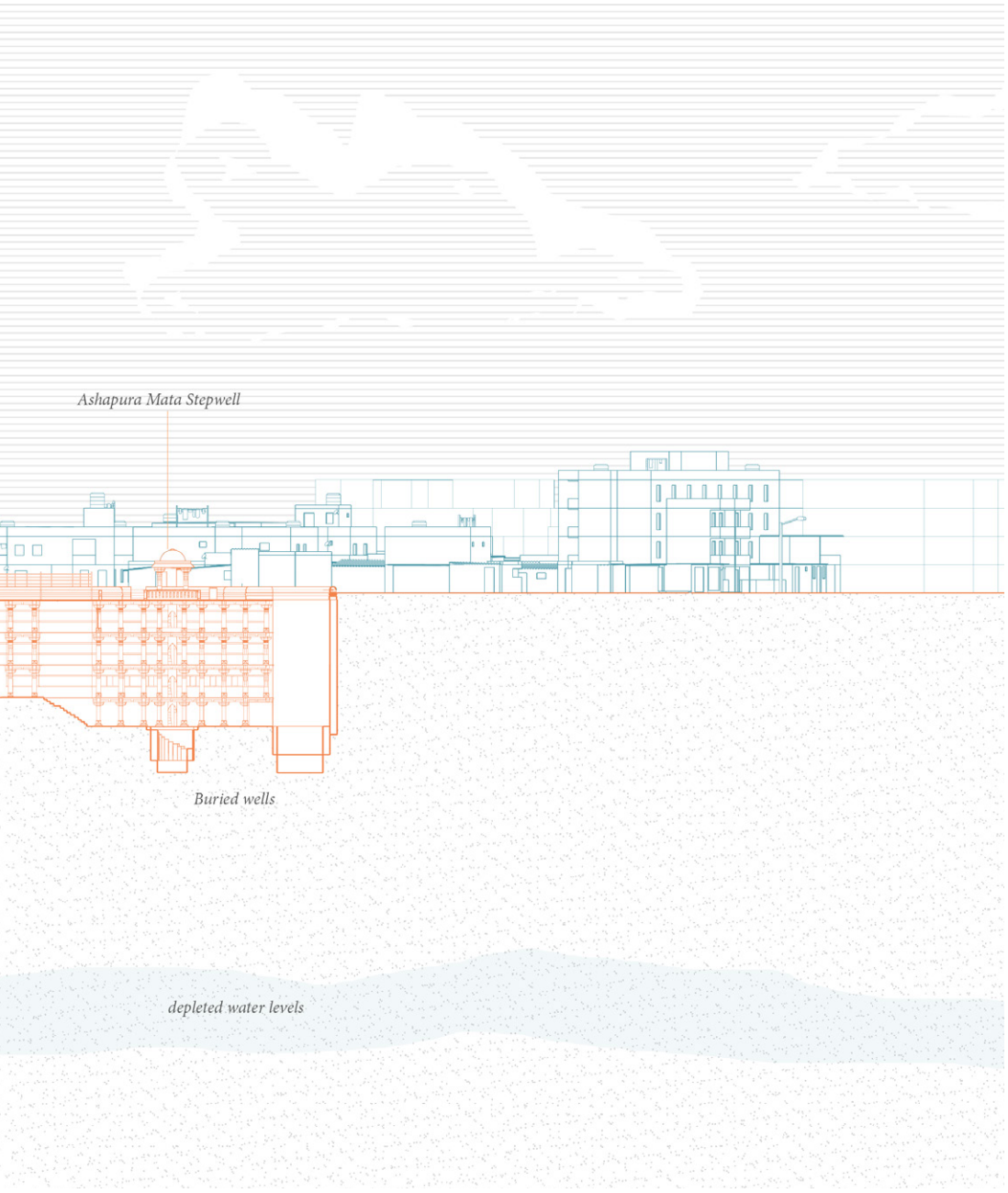

Ashapura Mata Stepwell
Buried wells
depleted water levels



Fig 3.9 - Entrance to Ashapura Mata temple complex.



Fig 3.10 - Ashapura Mata temple complex.



Fig 3.11 - Ashapura Mata ni Vav.



Fig 3.12 - Ashapura Mata Stepwell and its surrounding context.



Fig 3.13 - Residential community surrounding the stepwell.



Fig 3.14 - Residential community surrounding the stepwell.



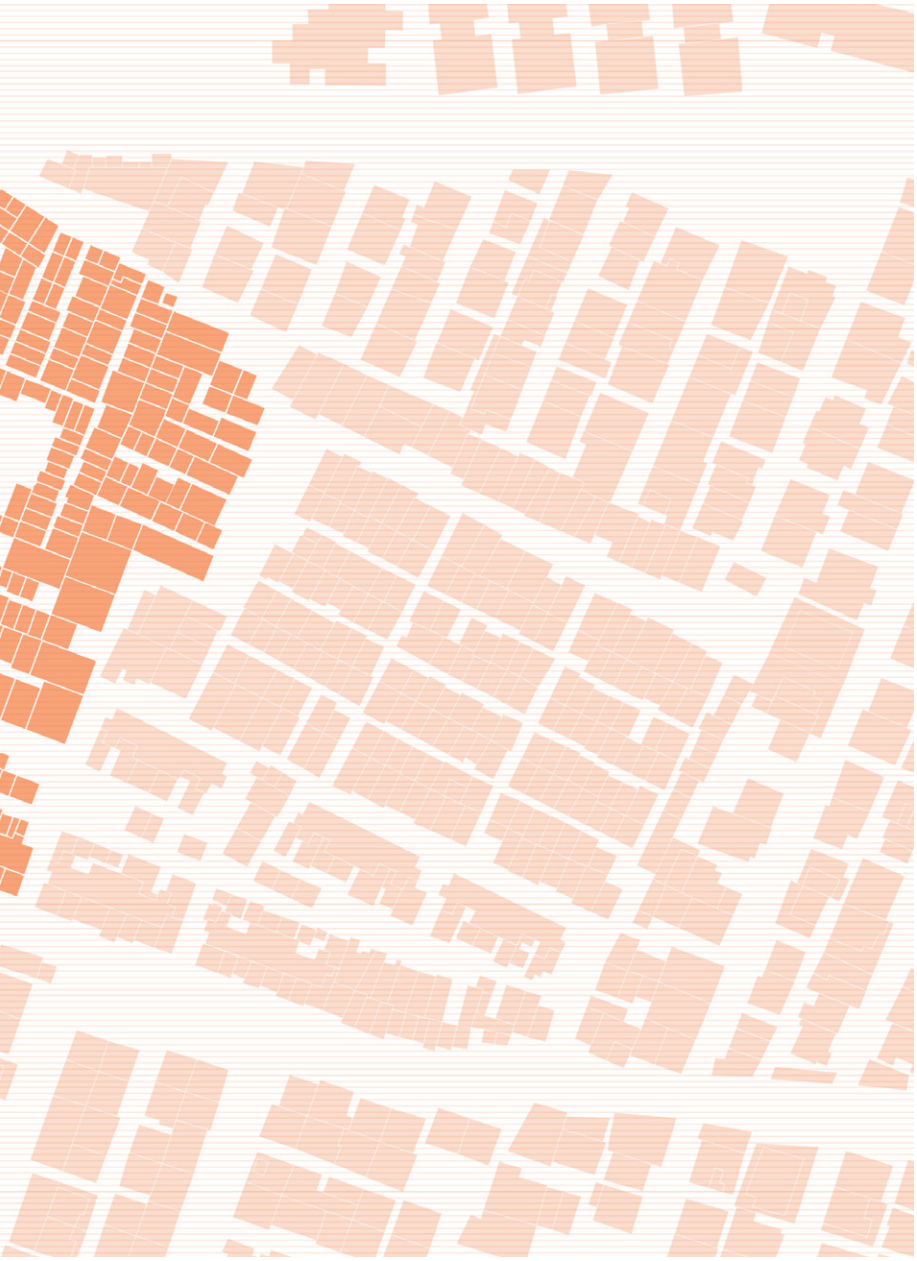
Fig 3.15 - Residential community surrounding the stepwell.



Fig 3.16 - Residential community surrounding the stepwell.



Fig 3.17 - The urban layout of the buildings within the site are distinct from the surrounding neighborhood, highlighting how the stepwell dictated urban growth.



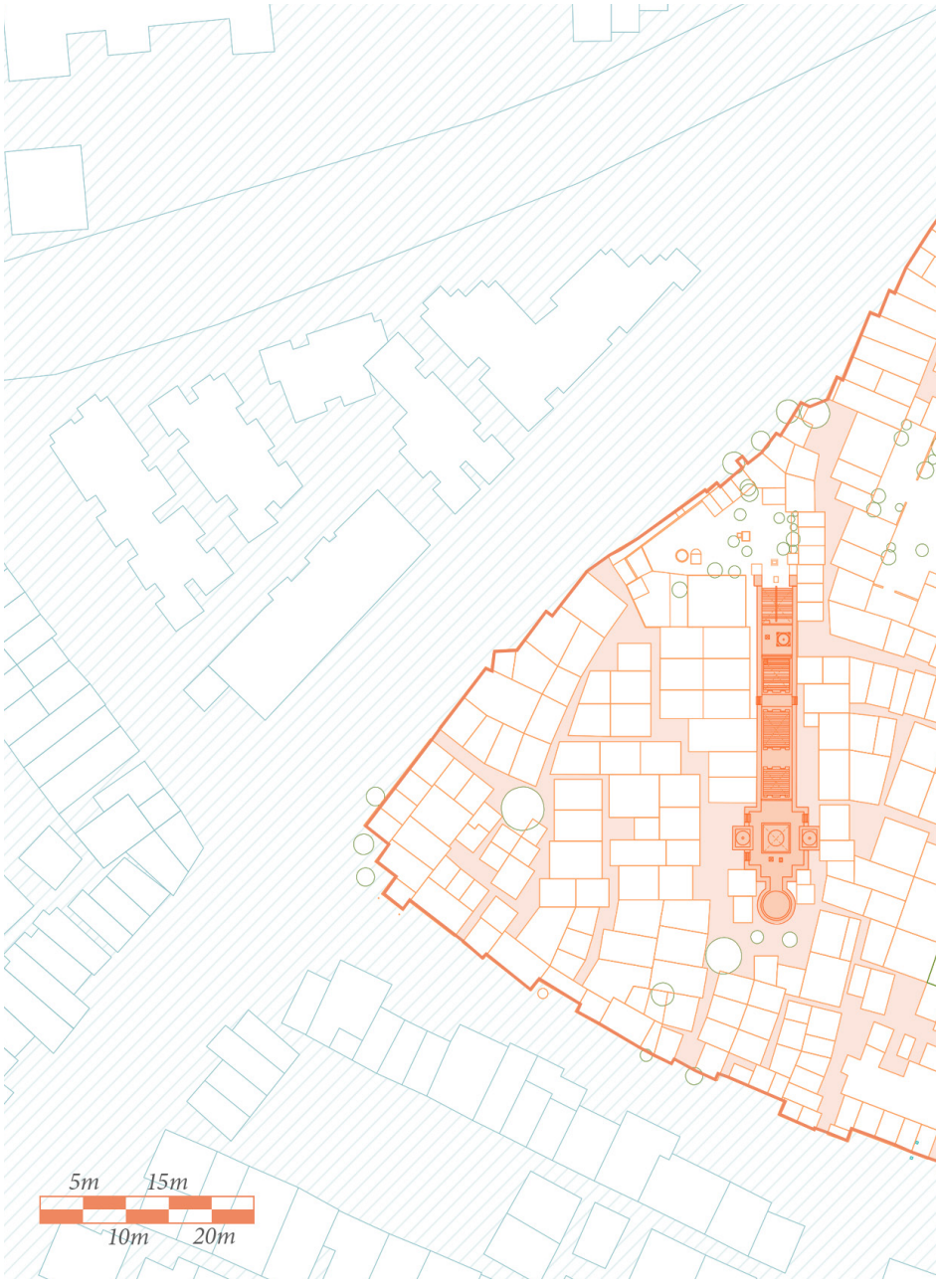


Fig 3.18 - Internal street/ alley network of the site.

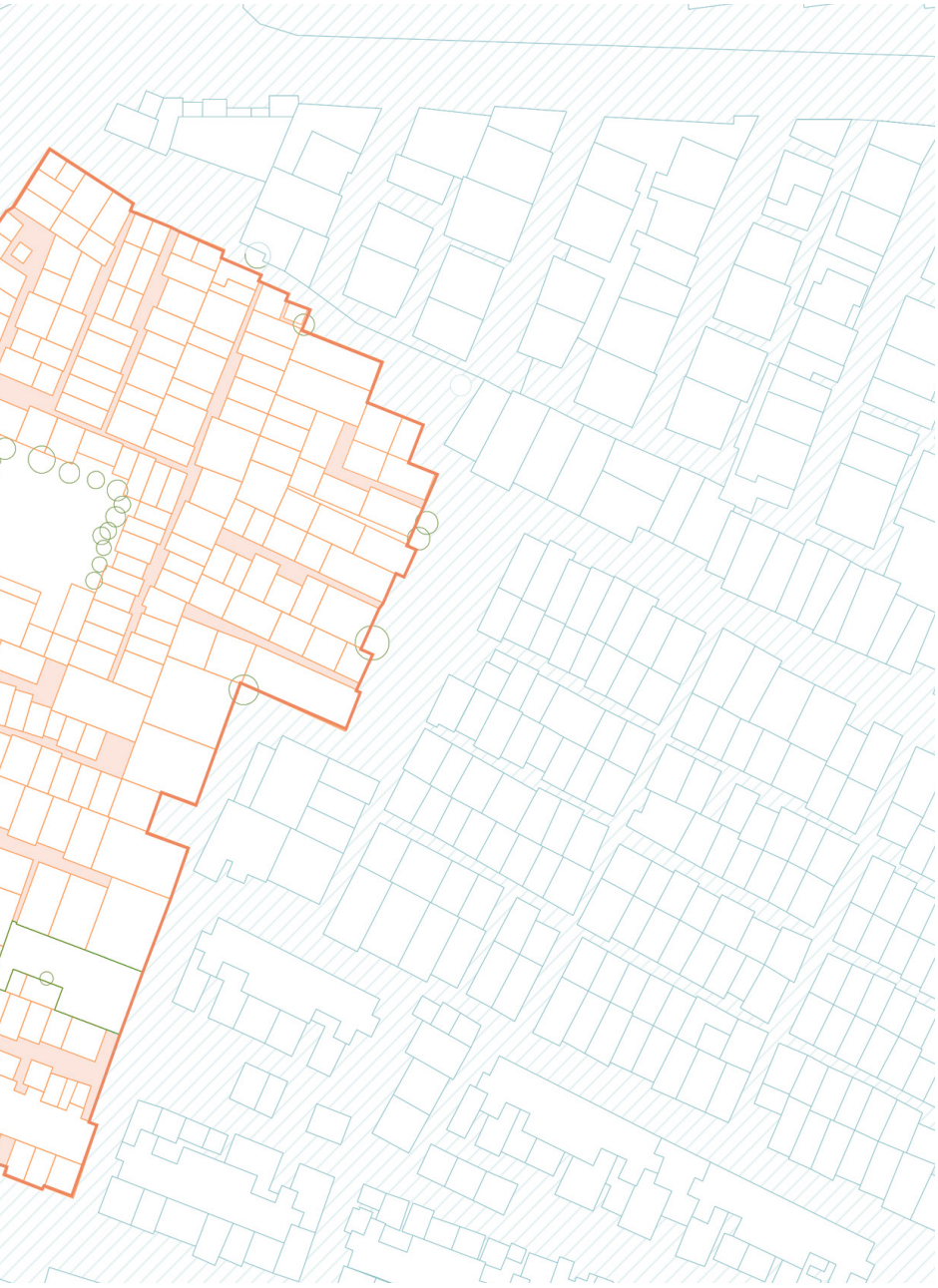




Fig 3.19 - Streets with stone pavement within the site.



Fig 3.20 - Streets with pavement blocks.





Fig 3.21 - Streets with stone pavement within the site.

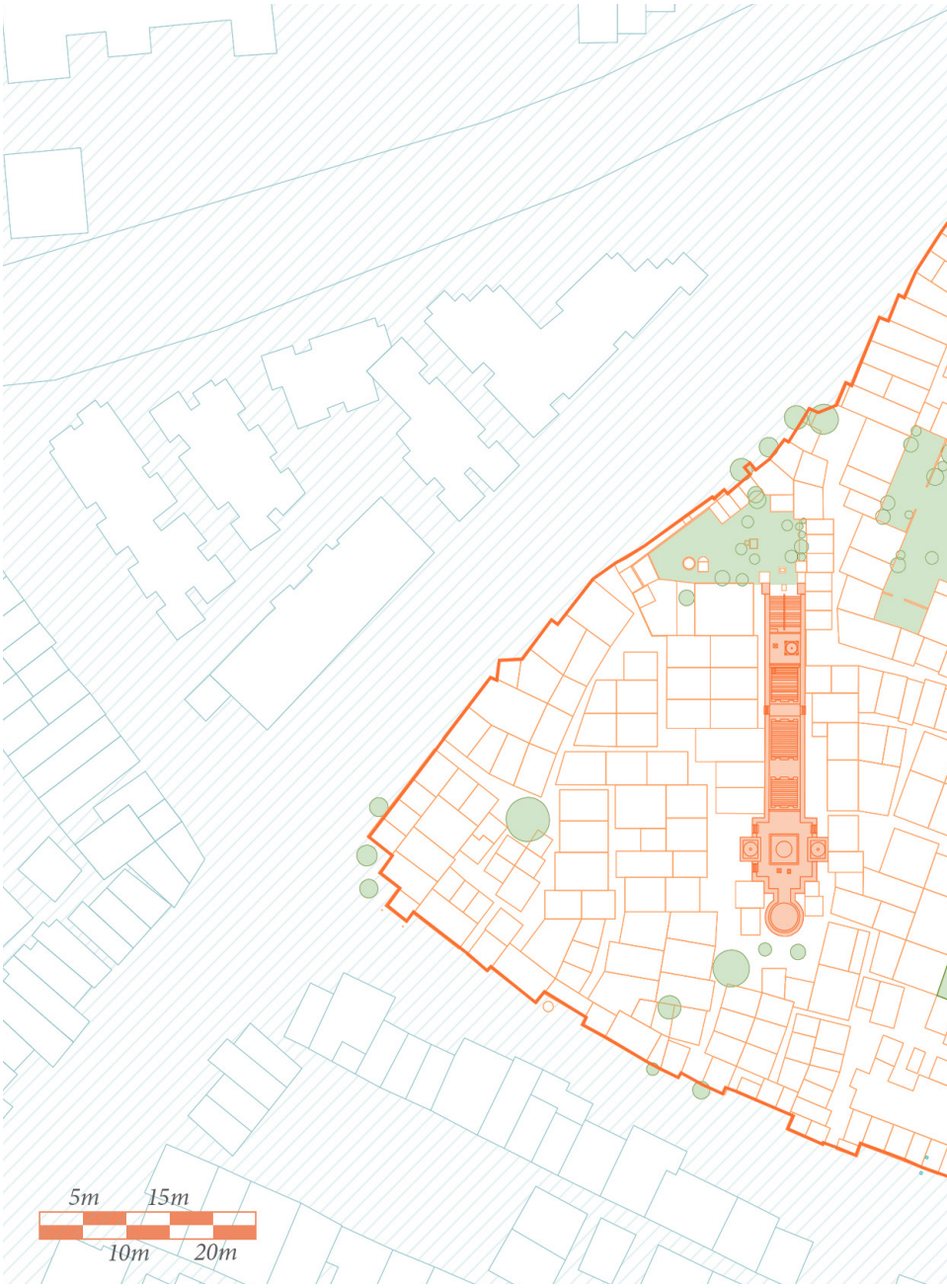


Fig 3.22 - Vegetation and open spaces within the site.

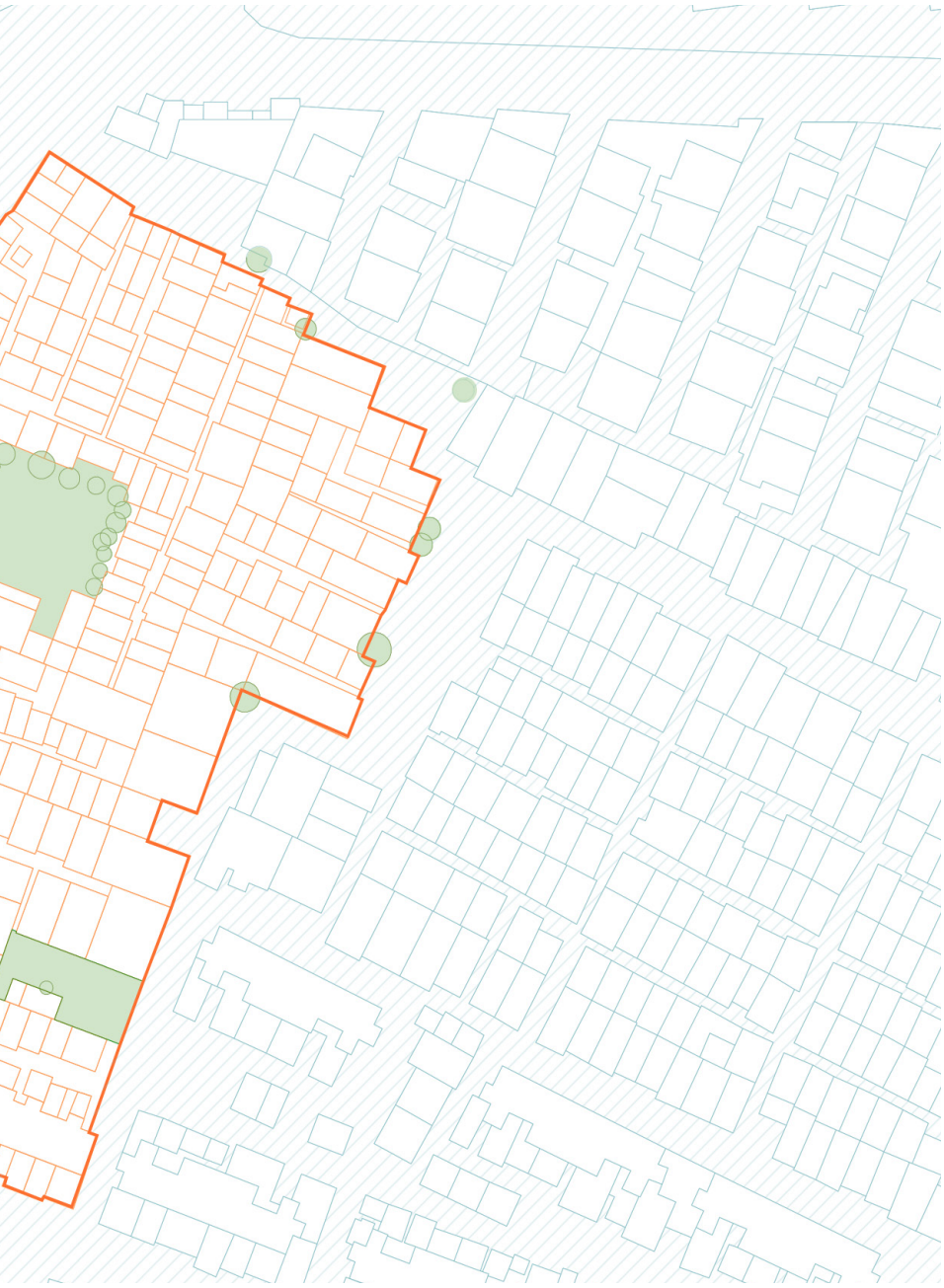




Fig 3.23 - Open space at the entrance of the stepwell.



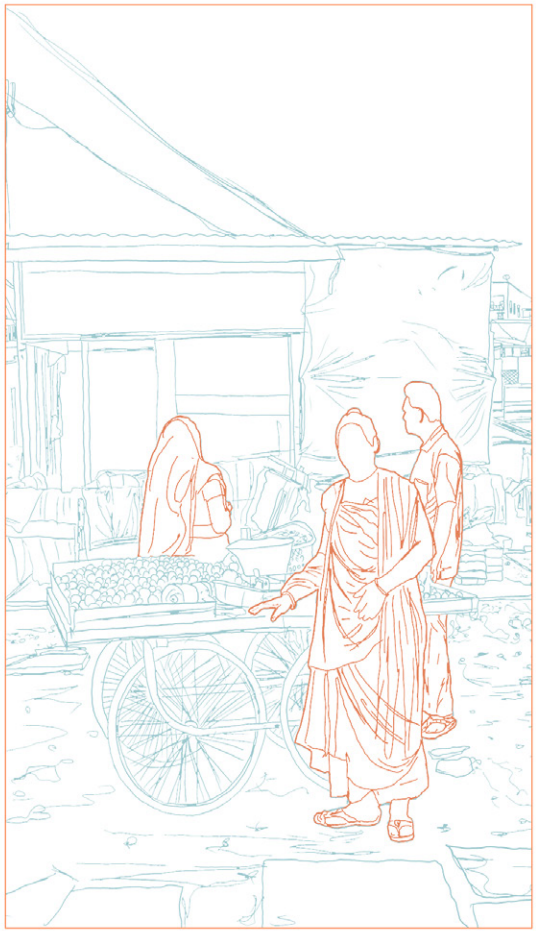
Fig 3.24 - Open space at the entrance of the stepwell.



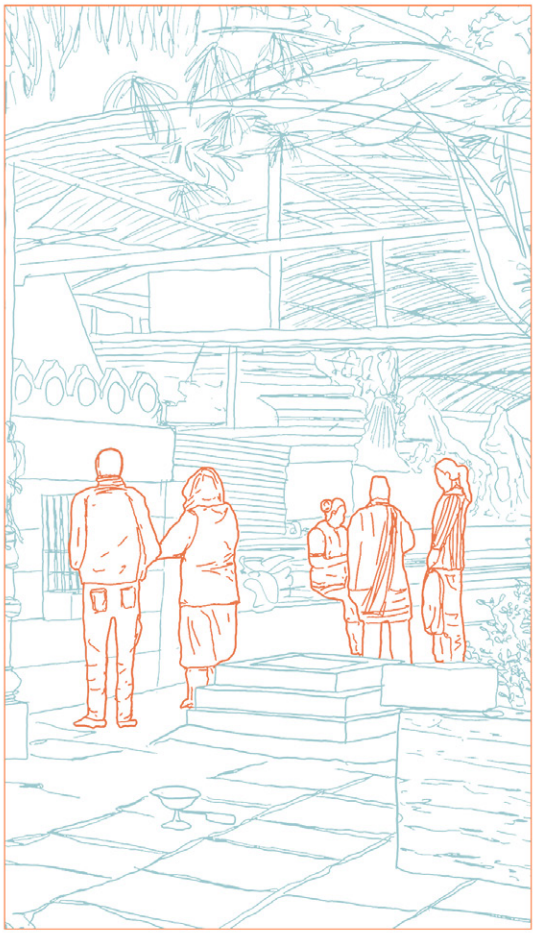
Fig 3.25 - Open space with vegetation within the residential community.



Fig 3.26 - Open space within the residential community.

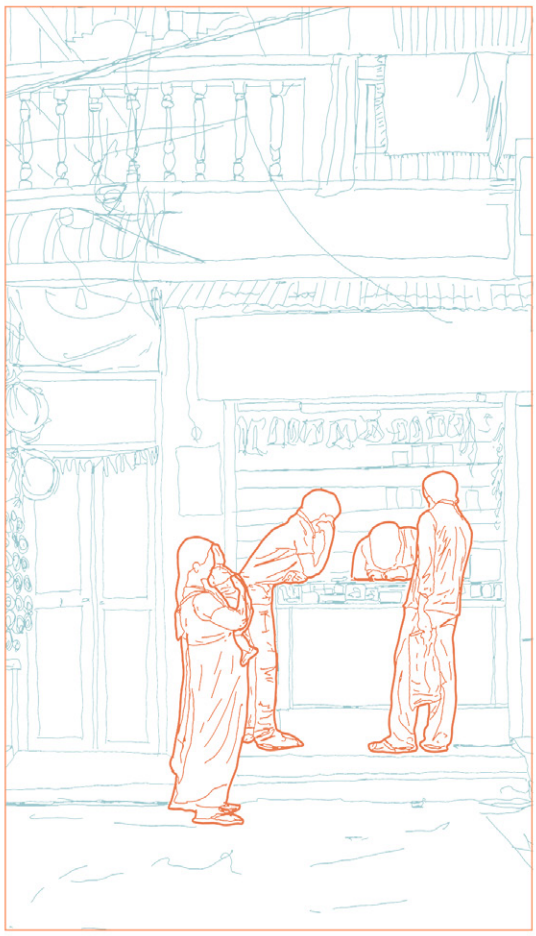


(i) Street Hawkers selling fresh fruits and vegetables.



(ii) Devotees visiting the temple.

Fig 3.27 - Activities within the site.



(iii) Commercial units along the main road.



(iv) Women working on textile.

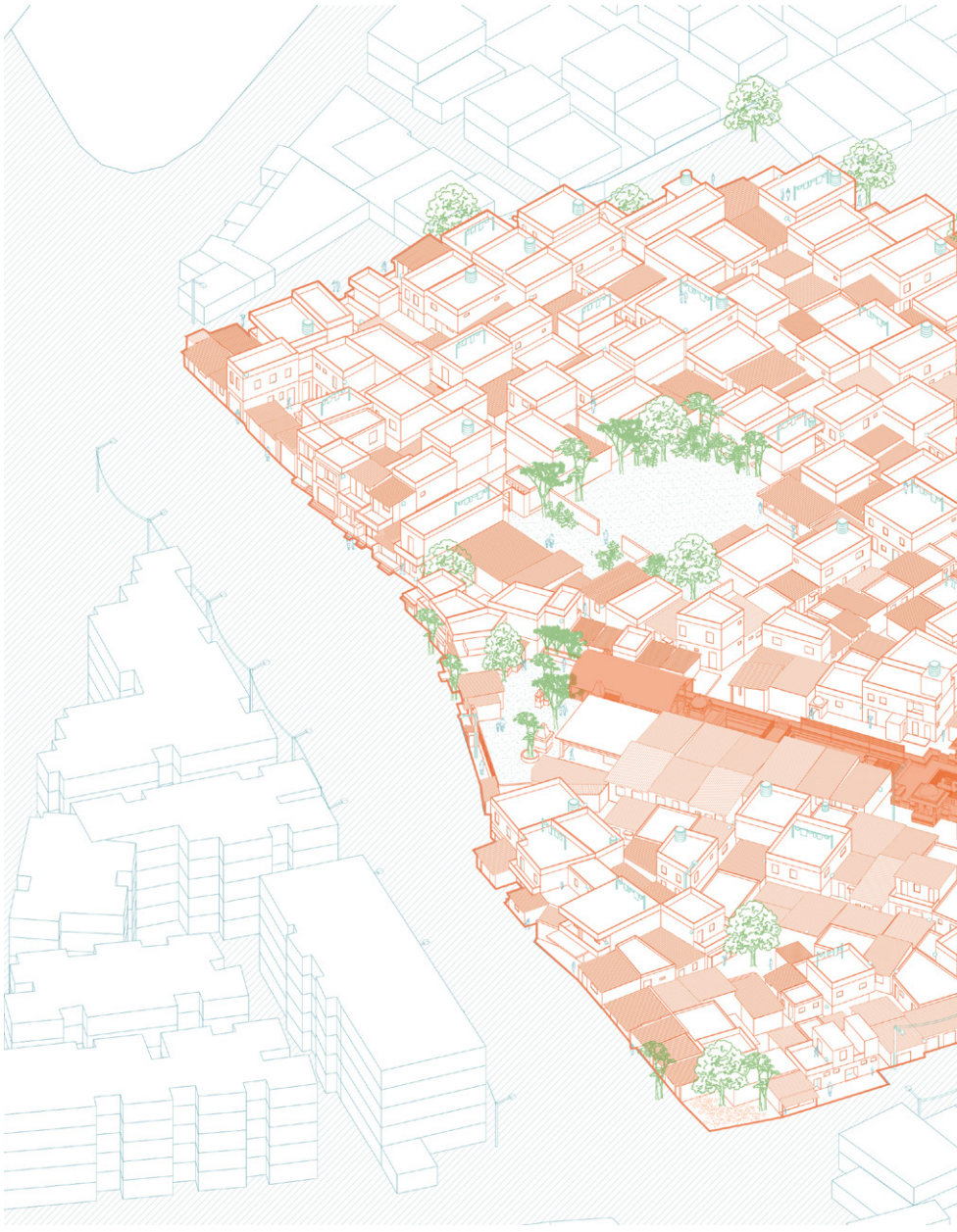
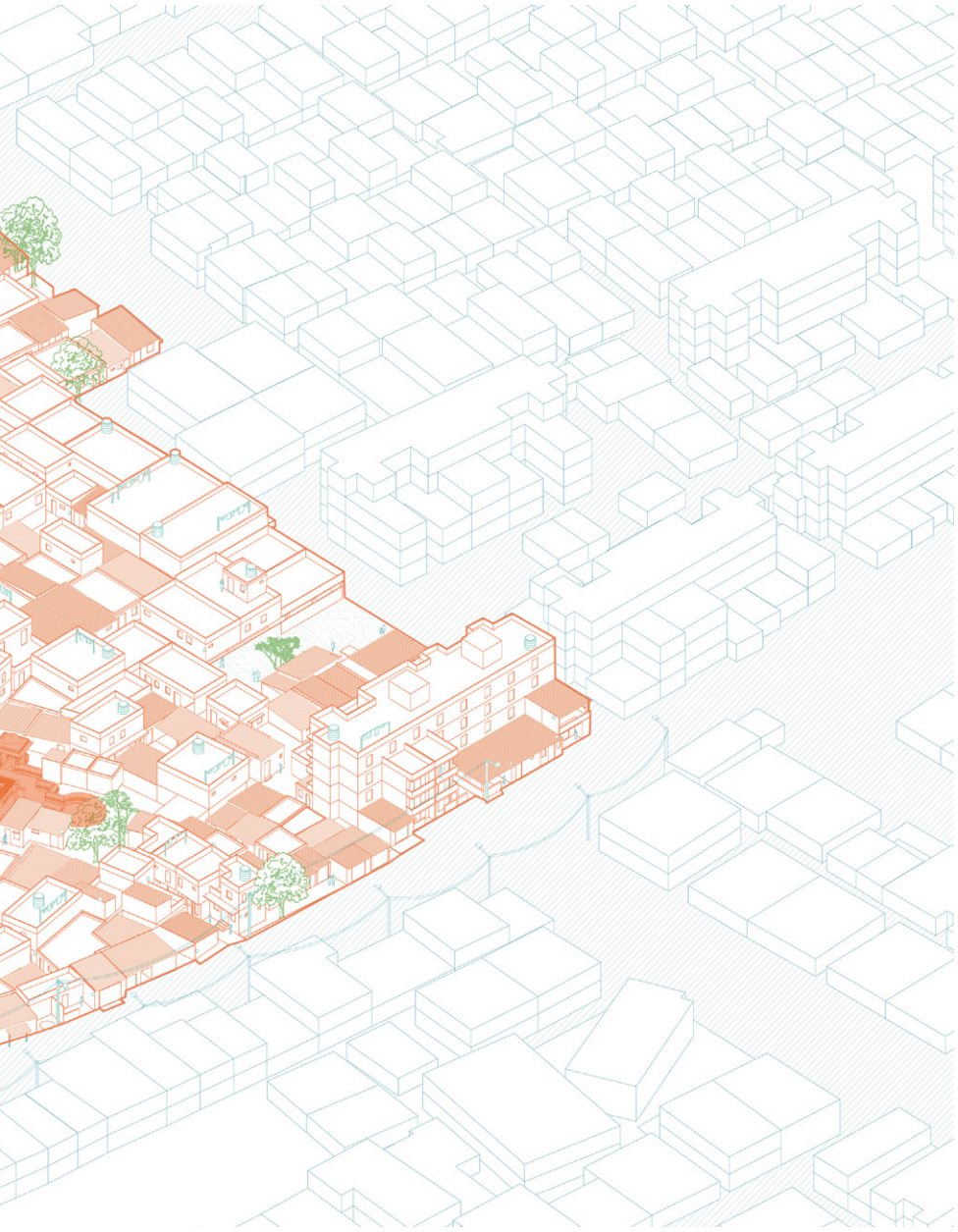


Fig 3.28 - Overview of the site and the surrounding neighborhood.



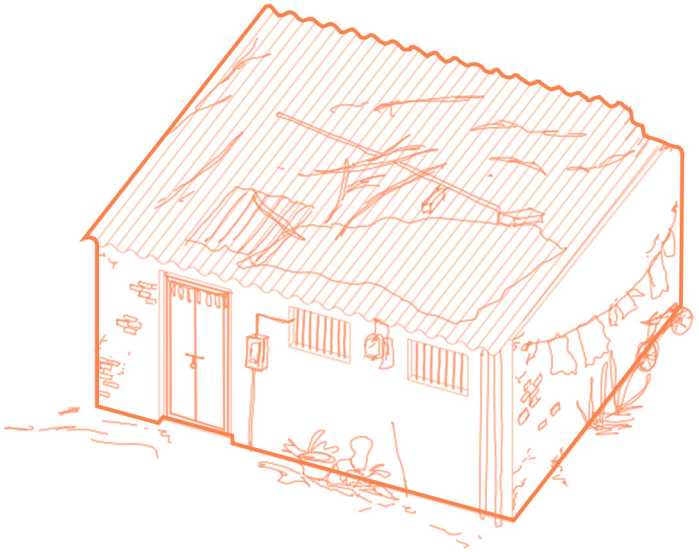


Fig 3.29 - Residential dwelling with temporary corrugated roof.

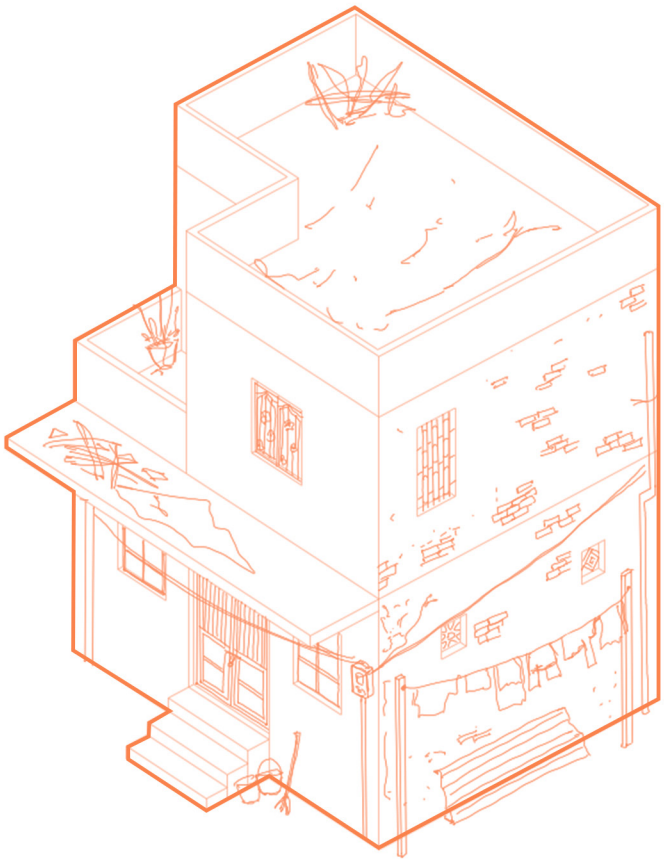


Fig 3.30 -Residential dwelling with flat roof.



Fig 3.31 - Stepwell and its immediate context.

Ashapura Mata Stepwell -

Built - 15th century

Location - Bapunagar, Ahmedabad

Number of levels - 4

Number of wells - 2

Number of Steps - 70

Number of columns - 180

Number of openings to sky - 6

Depth from ground - 20m

Horizontal length - 60m

Width - 5m

Architecture style - Indo-Islamic

Primary use - Currently first level being used by the temple and rest of the stepwell as a storage space (for the temple)



Fig 3.32 - Local deity, Ashapura Mata.

The Ashapura Mata Stepwell houses a temple on the first pavilion dedicated to the goddess Ashapura Mata. This ancient stepwell from the 15th century was named after this local deity. Although the stepwell played a vital role in the past, it is now used as a mere dumping ground for the temple. The temple stores clay pots, metal, and clay lamp stand. The materiality and compactness of the stepwell cools down the temperature of the space. Its complex geometry ensures minimal sunlight exposure to the water surface making the bottom level dark.

This stepwell contains two wells of varied sizes. The primary well is located on the complete back end of the stepwell, while the secondary well is at the end of the steps. Currently, both the wells are buried and filled with waste. Apart from the main flight of steps from the front, the internal levels of the stepwell can be accessed using the secondary entry points on either side of the stepwell. While the spiral staircase is blocked, the other one is still in use. The community has created an enclosed space on the back end of level 1 by building brick walls between the stone columns. They have barricaded the roofs with grills and barbed wires to prevent accidental falls from the ground level.

Even after efforts made by the locals to utilise the stepwell, it remains underutilized. Currently, it is a home for pigeons, squirrels, and bats.

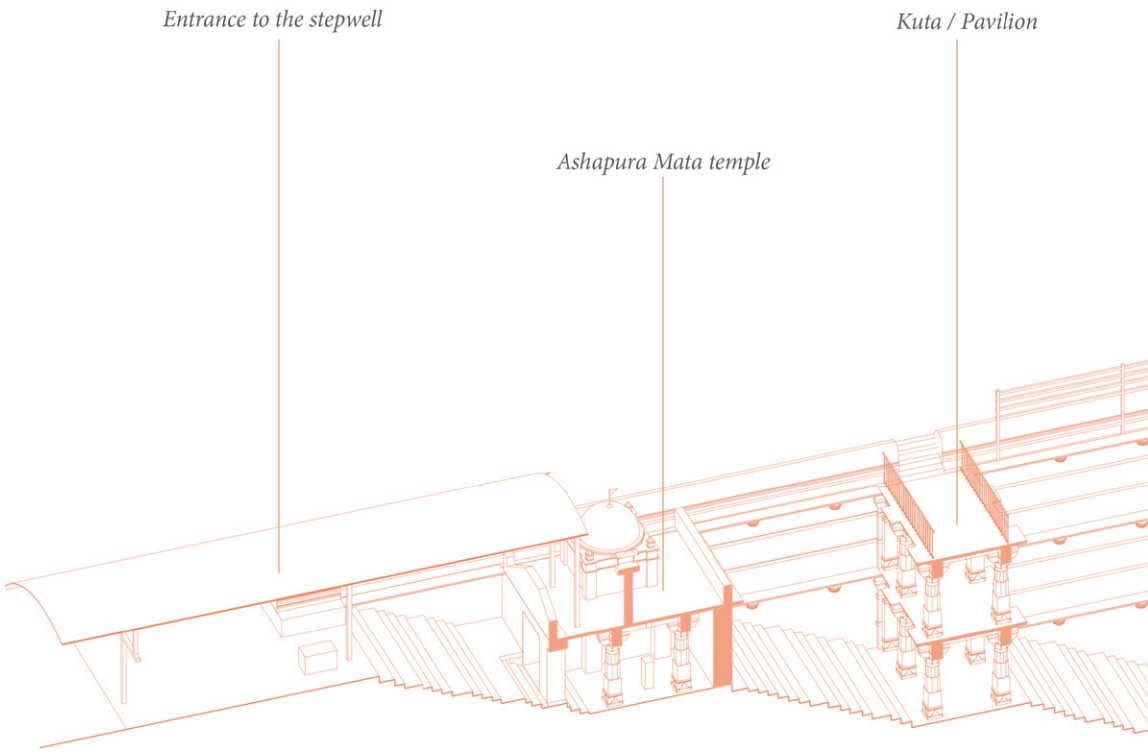
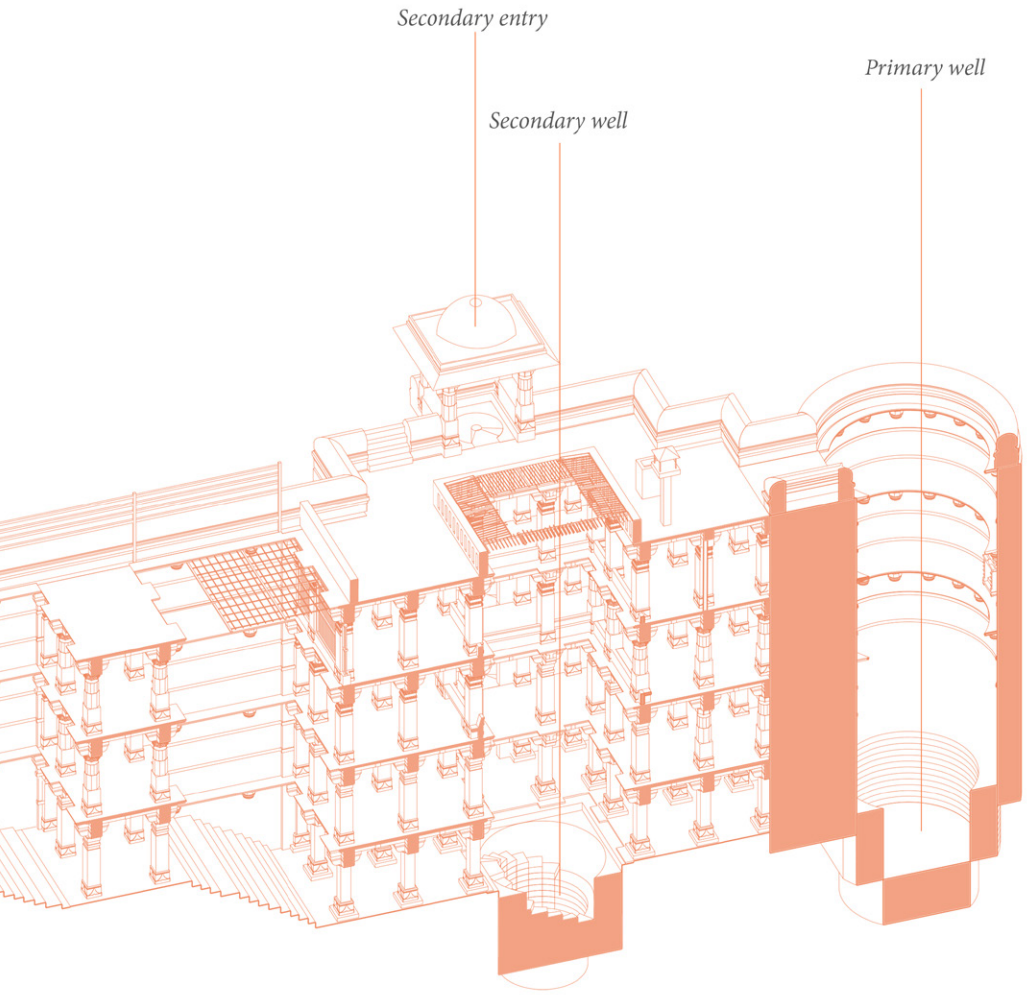
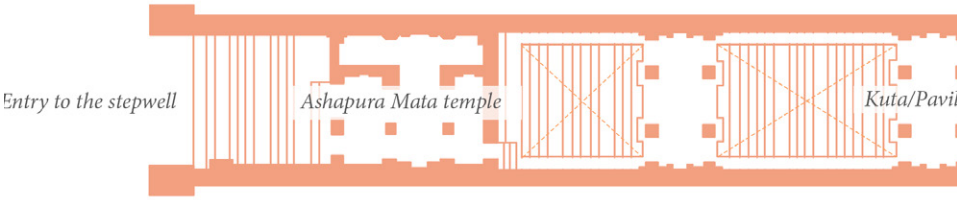


Fig 3.33 - Spatial organisation of Ashapura Mata Stepwell.


Secondary entry
Primary well
Secondary well



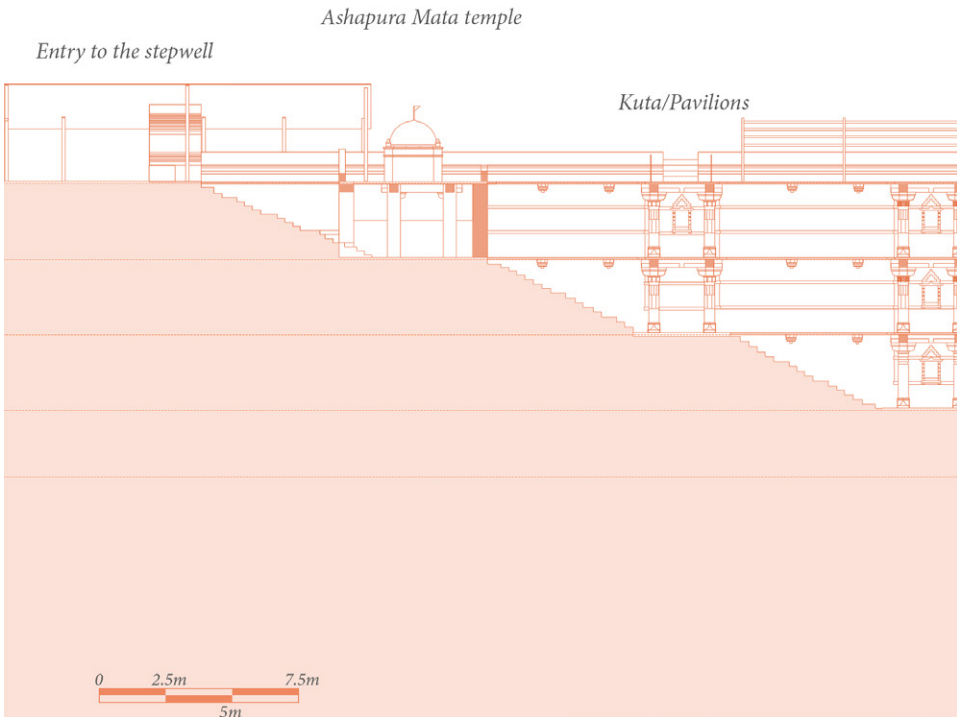
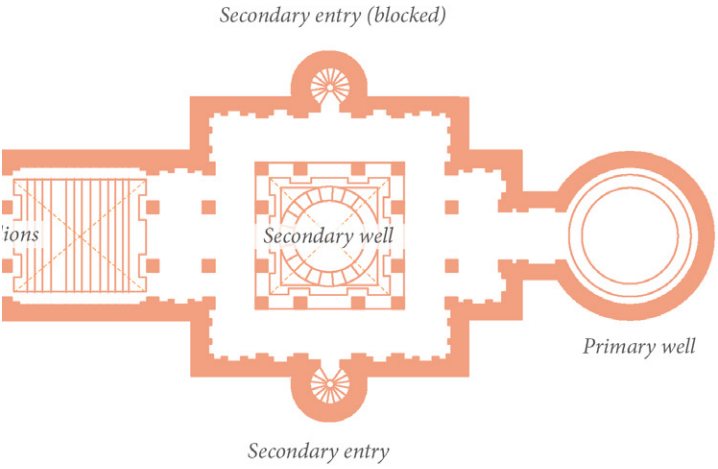
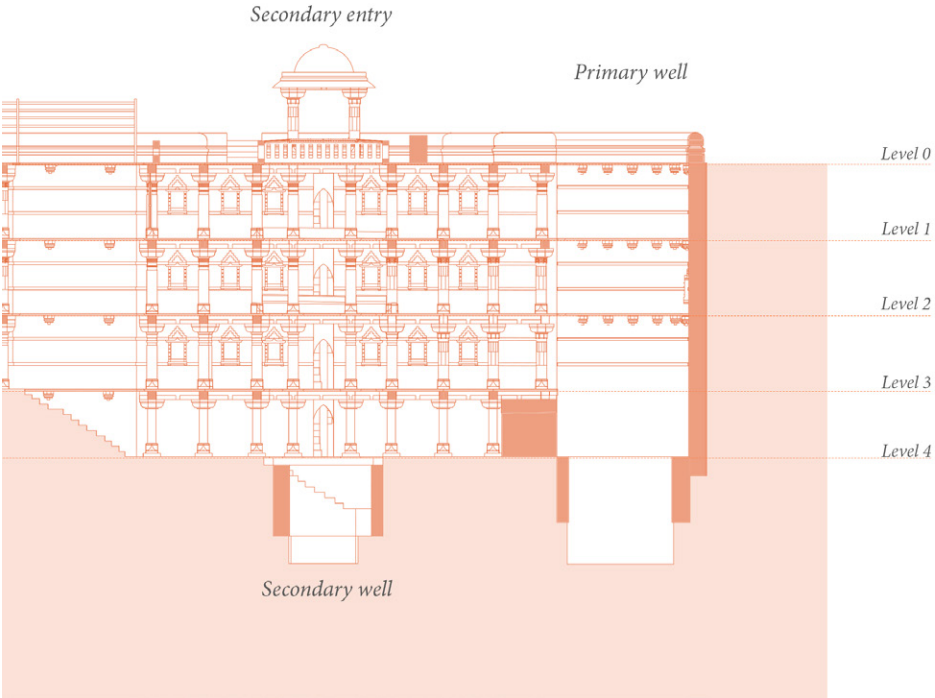


Fig 3.34 - Spatial organisation of Ashapura Mata Stepwell.


Secondary entry (blocked)
ions
Secondary well
Primary well
Secondary entry


Secondary entry
Primary well
Level 0
Level 1
Level 2
Level 3
Level 4
Secondary well

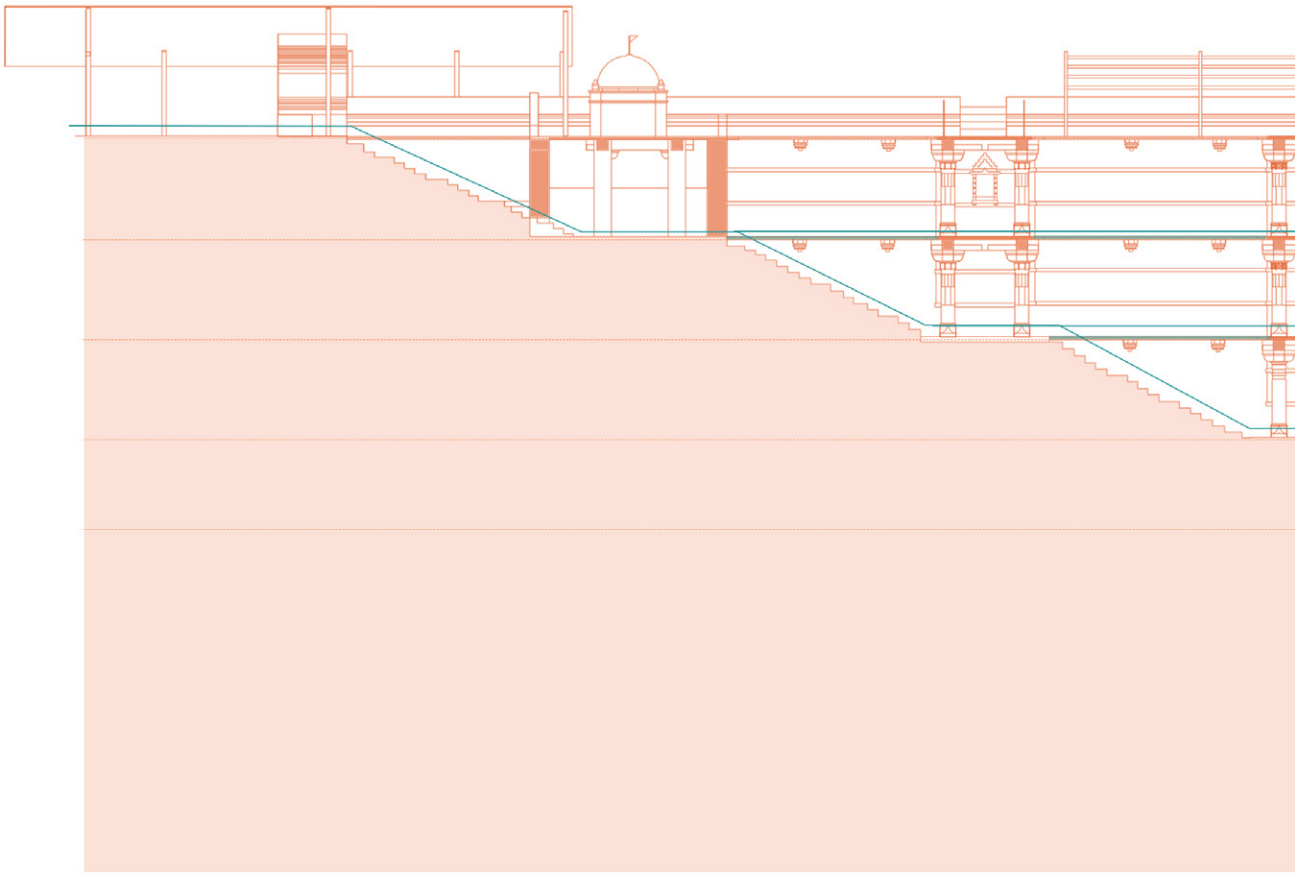
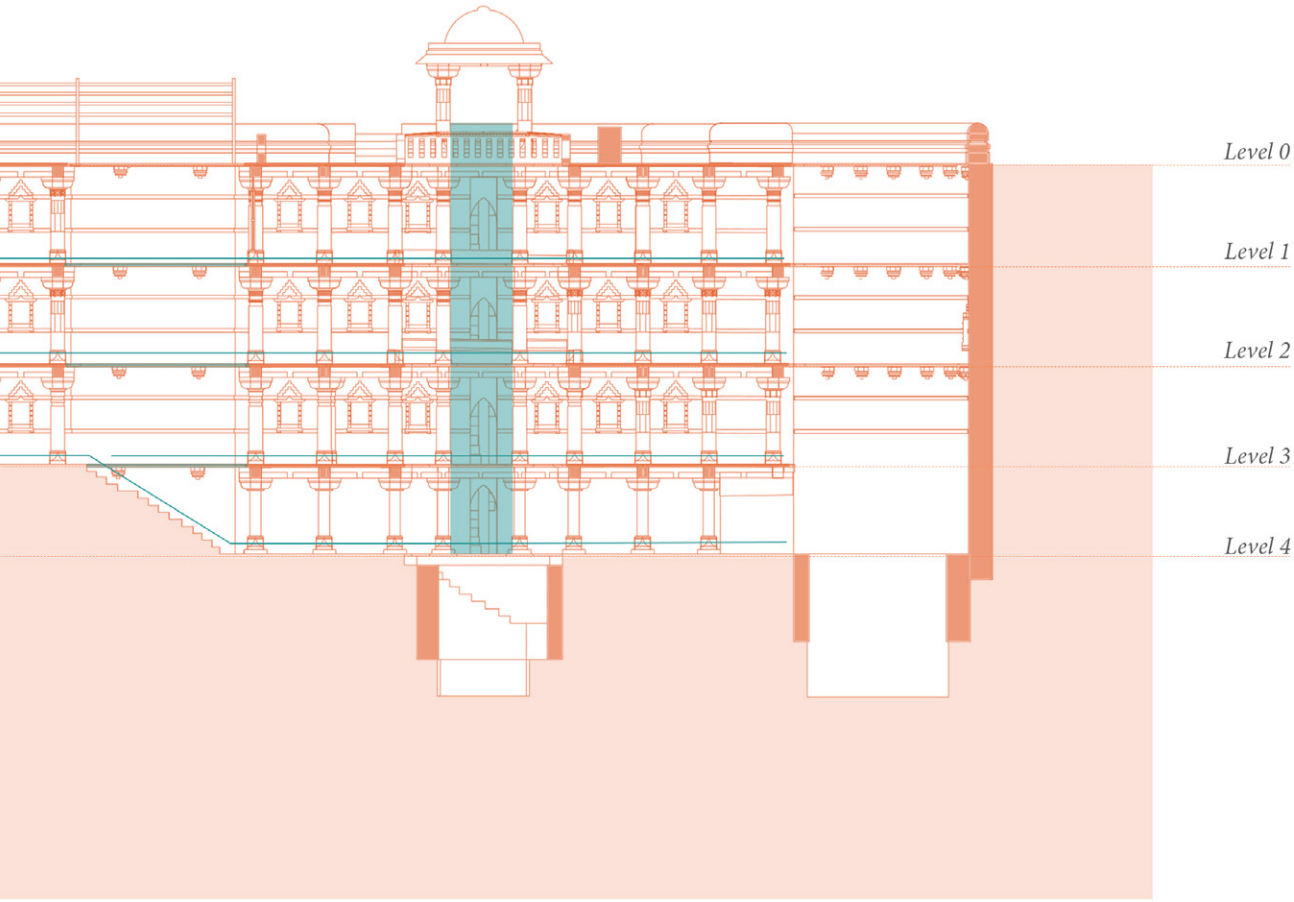


Fig 3.35 - Accessibility inside the stepwell.


Level 0
Level 1
Level 2
Level 3
Level 4

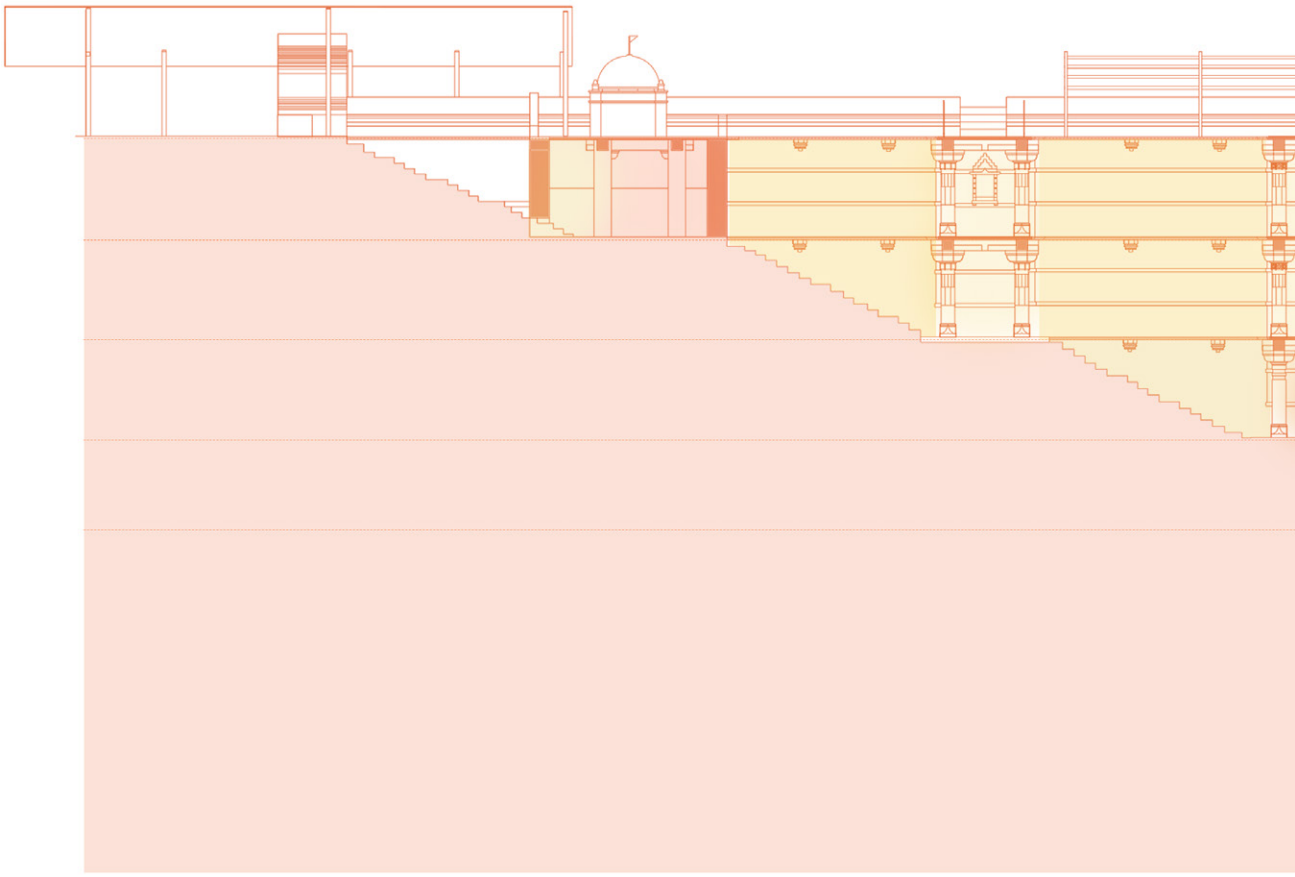
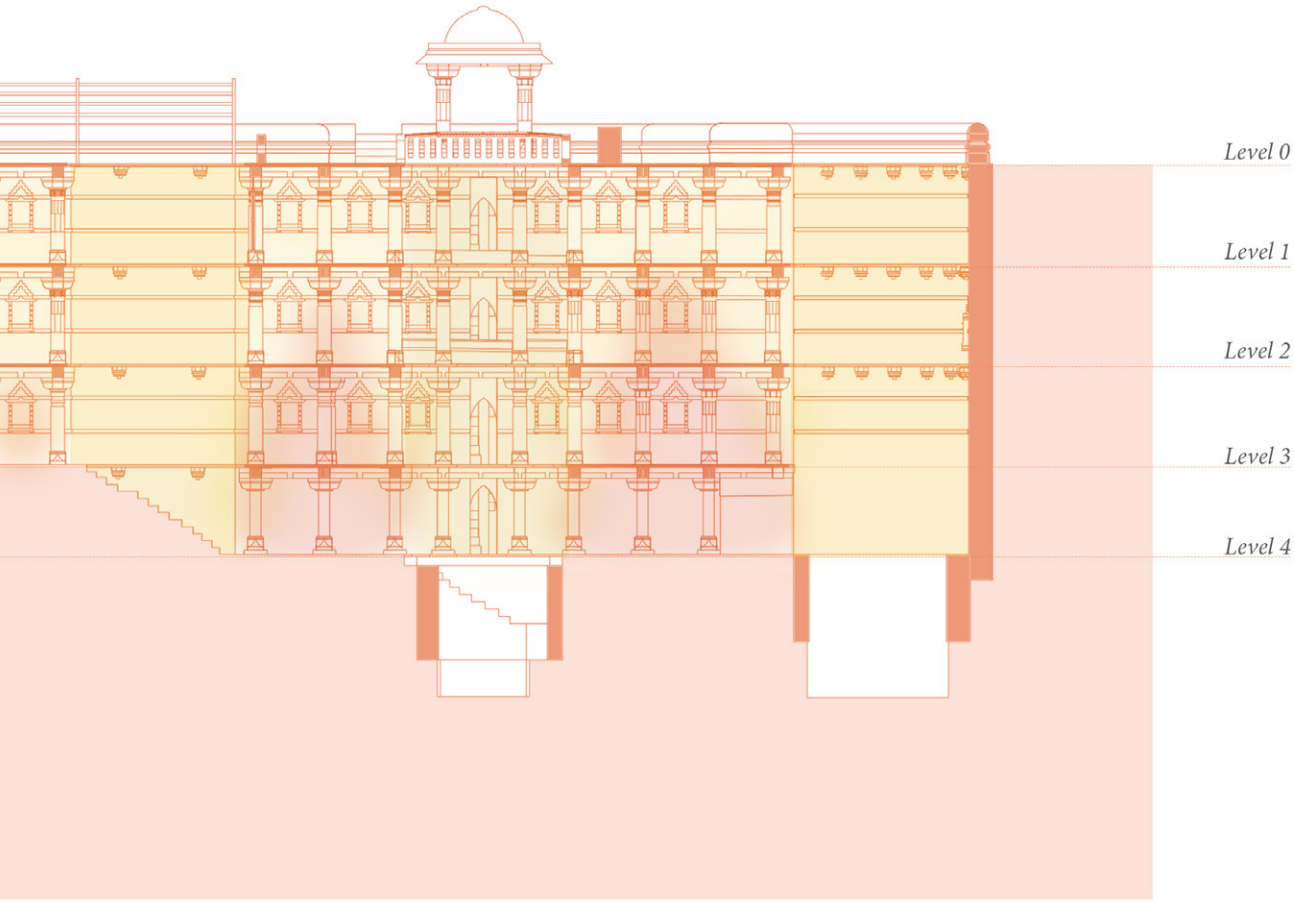


Fig 3.36 - Section highlighting the spaces with minimal and maximum sunlight exposure.


Level 0
Level 1
Level 2
Level 3
Level 4

The Stepwell reflects the beauty of the past. The engineering complexity and elaborate architectural features set it apart from other buildings from the past. As the structure remains intact for most of the stepwell, the intricacy of the architectural elements stands out.

The Ashapura Mata stepwell has a blend of Hindu and Islamic styles of architecture. There are over 180 columns, unique on each level. The level of intricacy on these columns reduces gradually as one descends to water. This probably could have been due to the rising water level. As the bottom level has a higher potential of getting filled with water from the wells, this level has minimal details. This can be observed even with niches. The carvings and motifs on the niches and inside them also differ from level to level. The motifs inside the niches have a religious significance associated with them. The walls represent Islamic architectural influence with nature-based patterns running along the steps down to the water. These intricate carvings narrate the architectural style of the past.

The sequential arrangement of the columns within the stepwell creates a striking visual illusion. The primary well on the back is adorned with architectural motifs, while the secondary well is designed as a typical water well with steps inside.

These architectural motifs add a layer of depth and vibrance to the stepwell. It sets itself apart from the surrounding neighbourhood and transcends the user into the past.



Fig 3.37 - Architectural motifs adorning the walls of the stepwell.



Fig 3.38 - Elaborate details on the walls and columns.



Fig 3.39 - Architectural details.



Fig 3.40 - The layout of columns creating symmetry and architectural rhythm.

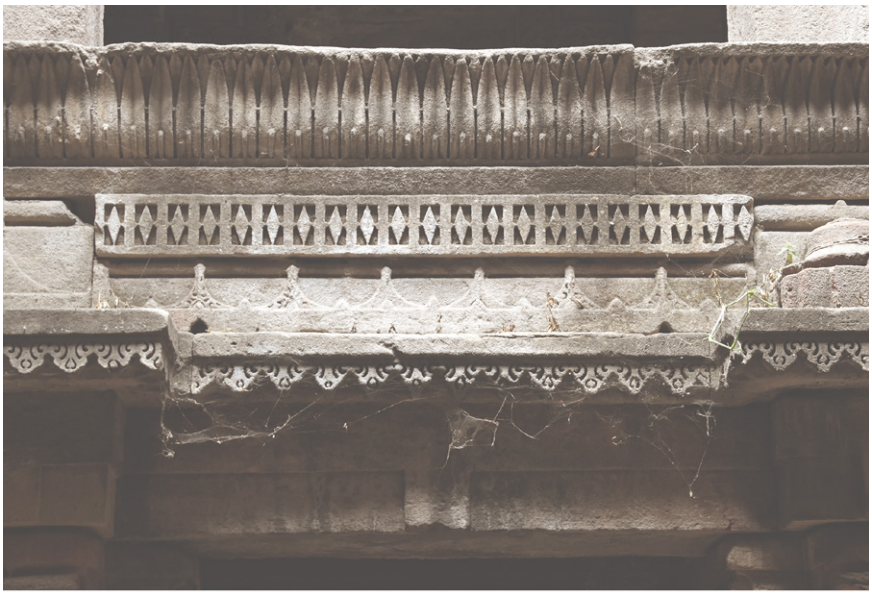


Fig 3.41 - Intricate wall carvings inside the stepwell.

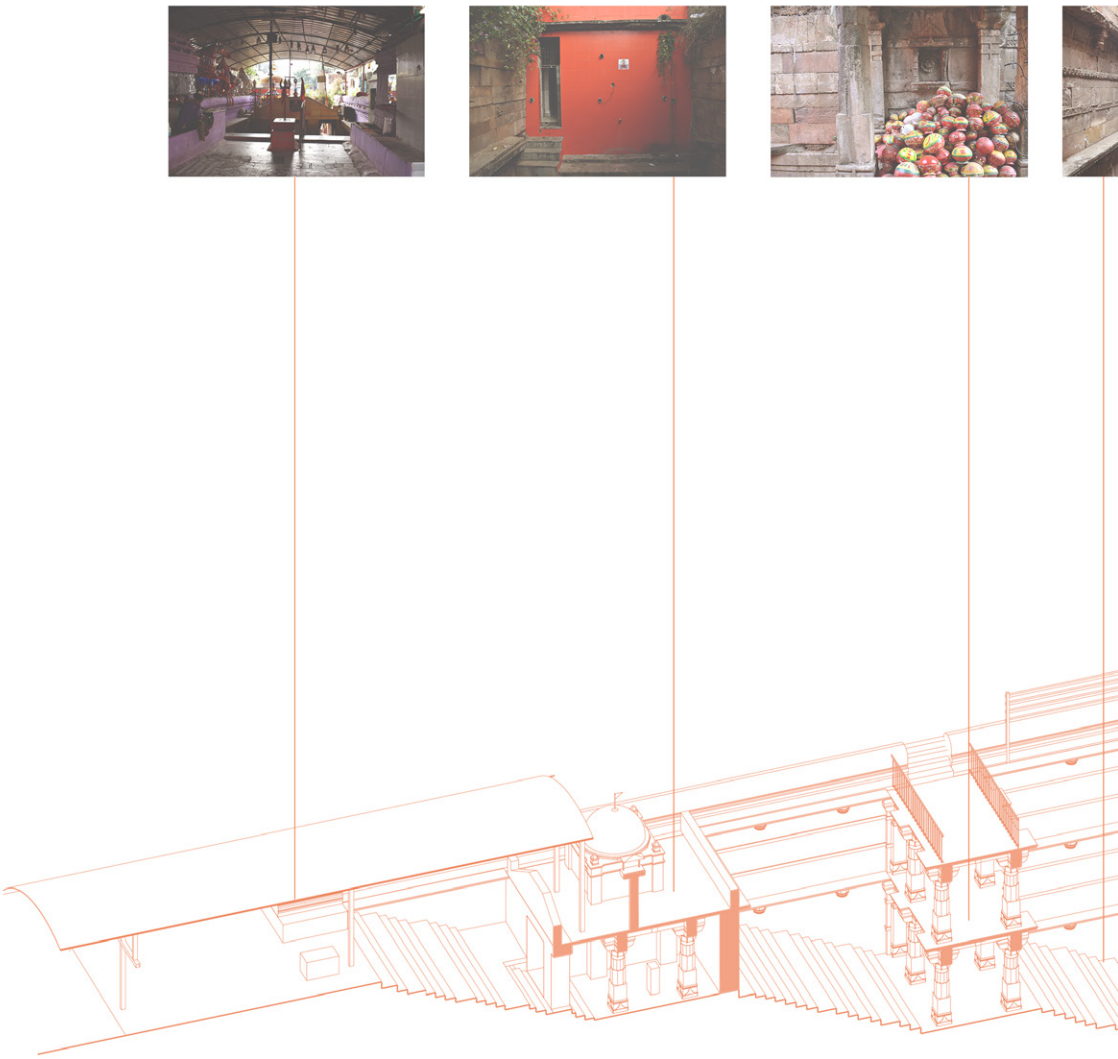
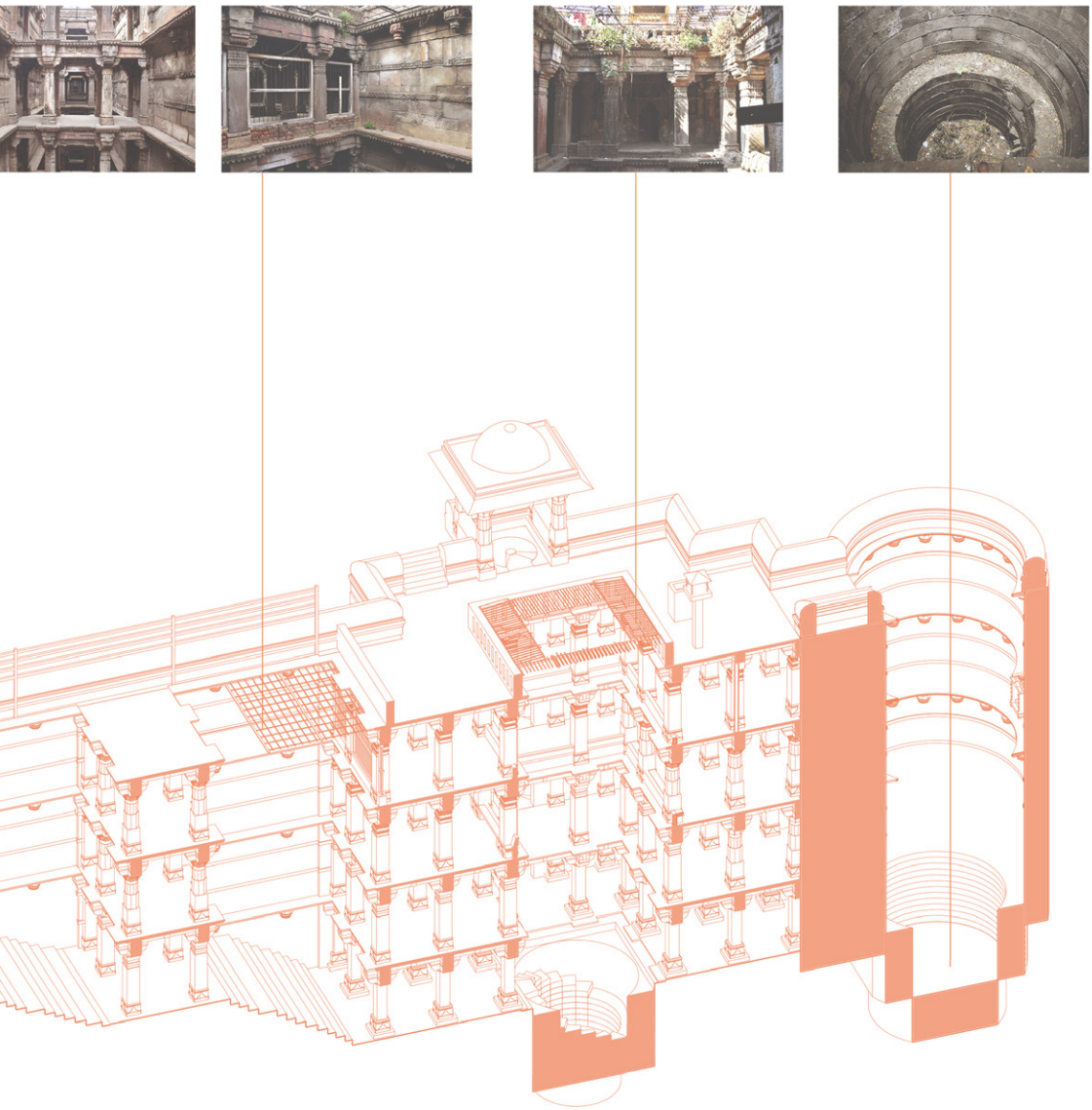


Fig 3.42 - Images highlighting the existing condition of the stepwell.



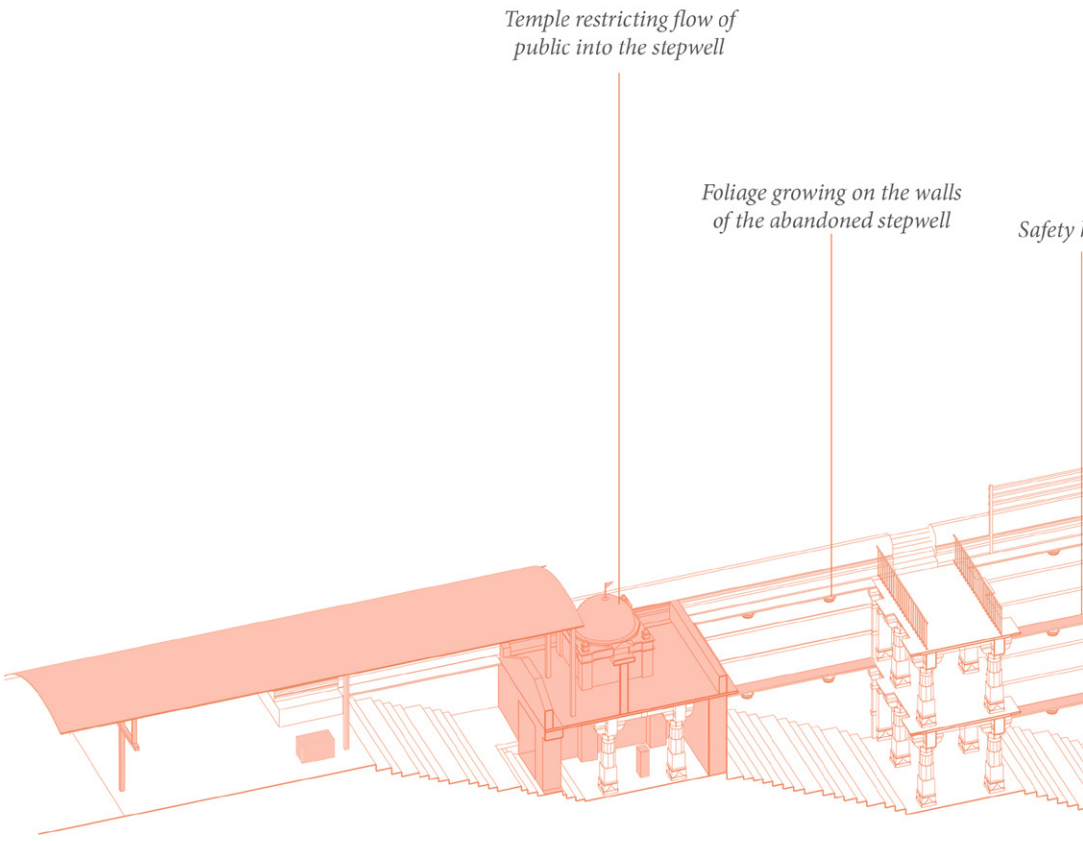
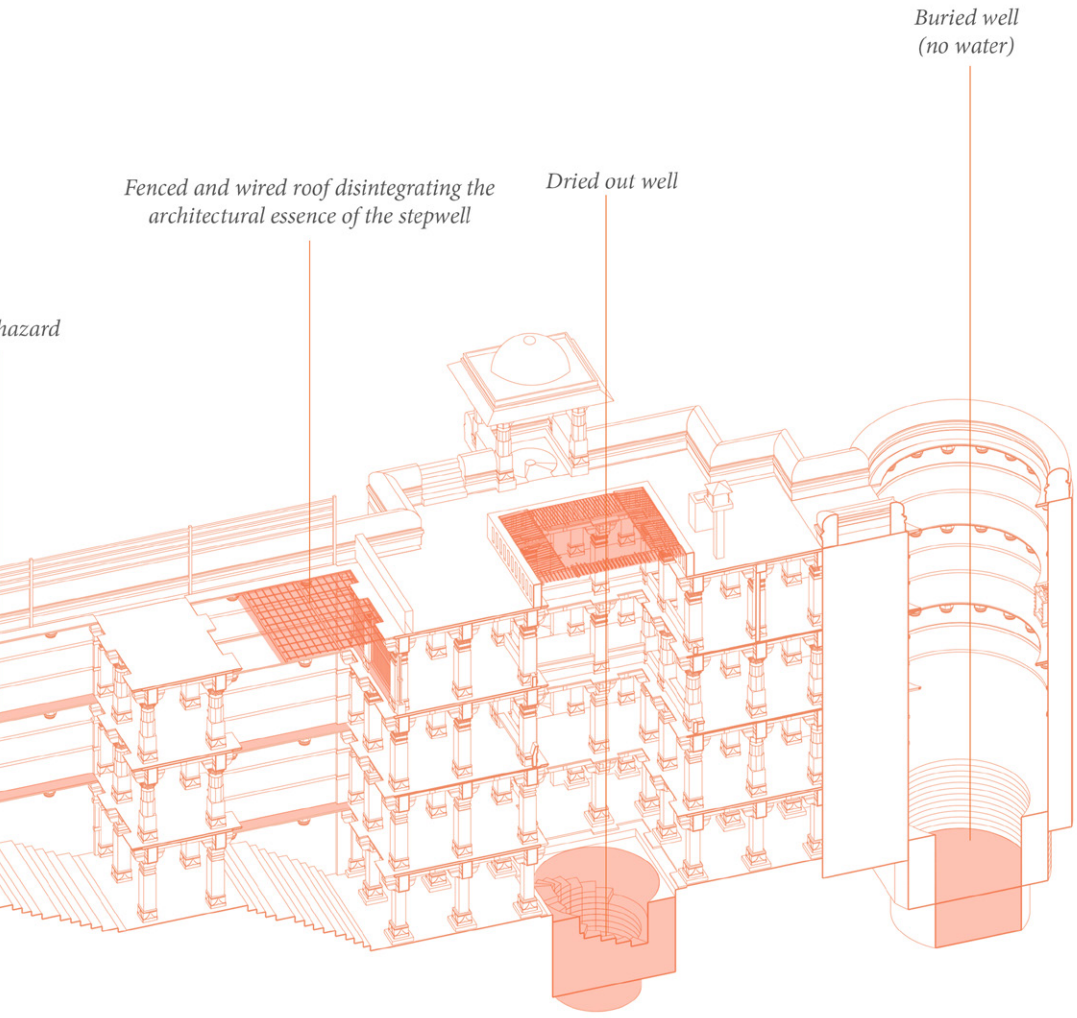


Fig 3.43 - Problems to be addressed for restoration of the stepwell.


Buried well
(no water)
Fenced and wired roof disintegrating the
architectural essence of the stepwell
Dried out well
hazard

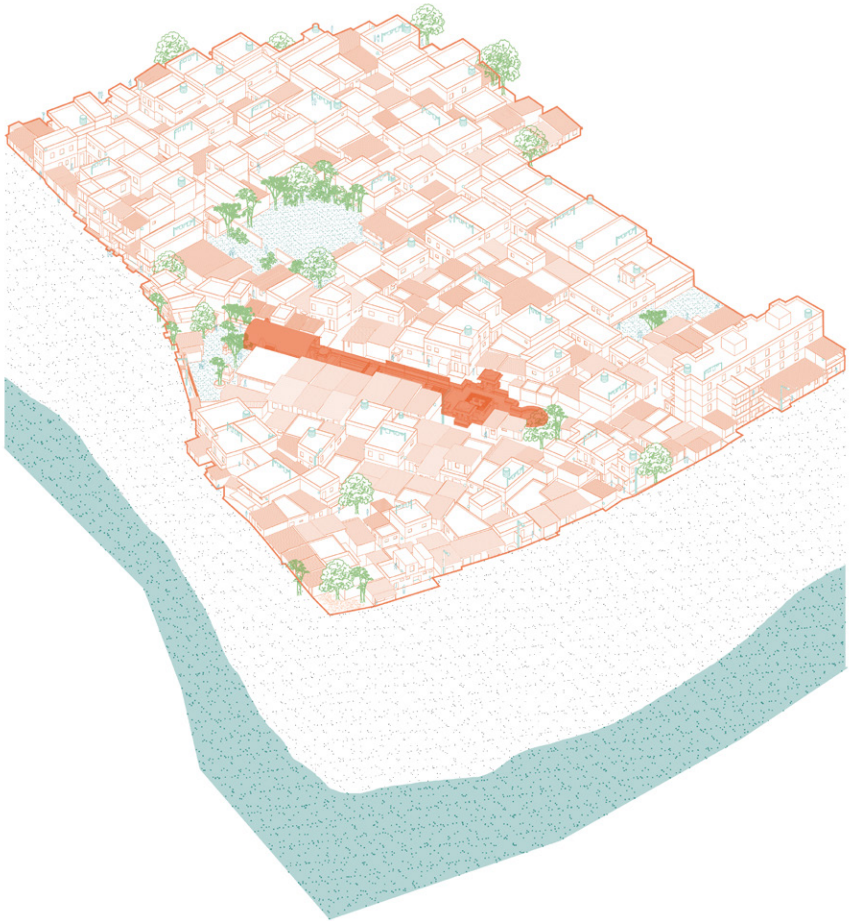


Fig 3.44 - Overview of the site.

The Ashapura Mata stepwell highlights a unique case of organic urban growth around the stepwell. The existing residential neighbourhood has absorbed the stepwell as a part of the community. However, it is unfortunate that the historical artifact that played a significant role as a communal gathering space in the past remains abandoned today.

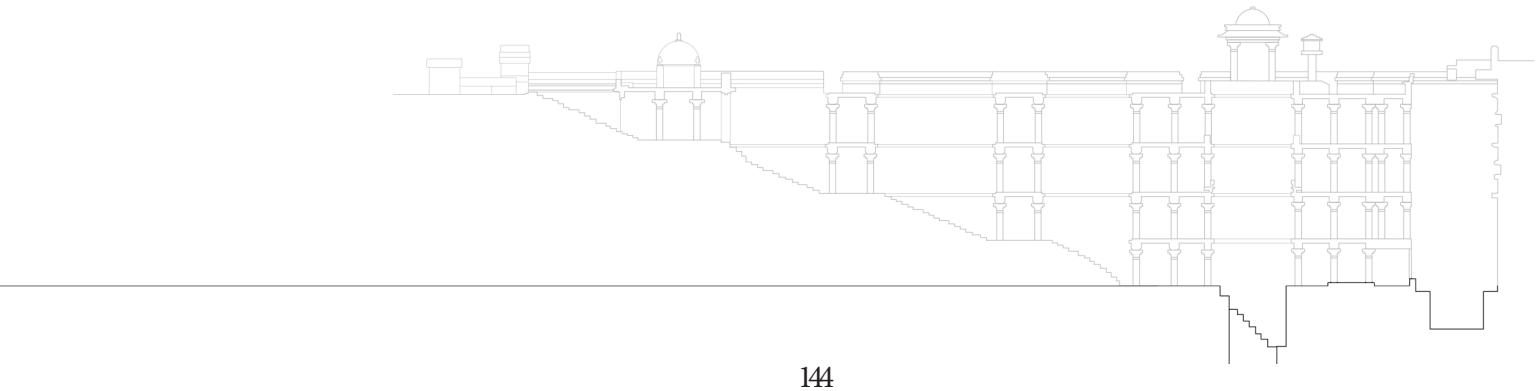
The stepwell remains hidden behind the Ashapura Mata temple and is currently inaccessible to the general public unless requested. The only primary user of the space is the temple, as they are currently using it as a back-end storage space. The positioning of the temple on the first pavilion restricts the flow of public movement into the stepwell. The walls of the temple block the visual axis from the main street leaving the stepwell to remain unnoticed. Although there is a continuous flow of devotees to worship the local deity, the stepwell is not open to the public. Accessibility and safety concerns become the primary reason for this. Traces of human intervention within the stepwell support that safety is the primary concern of the community. As the stepwells go deeper into the ground there is an alarming concern for safety. The metal fencing and barbed wires were added on the ground level by the local community to prevent accidents. As the stepwell remains uninhabited, the wells have dried up and are now buried. As there is an unavailability of water in the wells, the community has no purpose to go down to the stepwell. As the problems within the stepwell indicate the reliance on the local community, it becomes important to address these problems at micro and macro levels.

Looking at the surrounding residential community, it was identified that the community lacks proper infrastructure. Residential dwellings can be classified as low-income housing units. About 50 per cent of the residential dwellings have a temporary corrugated roof which is currently not in good condition. Women from the community end up working out in the open amongst dirt and debris. Due to the high density of the community, there is no dedicated gathering space for the women or the public. The water availability within the community is inconsistent due to the adverse effects of climate change and global warming. As mentioned earlier, the city is currently one of the most groundwater-stressed regions in the country. It is essential to promote water conservation strategies in such neighbourhoods. While these are the problems that might look like they need new infrastructure and high investment, the community needs to use the existing resource to its highest potential. The restoration of the Ashapura Mata stepwell will not revive the lost culture and heritage but will also become a significant asset to the local community.



Part 4

Design Intervention



4.1 - Concept

The proposal for the restoration of Ashapura Mata Stepwell requires community involvement at various levels. The existing condition of the stepwell and the local community calls for a comprehensive design solution. As the context plays a crucial role in shaping the restoration of the stepwell, it is important to address issues faced at the community level. All the problems within the stepwell and the local community are interconnected. Proposing design strategies for one will have a beneficial impact on the other.

The stepwell as an urban artifact needs to be restored to preserve its historical and cultural values. To do this, the existing organisation of the local community needs to be improved. Apart from restoring the stepwell as a space, it is also being revitalized as an existing infrastructure to curb the groundwater crisis in the city. Community-level design strategies are necessary to recharge the aquifers and make water available in the wells for public need. These strategies would not only help with restoring the stepwell and groundwater but also help in creating a resilient and self-sustaining community.

The overall concept for the revitalization of the stepwell is categorized into three important zones or layers. The first is the restoration of the stepwell by proposing activities for the space and making conscious additions to improve accessibility and safety inside the stepwell. The second layer is the rehabilitation of the front plaza. Redeveloping the space and proposing new activities will open the stepwell for the public. The final layer is regeneration. These strategies are proposed at the community level to recharge the aquifers. All three layers demonstrate the interrelationship between each other and function as key tools for the revitalization of the stepwell.

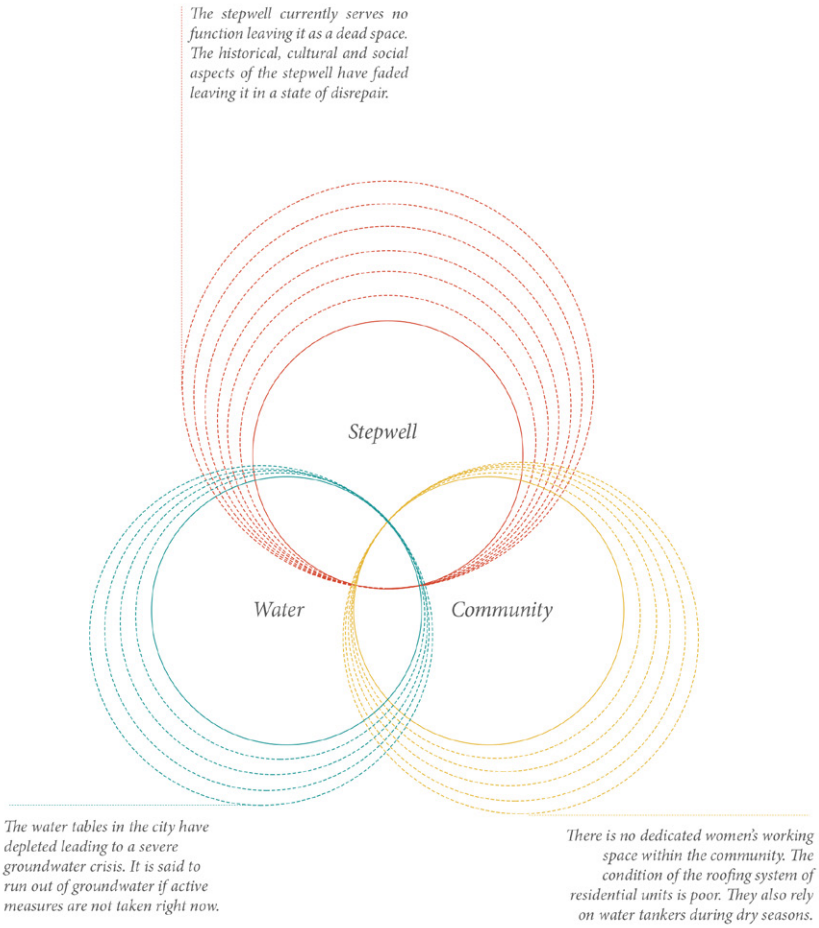
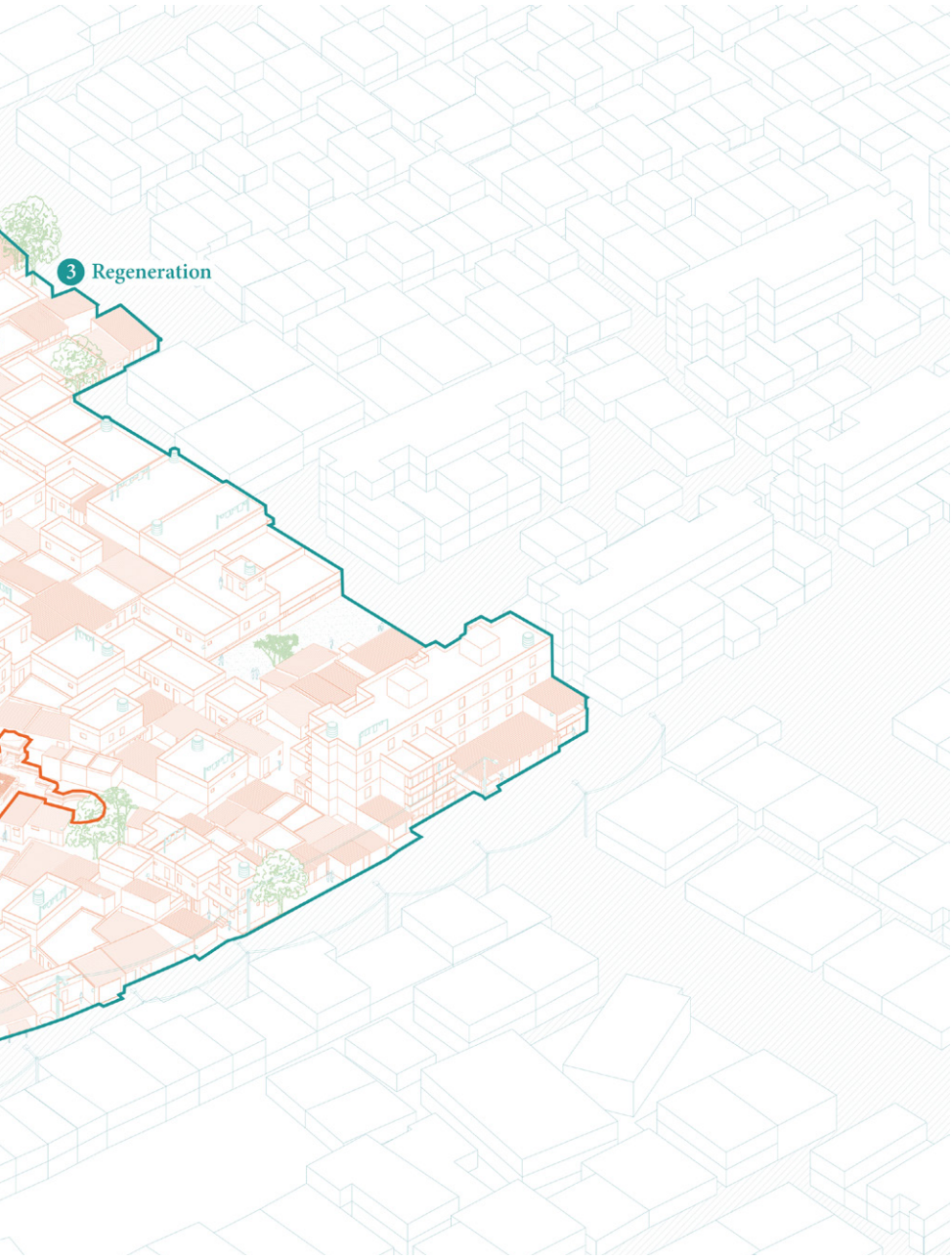


Fig 4.1 - Venn diagram showing the interdependency of stepwell, groundwater and the local community.



Fig 4.2 - Design concept - zoning for design strategies of different scales.


3 Regeneration

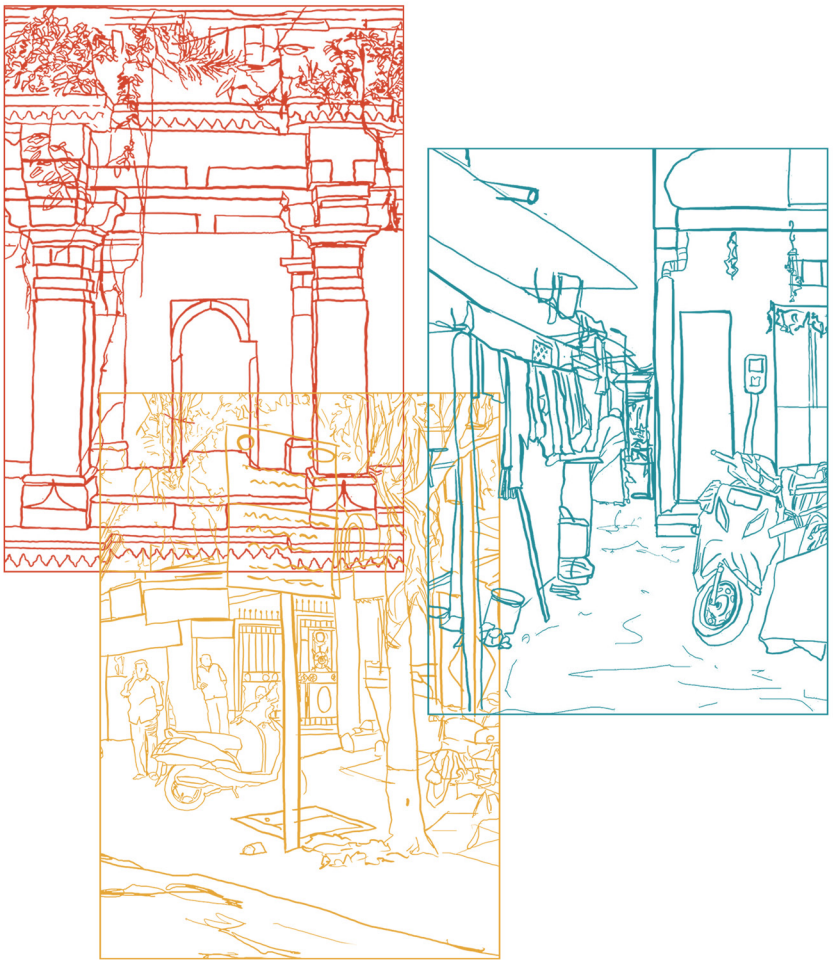


Fig 4.3 - Program Brief

RESTORAT

Programming of th

+ *Textile demonstr*
+ *Women worksho*
+ *Performance spa*
+ *Resting space*
+ *Learning space*
+ *Sculpture gallery*
+ *Temple*
+ *Ritual space*
+ *Storage room*
+ *Elevator*
+ *Railing for safety*
+ *Seating space*

TION

e stepwell

ation zone
p space
ce

REHABILITATION

Reorganisation of the front plaza

+ Gift shop
+ Information center
+ Seating space
+ Restrooms

REGENERATION

Groundwater recharge strategies

+ Roof rainwater harvesting system
+ Recharge pits
+ Permeable pavement
+ Groundwater retaining trees
+ Informal and formal gathering spaces

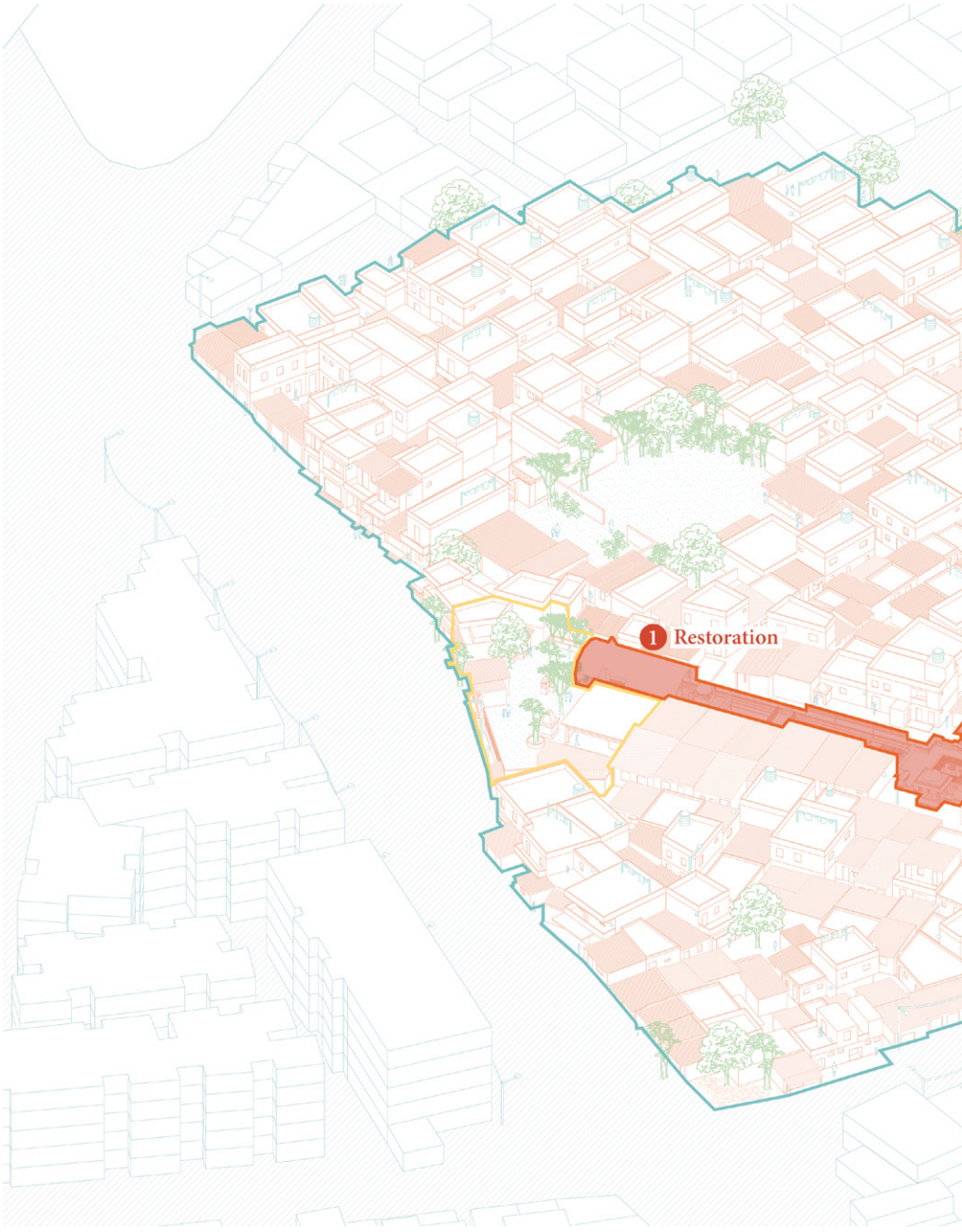
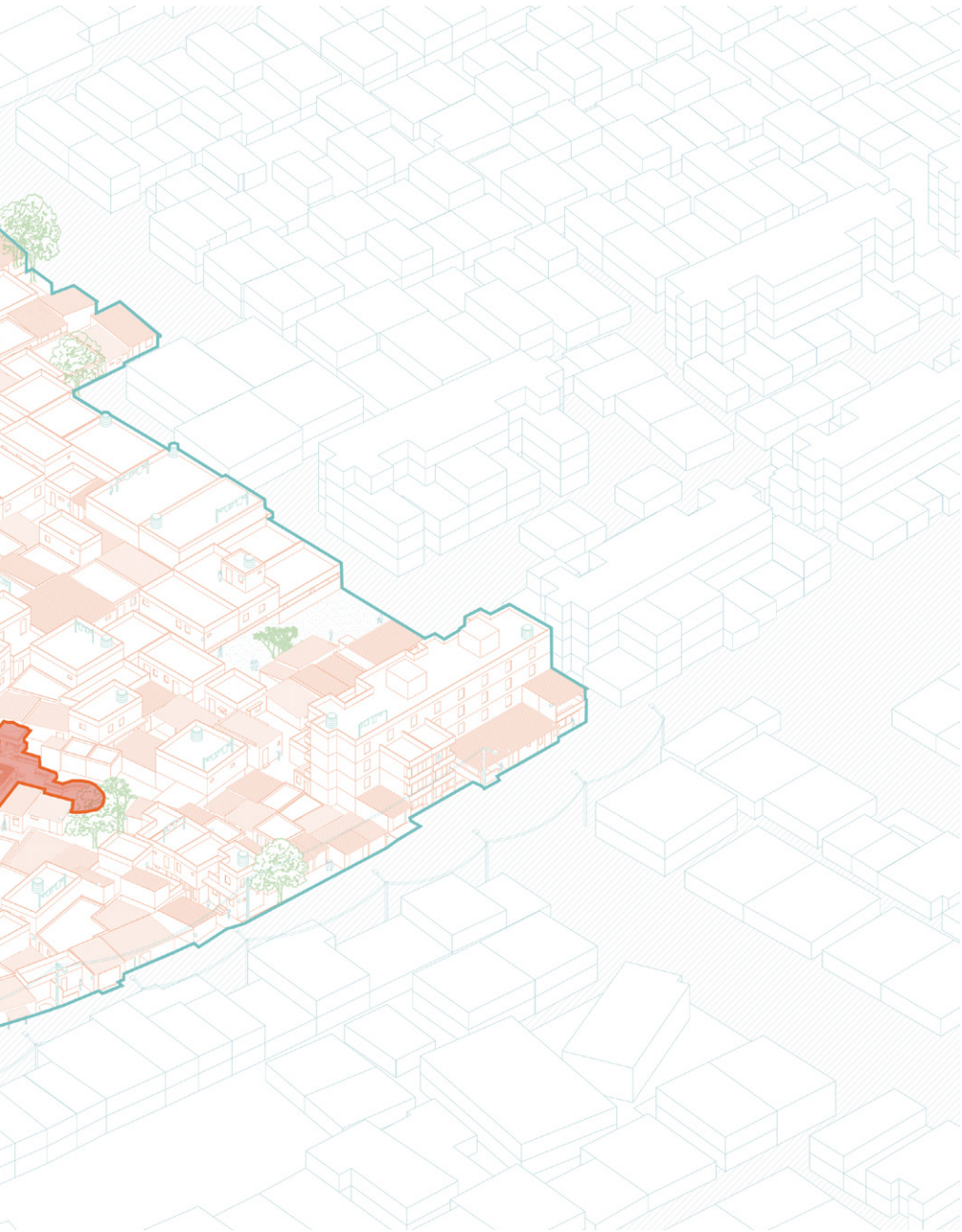


Fig 4.4 - Zone 1 - Restoration



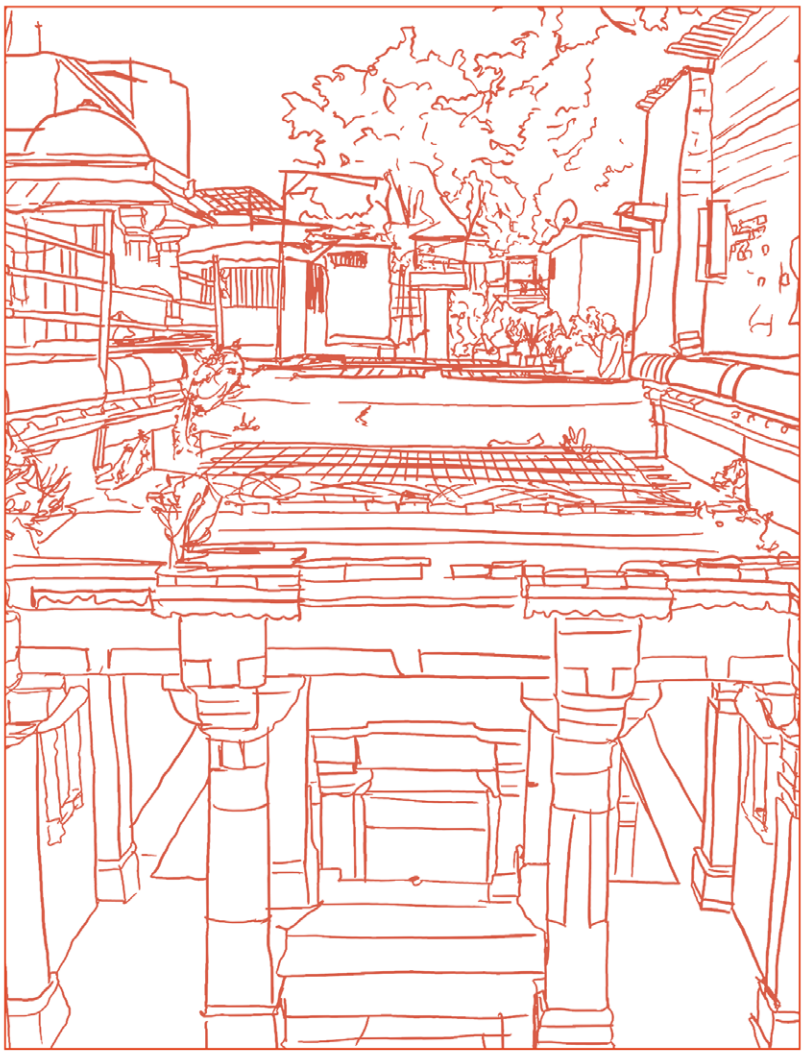


Fig 4.5 - Existing condition of the stepwell.

4.2 - Design Development

As already noted in the earlier research, stepwells were once used as a space for sourcing water, gathering space for women and resting space for travelers. They functioned as crucial icons in building the social life of the communities. Restoring these functions to fit the needs of the current urban context is important for regaining the social value of the stepwell.

Within the stepwell, the programming of activities is organized to cater to the needs of the local community and the public. The first level is dedicated to women from the local community. This level has a textile demonstration zone in the front and a workshop space in the back. Since the women in the neighbourhood lack a communal gathering space, this level is dedicated to them. This way the historical role of stepwells as a space for women is revived. This space intends to promote women's empowerment by creating a learning environment and promoting incoming generation opportunities for women in the community.

The second level is a flexible space with a performance zone in the front and a learning and leisure space in the back. It promotes flexible movement with fixed seating around the central well to blend in with the architecture.

The third level is designated for a sculpture display gallery to promote the ancient artefacts. This zone is proposed to have rolling displays with displays changing seasonally.

The Ashapura Mata temple from the first level is moved to the bottom level to create a dedicated worship space. Inspired by the movement inside a Hindu temple, the journey to the bottom level intends to create a similar experience. Moving the temple to the bottom level would bring it closer to water.

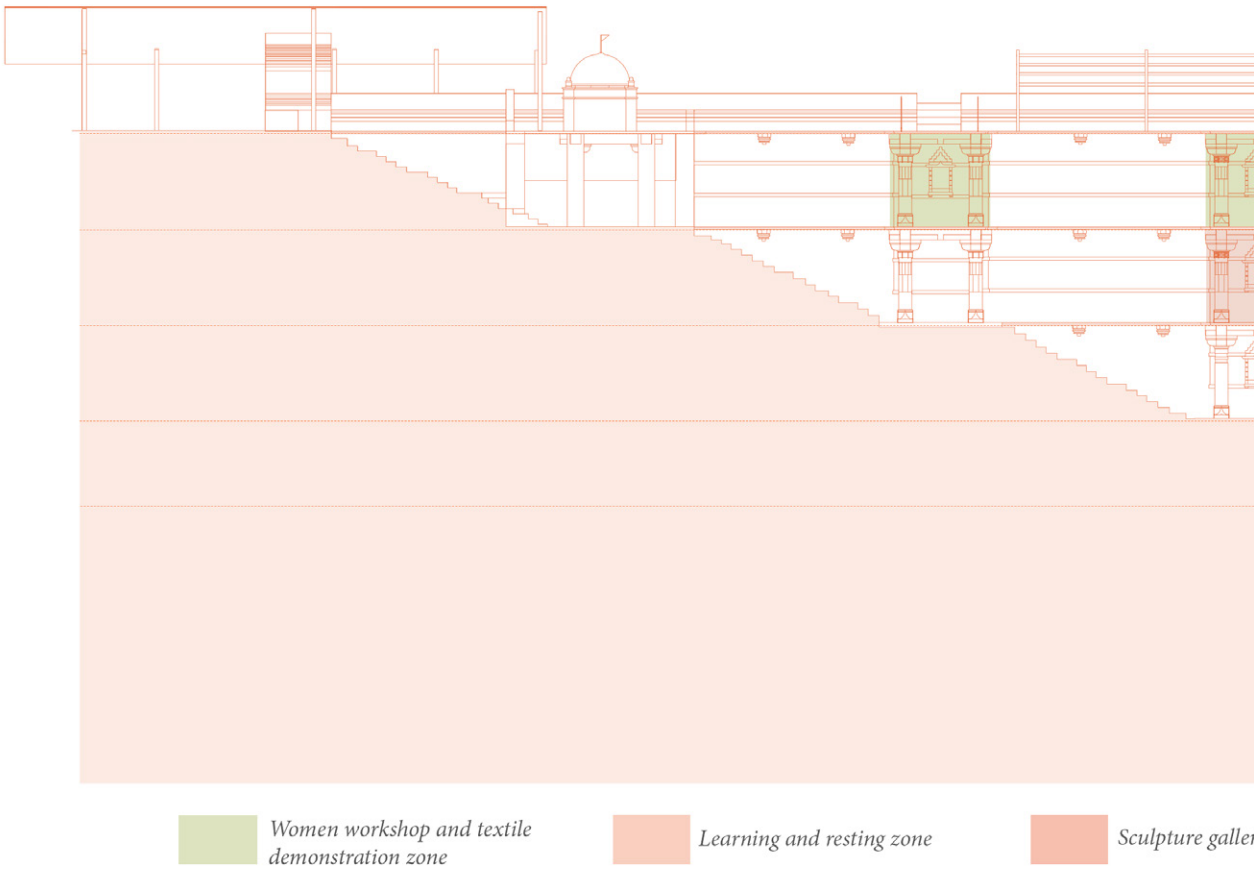


Fig 4.6 - Internal programming for the stepwell.



y *Ritual space and temple* *Backend storage*

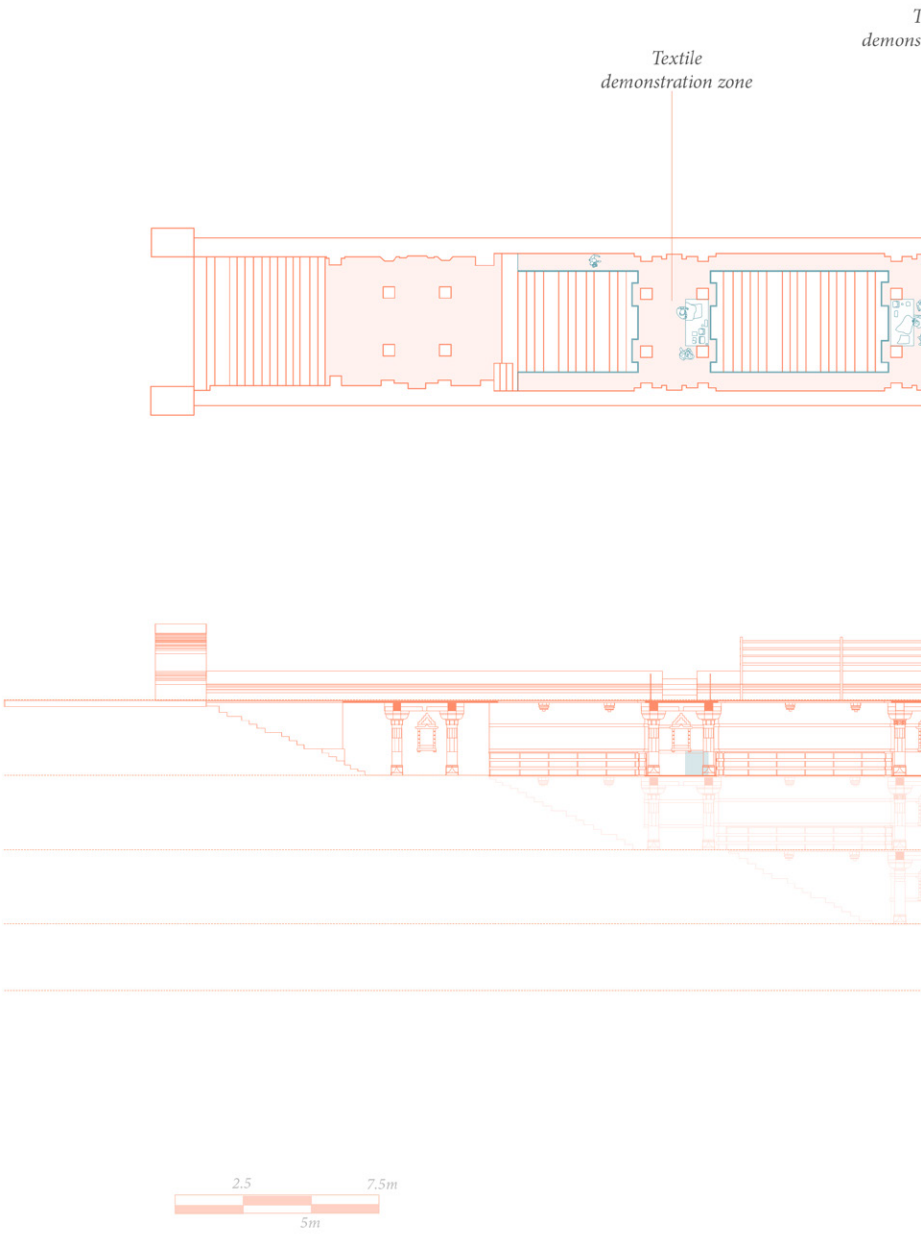
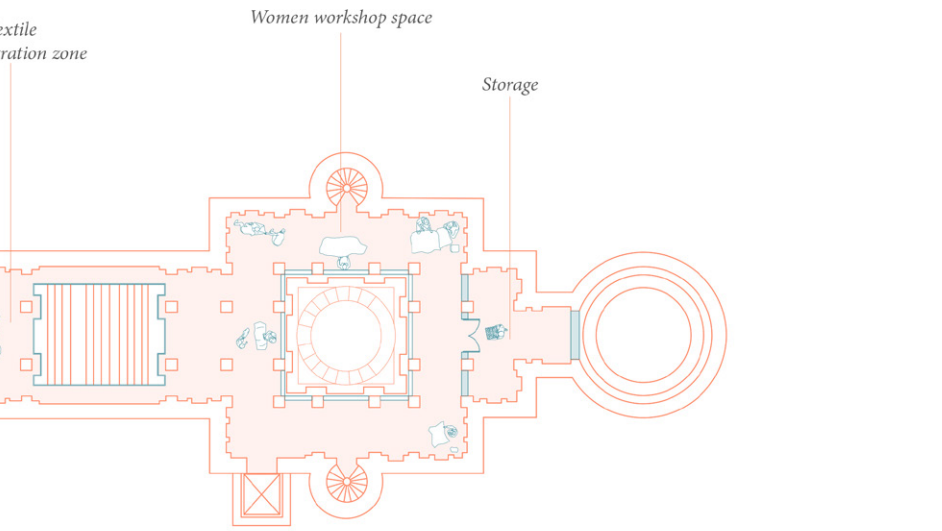
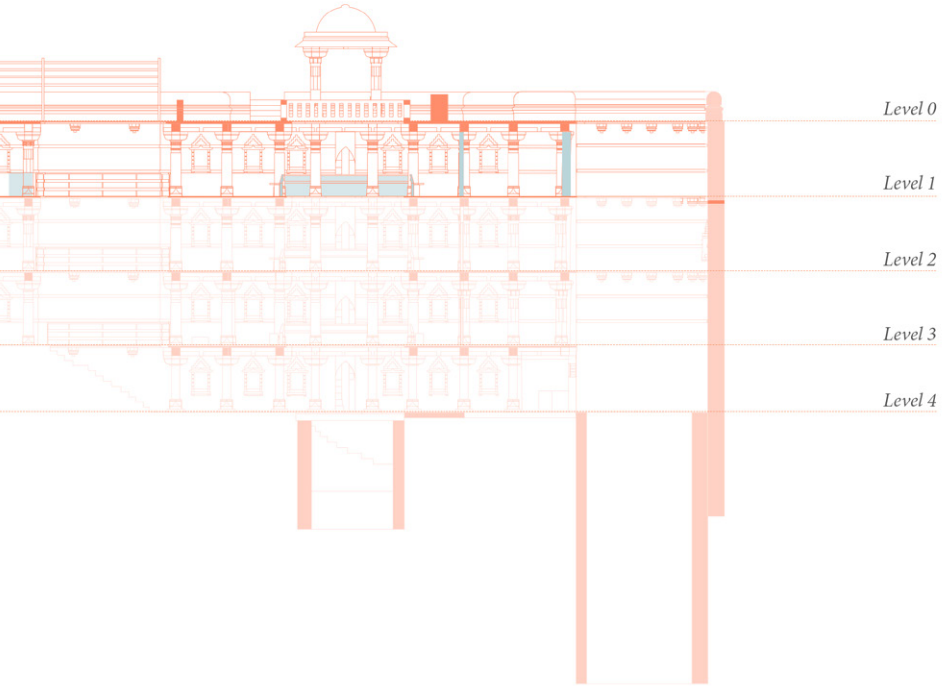


Fig 4.7 - Level 1 - Women workshop zone.


extile
ration zone
Women workshop space
Storage


Level 0
Level 1
Level 2
Level 3
Level 4

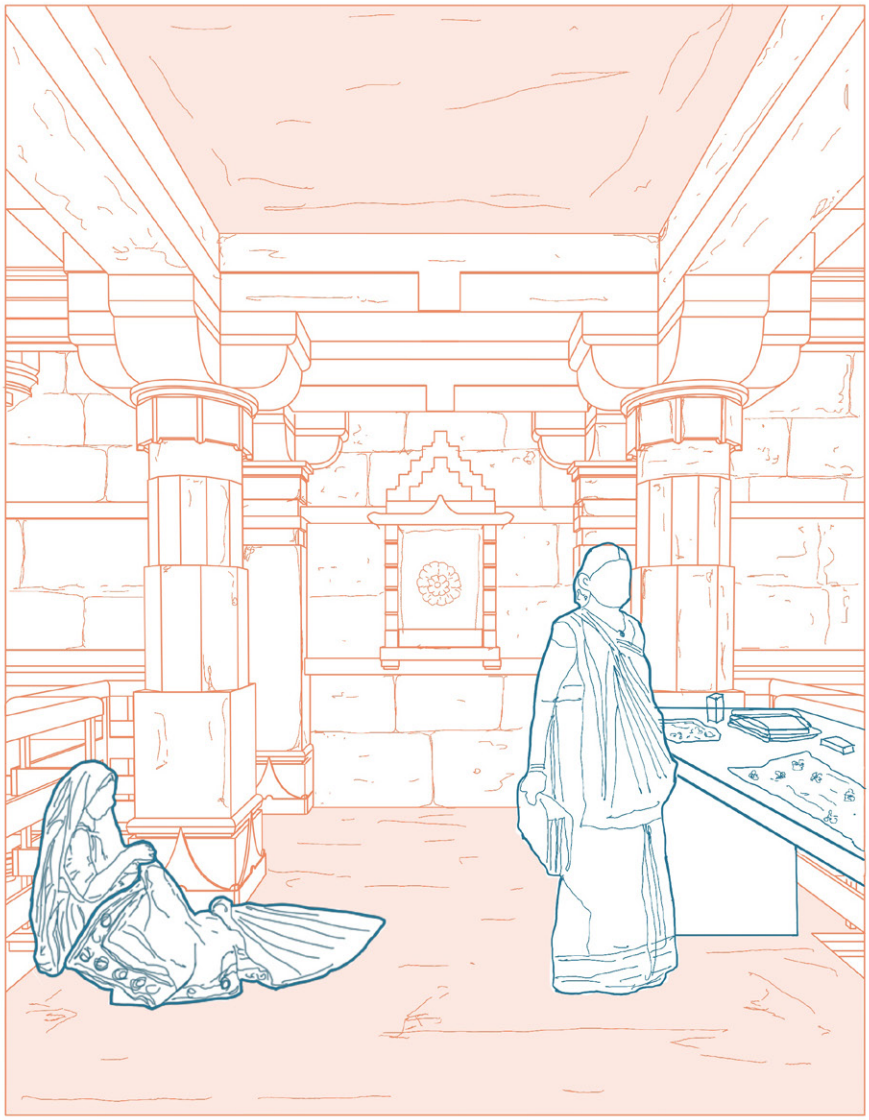


Fig 4.8 - View of textile demonstration zone.

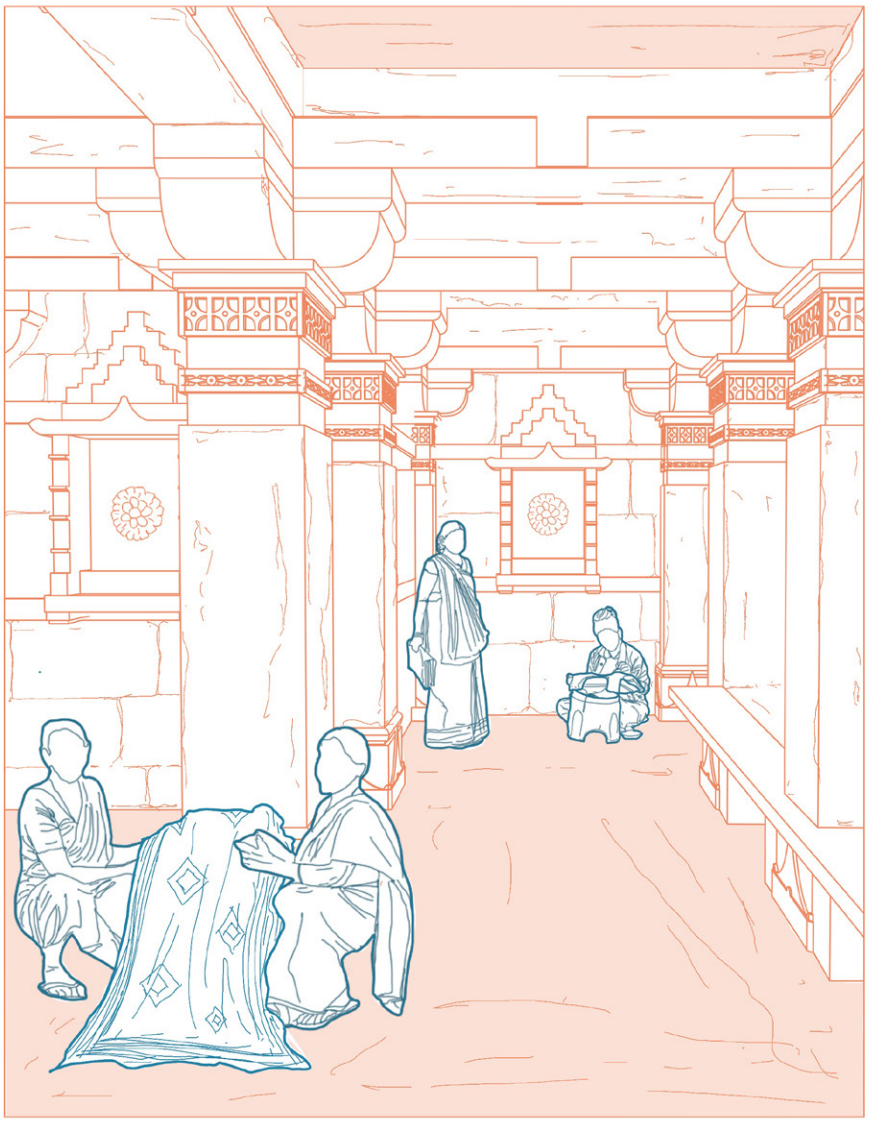


Fig 4.9 - View of women workshop space.

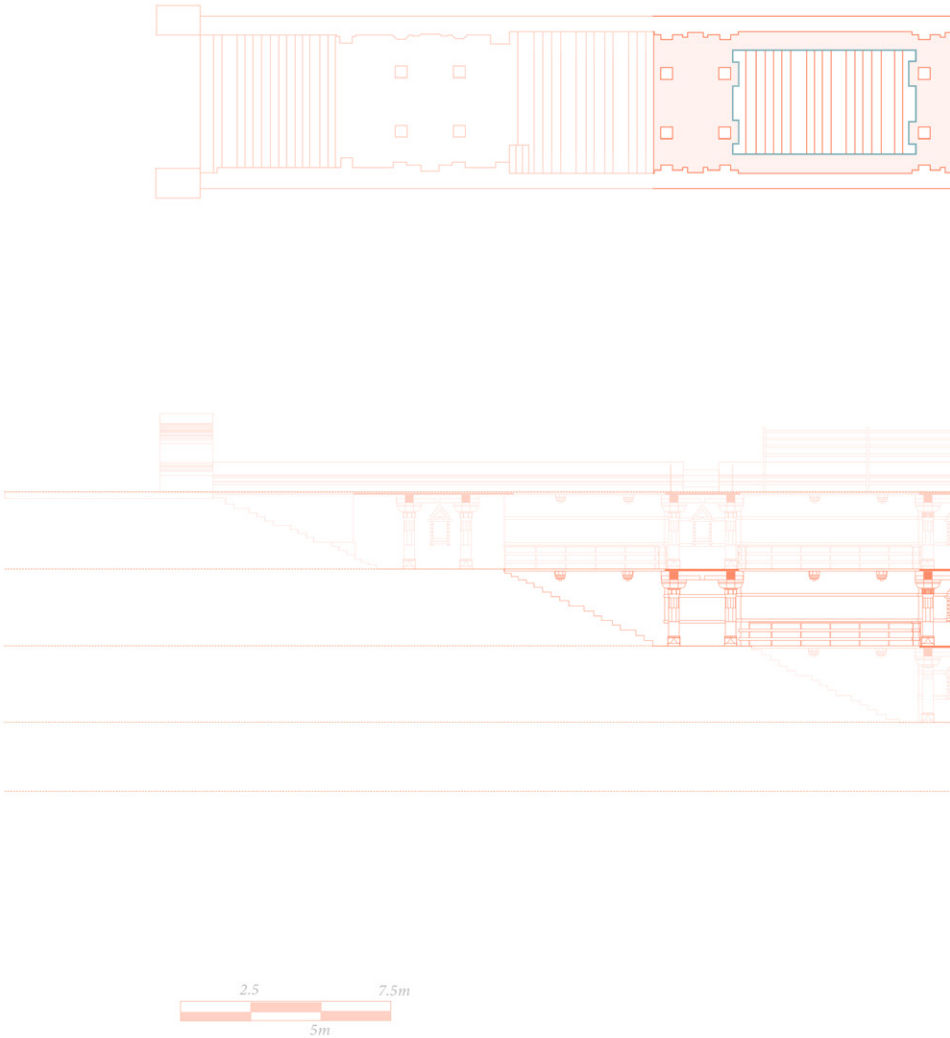
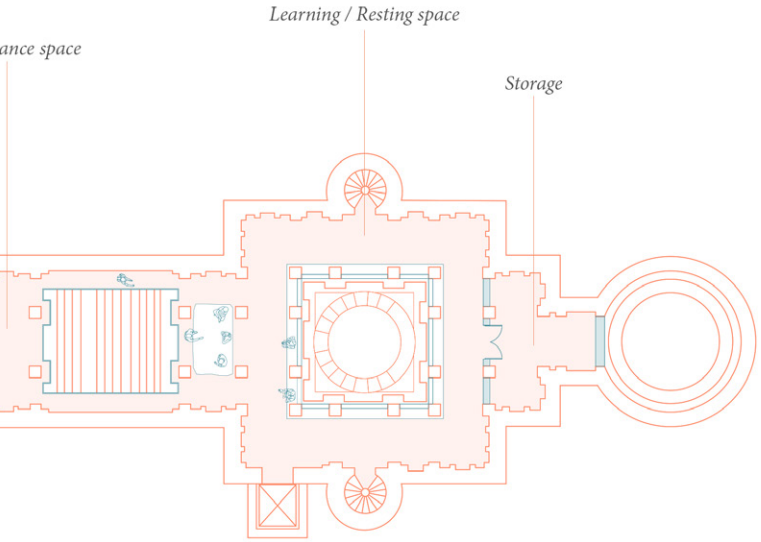
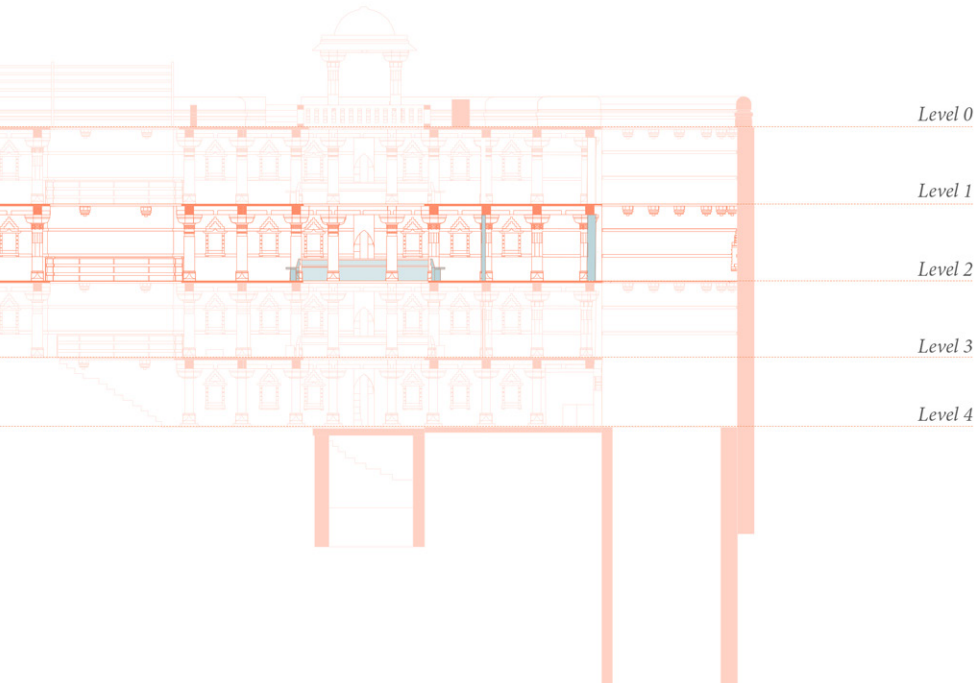


Fig 4.10 - Level 2 - Performance space designated for the front kuta with learning and resting space on the back.


ance space
Learning / Resting space
Storage


Level 0
Level 1
Level 2
Level 3
Level 4

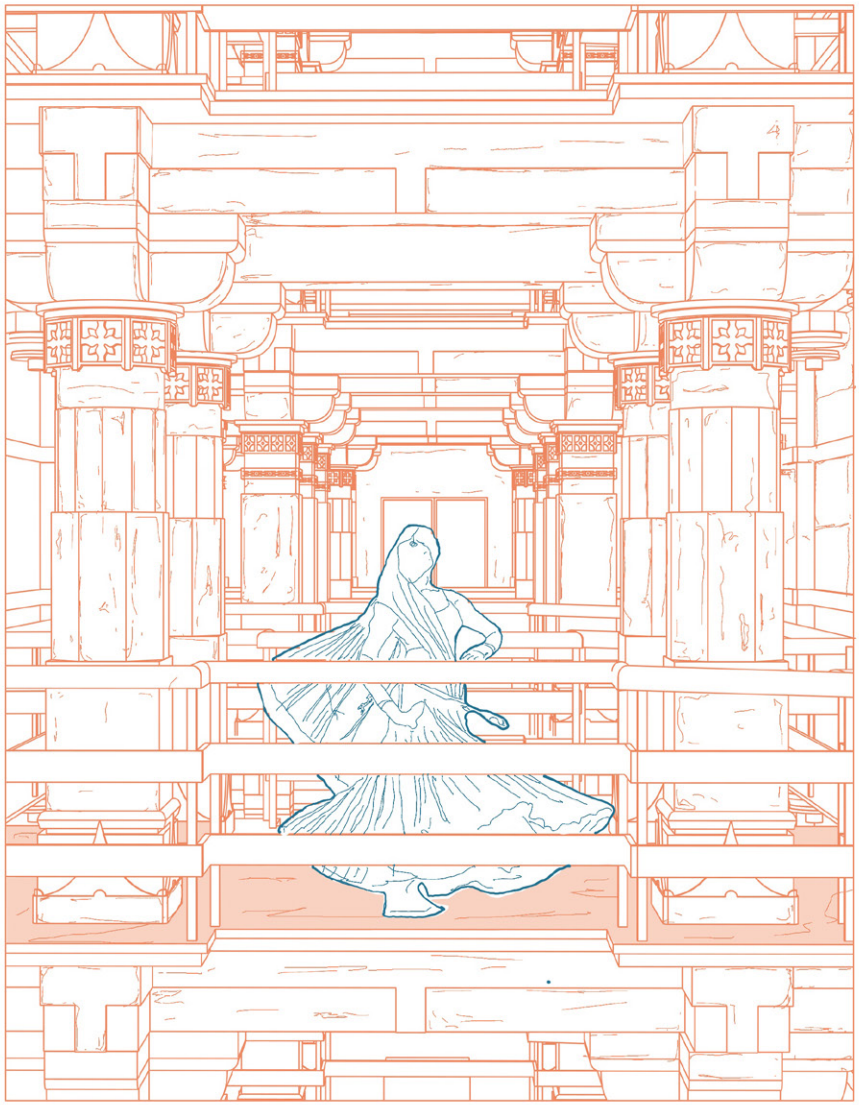


Fig 4.11 - View of performance space on the front kuta.

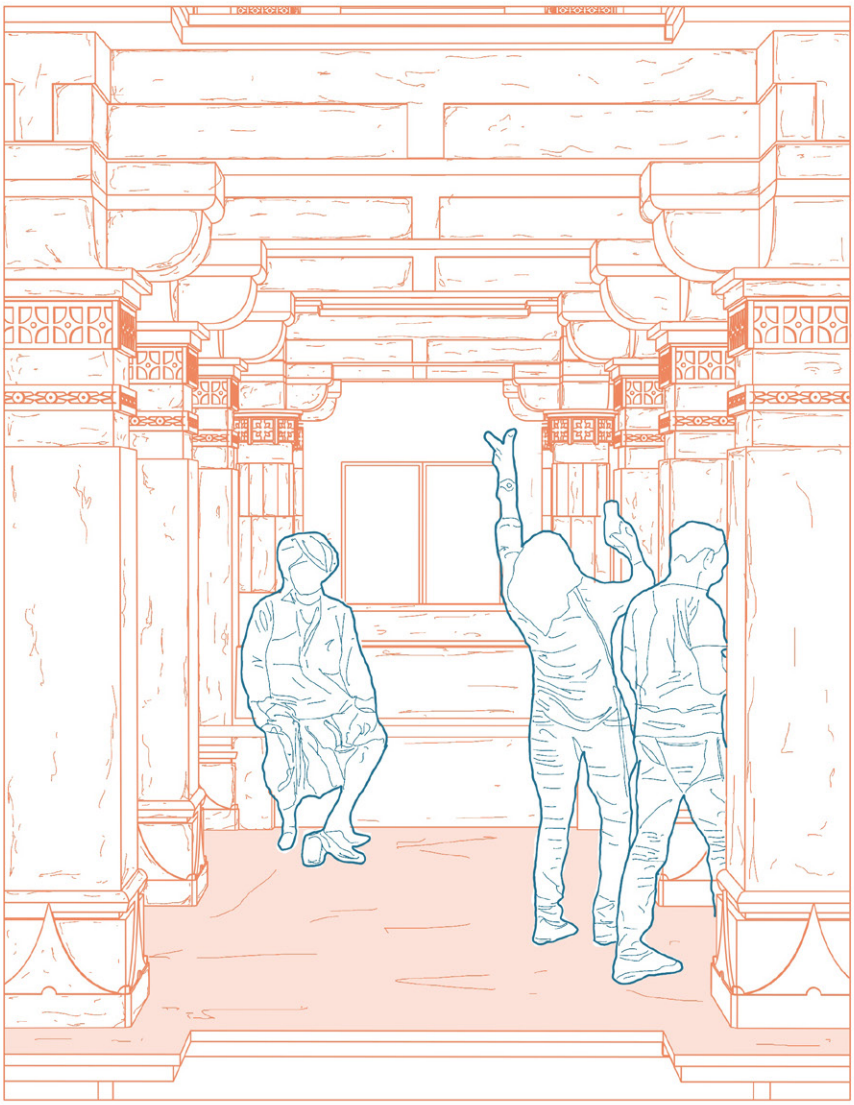


Fig 4.12 - View of resting space on the back.

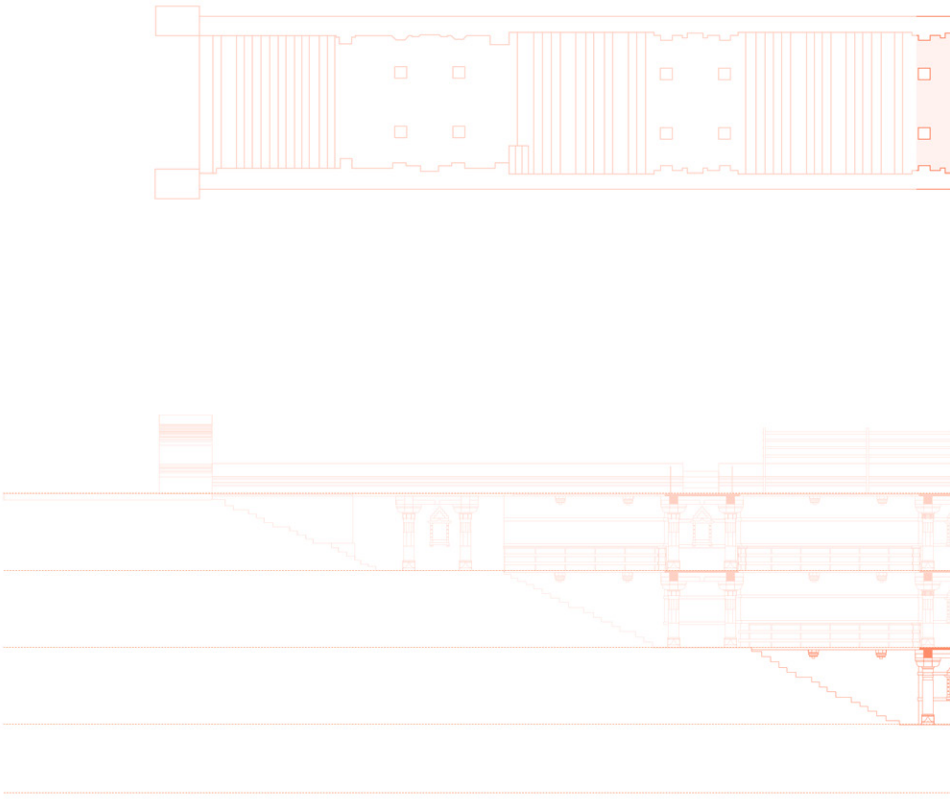
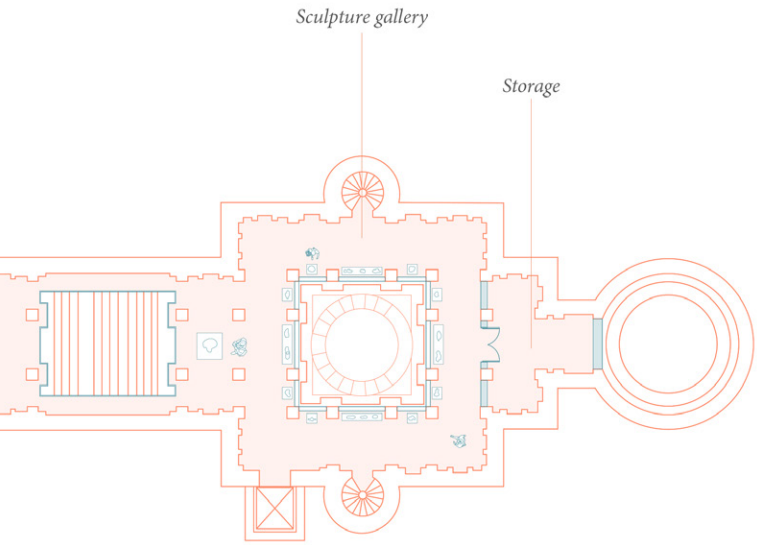
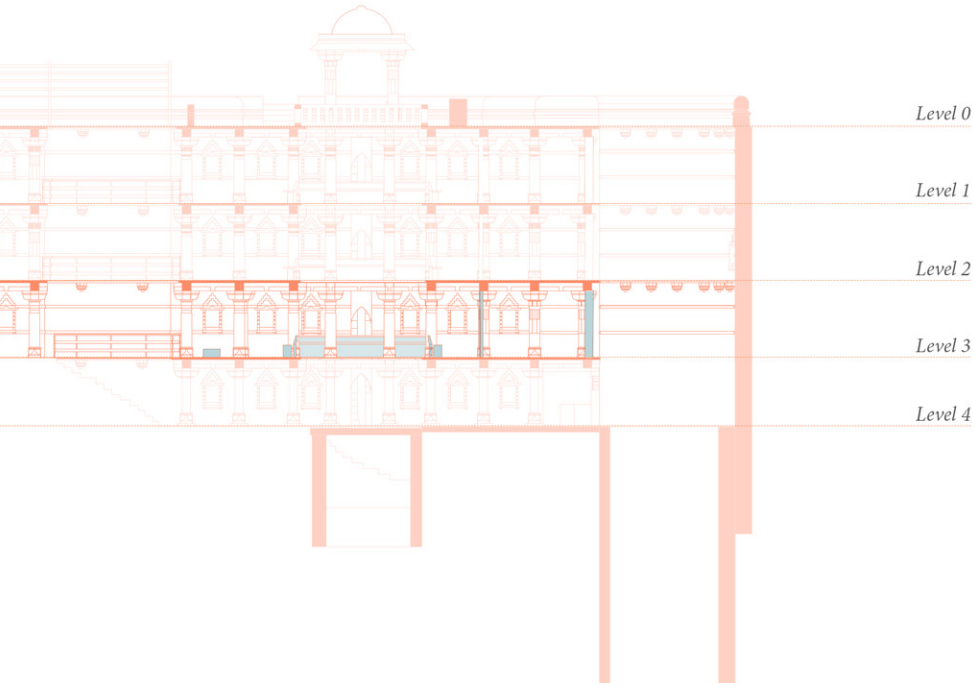


Fig 4.13 - Level 3 - dedicated for sculpture gallery.


Sculpture gallery
Storage


Level 0
Level 1
Level 2
Level 3
Level 4

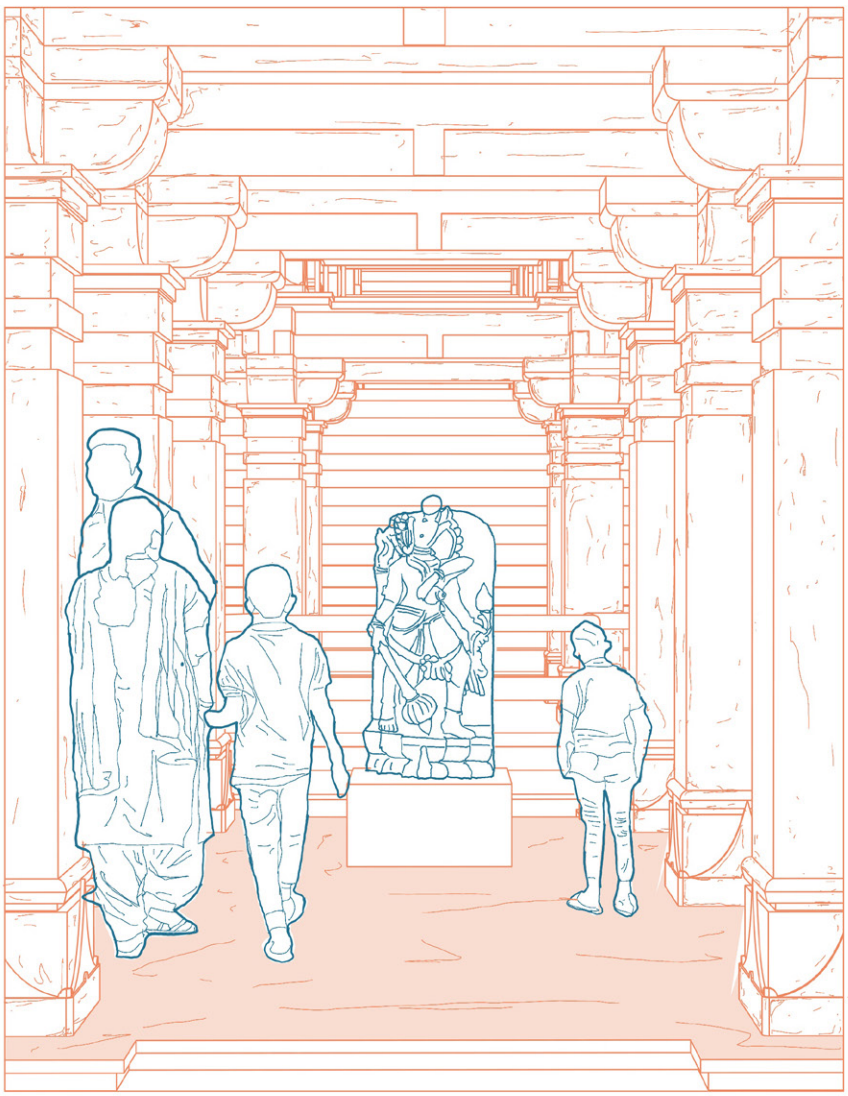


Fig 4.14 - View of the sculpture gallery.

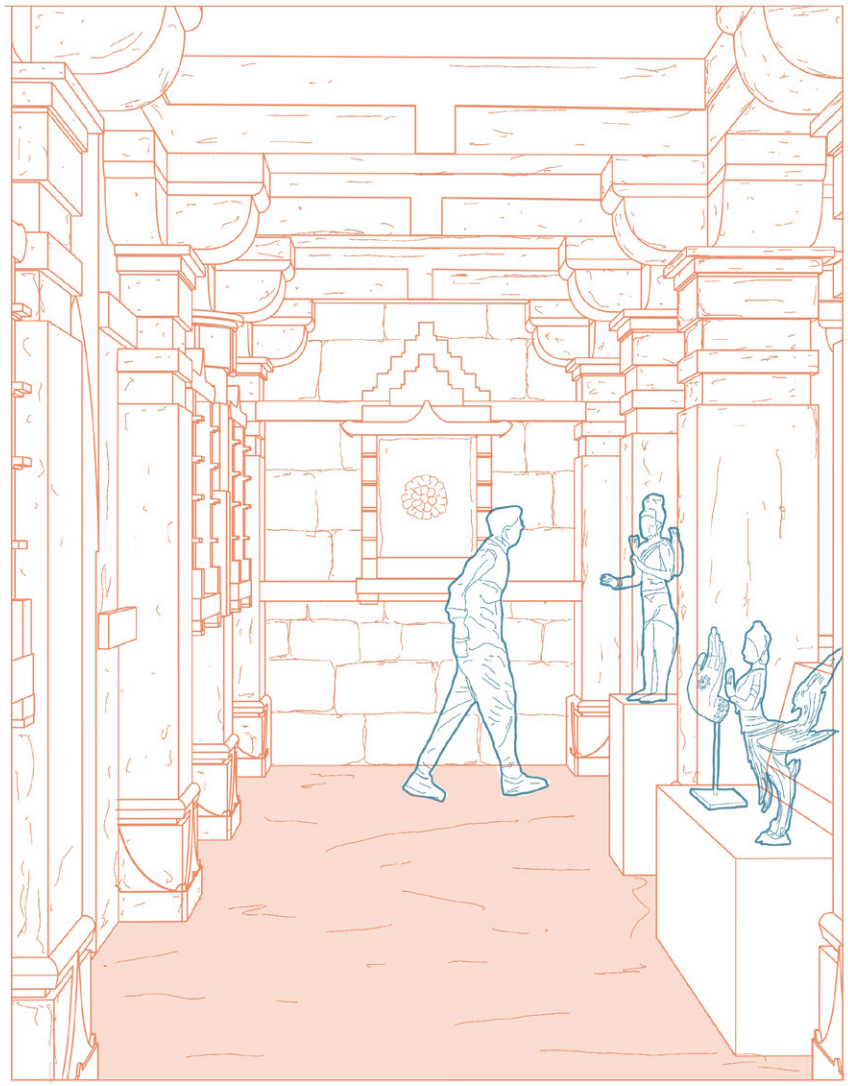
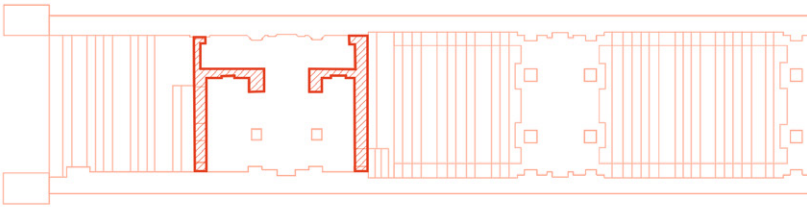


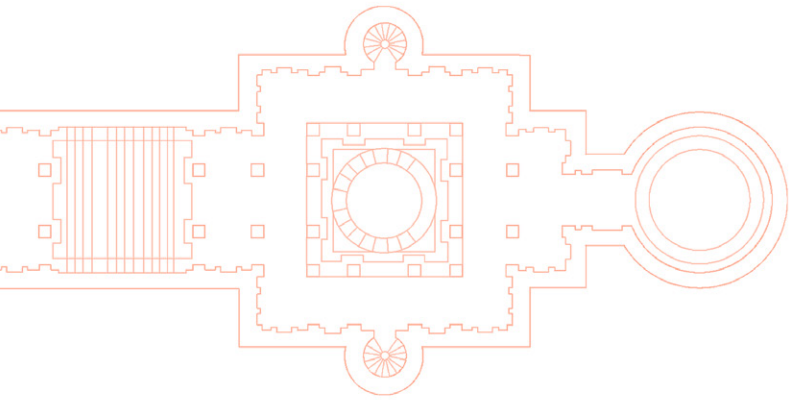
Fig 4.15 - View of the sculpture gallery.

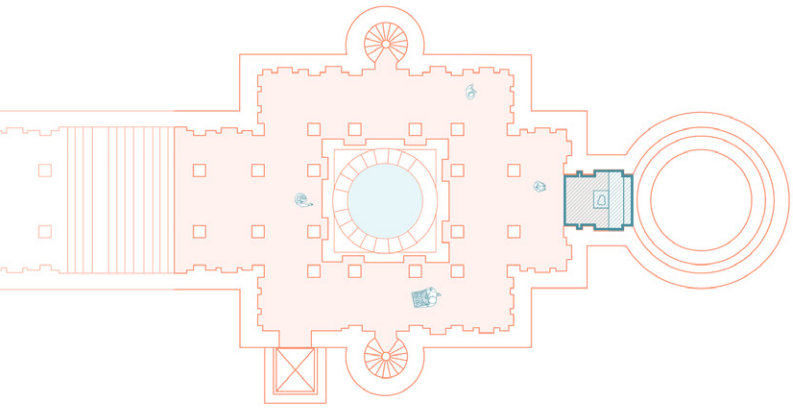
Existing plan (level 1)

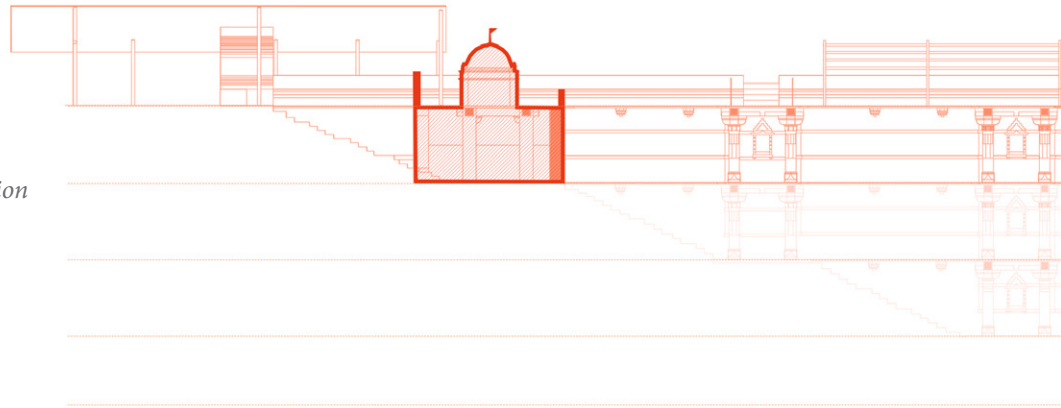


Proposed plan (level 4)

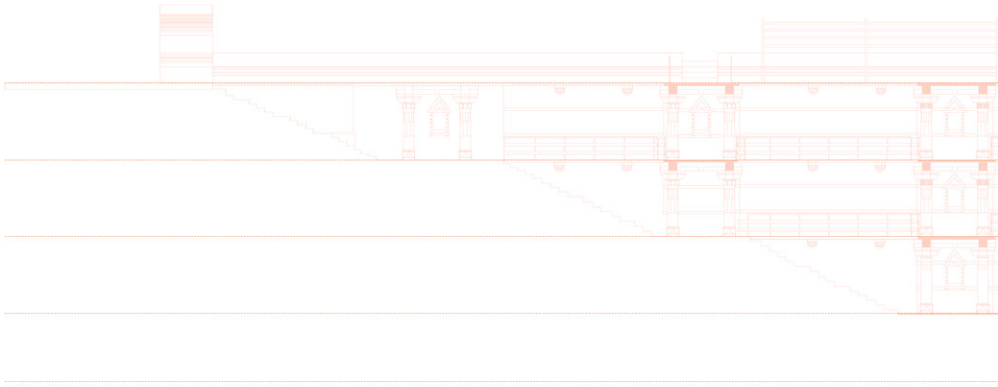
Fig 4.16 - The temple from level 1 (top plan) has been moved to level 4 (bottom plan) to bring it closer to water create a dedicated ritual space.







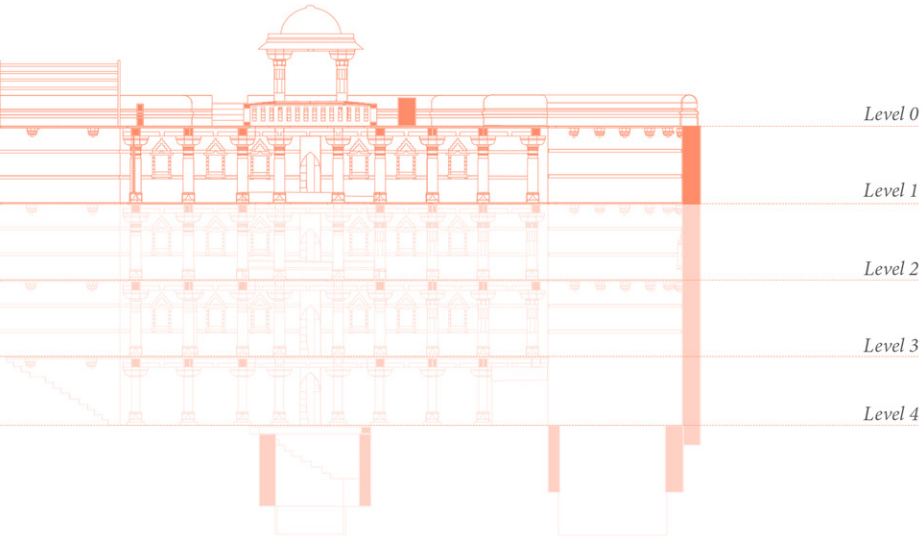
Existing section

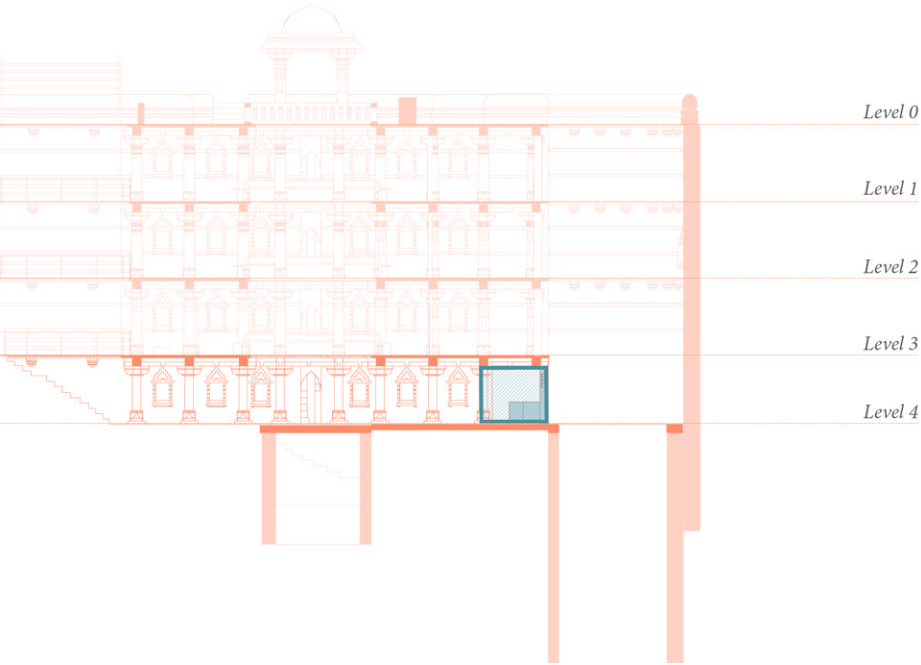


Proposed section



Fig 4.17 - The temple from level 1 (top plan) has been moved to level 4 (bottom plan) to bring it closer to water create a dedicated ritual space.


Level 0
Level 1
Level 2
Level 3
Level 4


Level 0
Level 1
Level 2
Level 3
Level 4

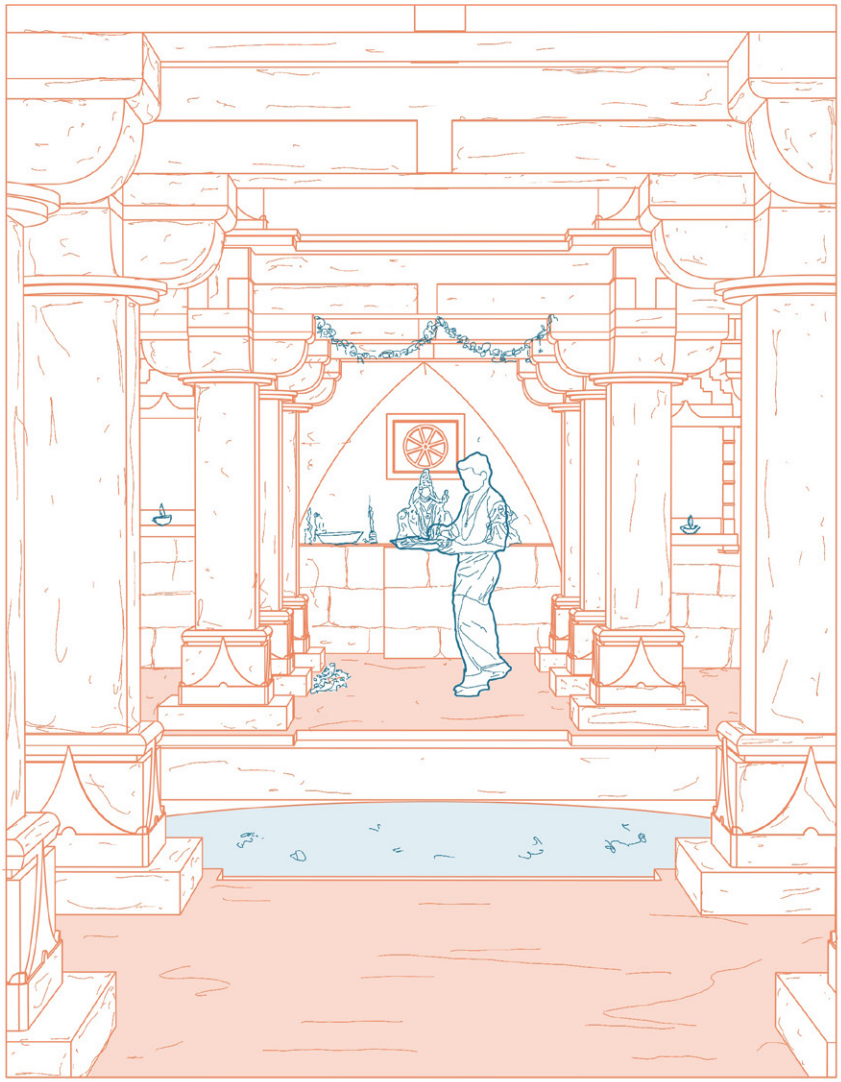


Fig 4.18 - View of the temple.

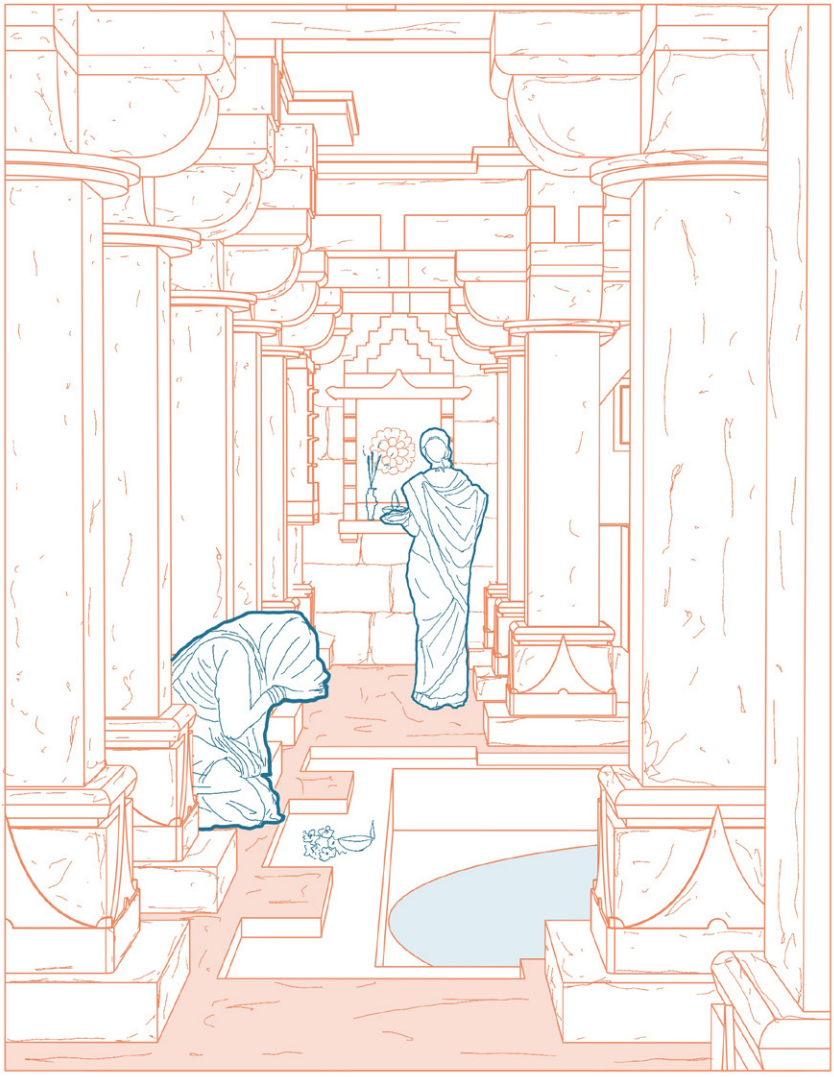


Fig 4.19 - View of women performing rituals to water and local deity, Ashapura Mata.

Apart from providing activities inside the stepwell, small-scale additions are proposed to improve accessibility and safety. These interventions are minimal and subtle to ensure that they do not take away the essence of the space.

The only way to access the levels of the stepwell is by walking on the ledge along the main walls. Since the width of this ledge is minimal making it hard for people to walk, a metal base plate along with a railing is added to improve accessibility. Apart from this, fixed seating and storage rooms are provided on the top three levels to support the functioning of the stepwell. A lift is provided on the backend to ensure all users can access the space.

Cleaning up and increasing the depth of the primary well will enhance the reachability of water from current aquifers. The water source in the well is connected to a submerged filtration tank which filters the water and makes it available for community use. The filtered water source point is provided inside a water temple. The water temple is placed on the other end of the stepwell to create a dedicated space for water. The design for the structure intends to highlight the structure in the urban context.

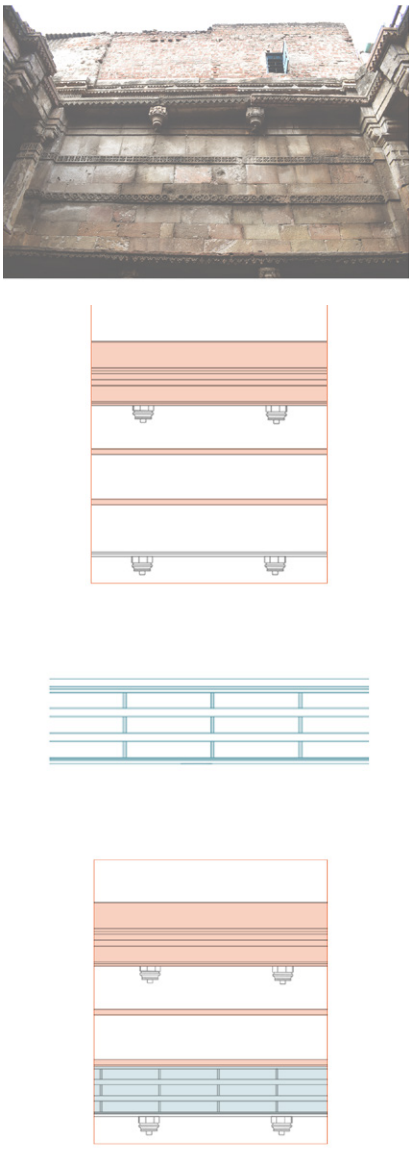


Fig 4.20 - Design of metal railing based on the existing wall details inside the stepwell.

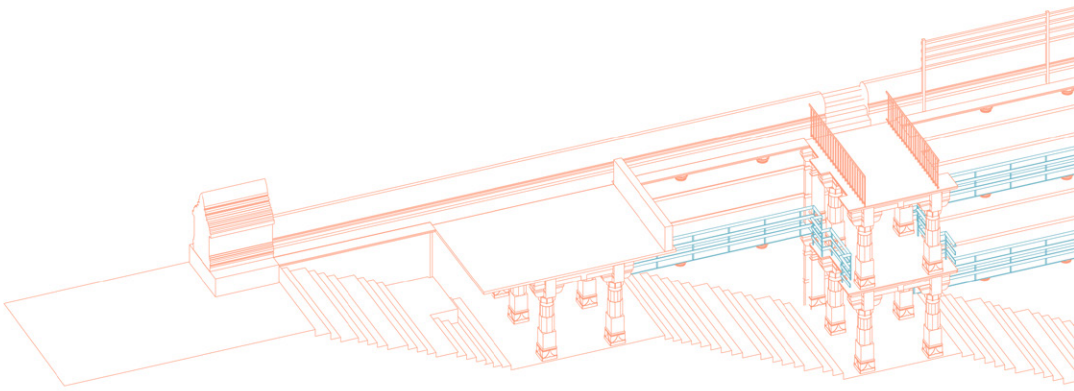
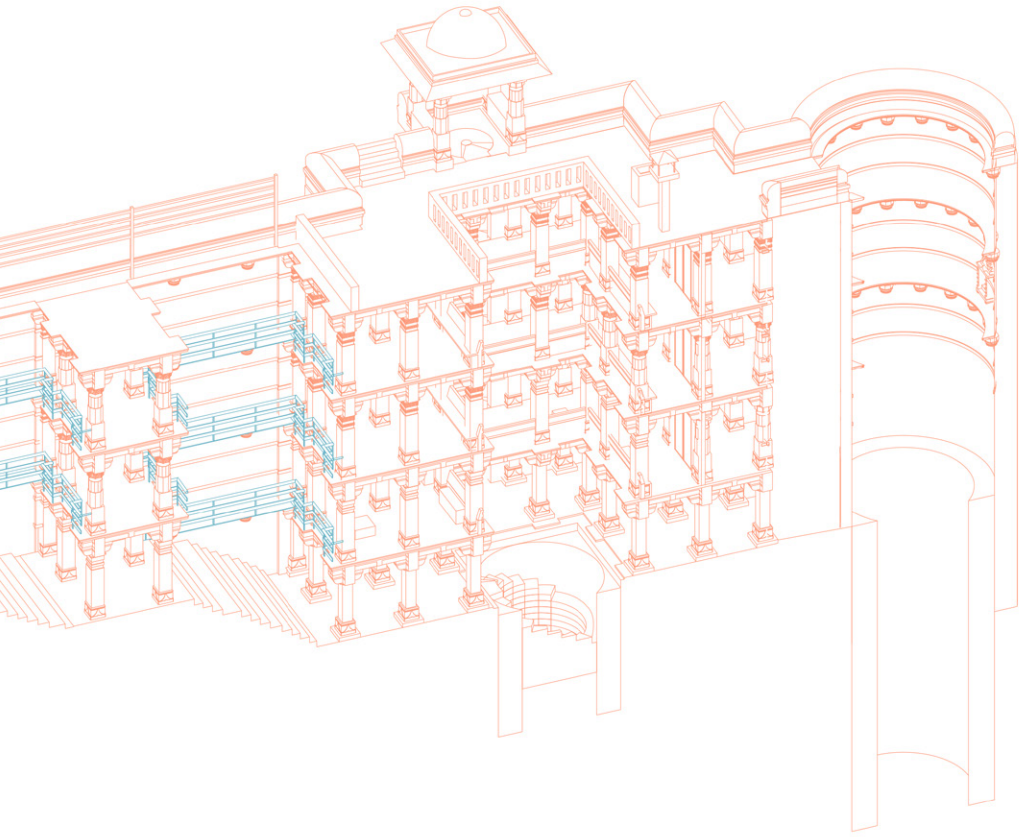


Fig 4.21 - Proposed railing locations inside the stepwell to improve accessibility and safety.



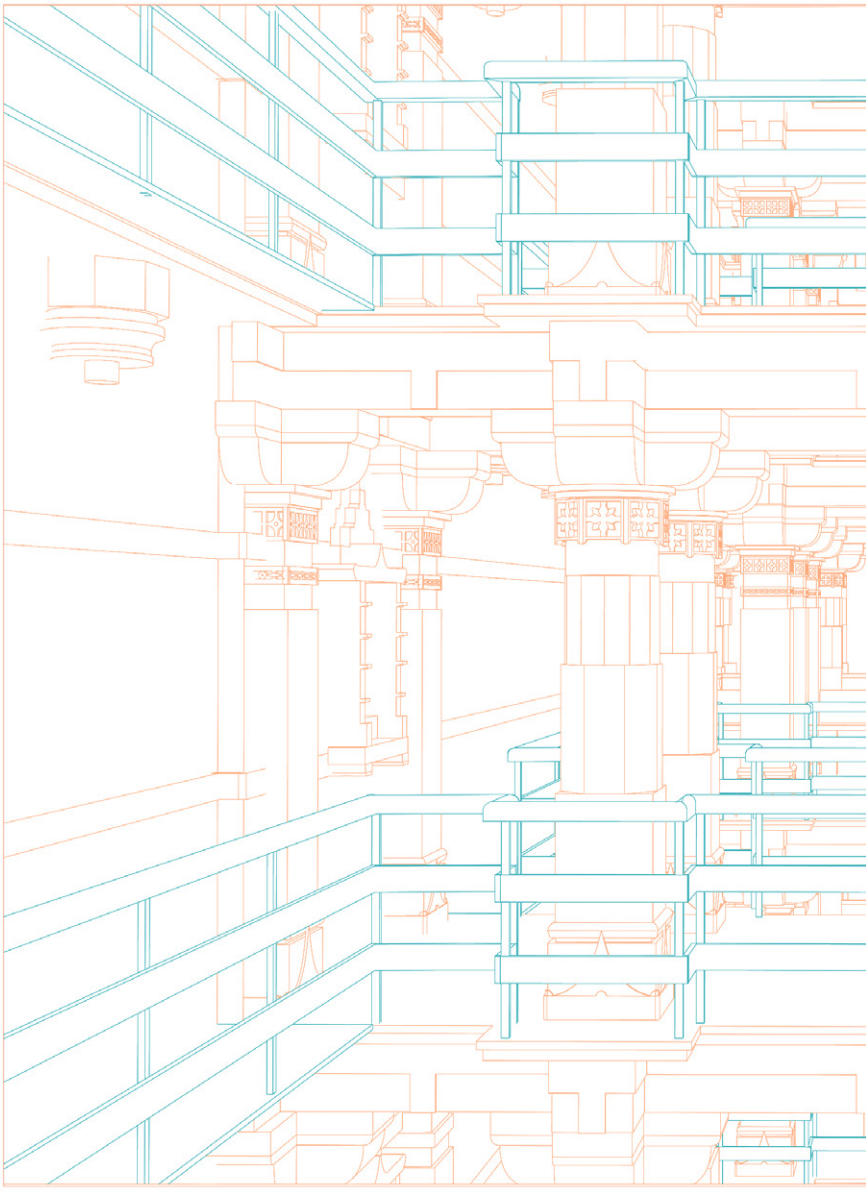
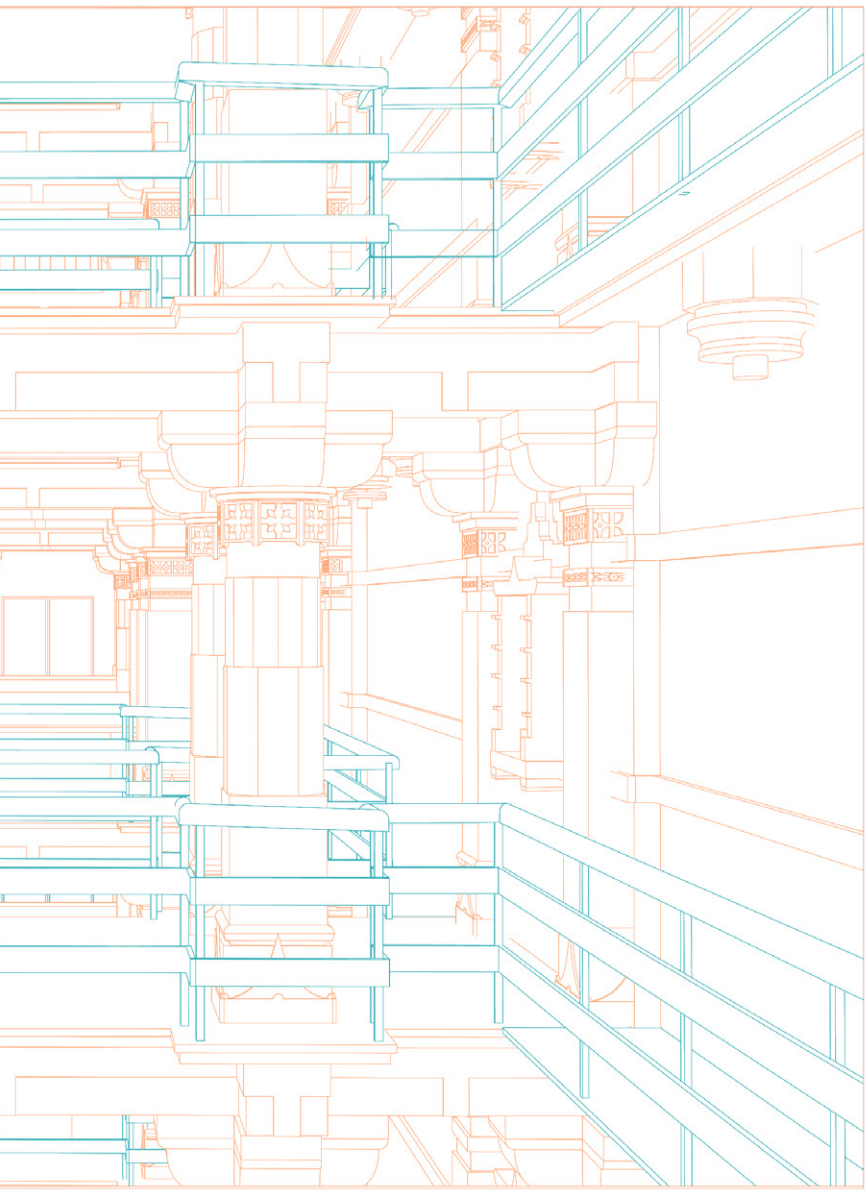


Fig 4.22 - View highlighting the proposed railing.



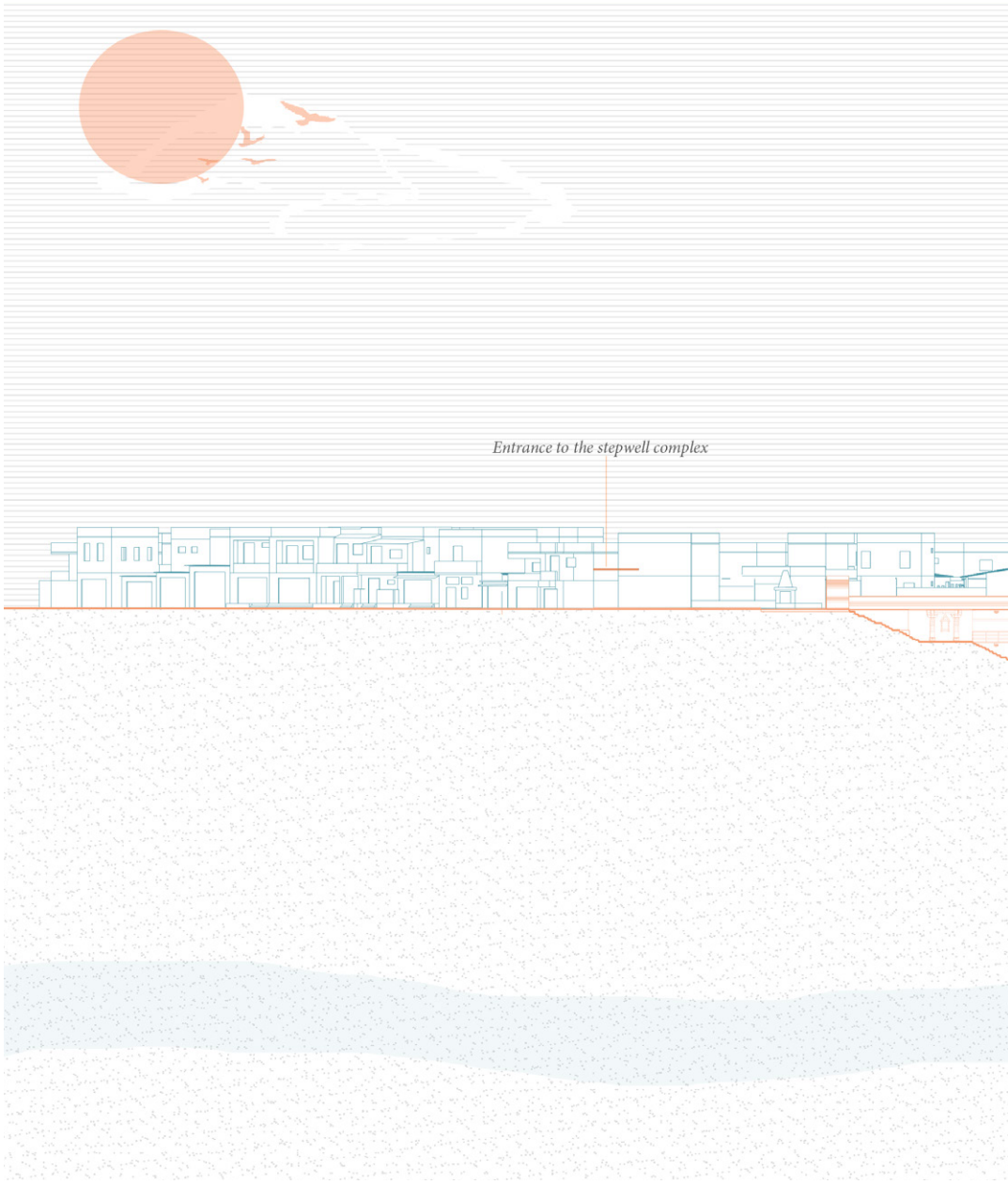
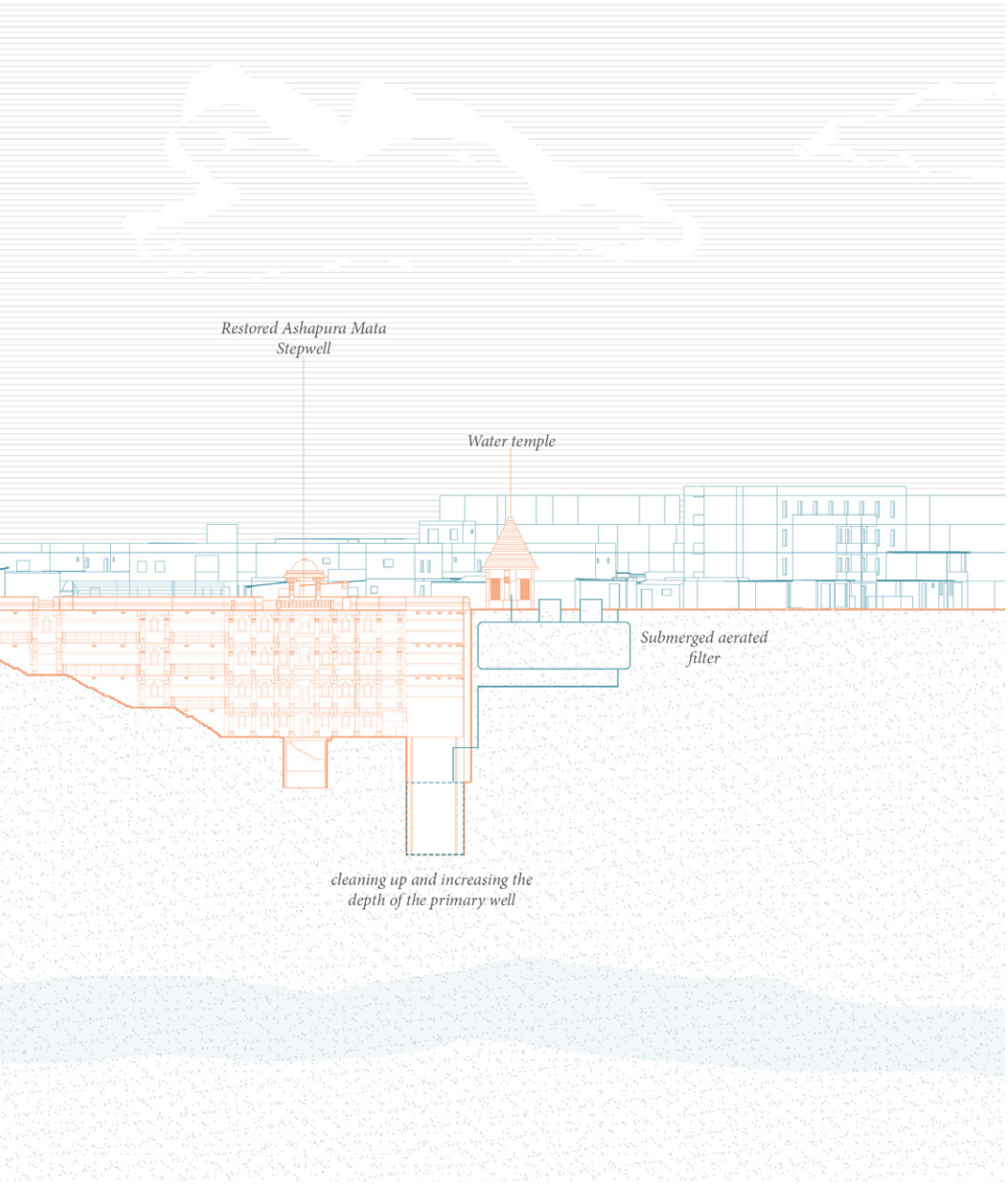


Fig 4.23 - Section showing the increased depth of the primary well and submerged aerated filtration system.


Restored Ashapura Mata
Stepwell
Water temple
Submerged aerated
filter
cleaning up and increasing the
depth of the primary well

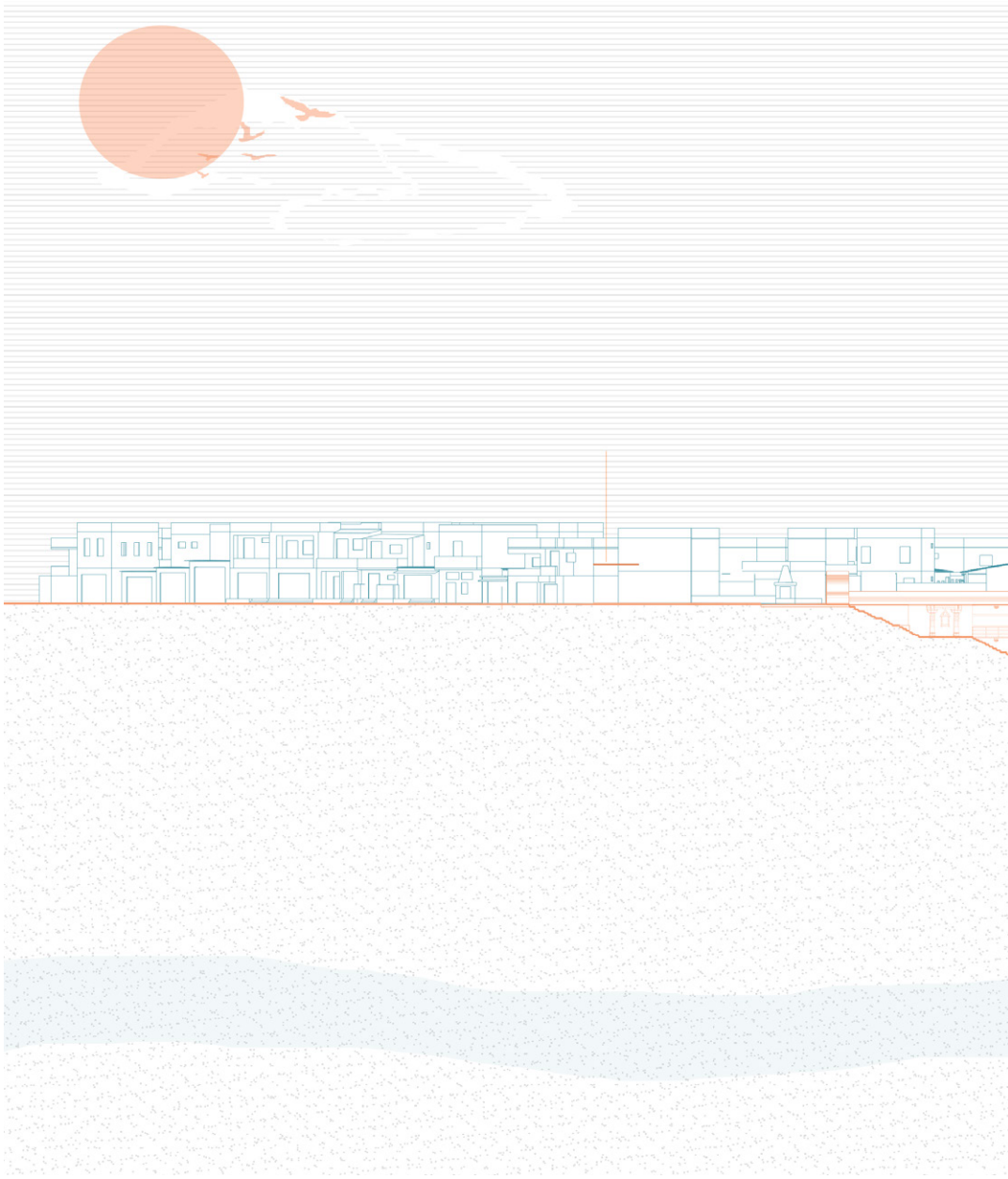
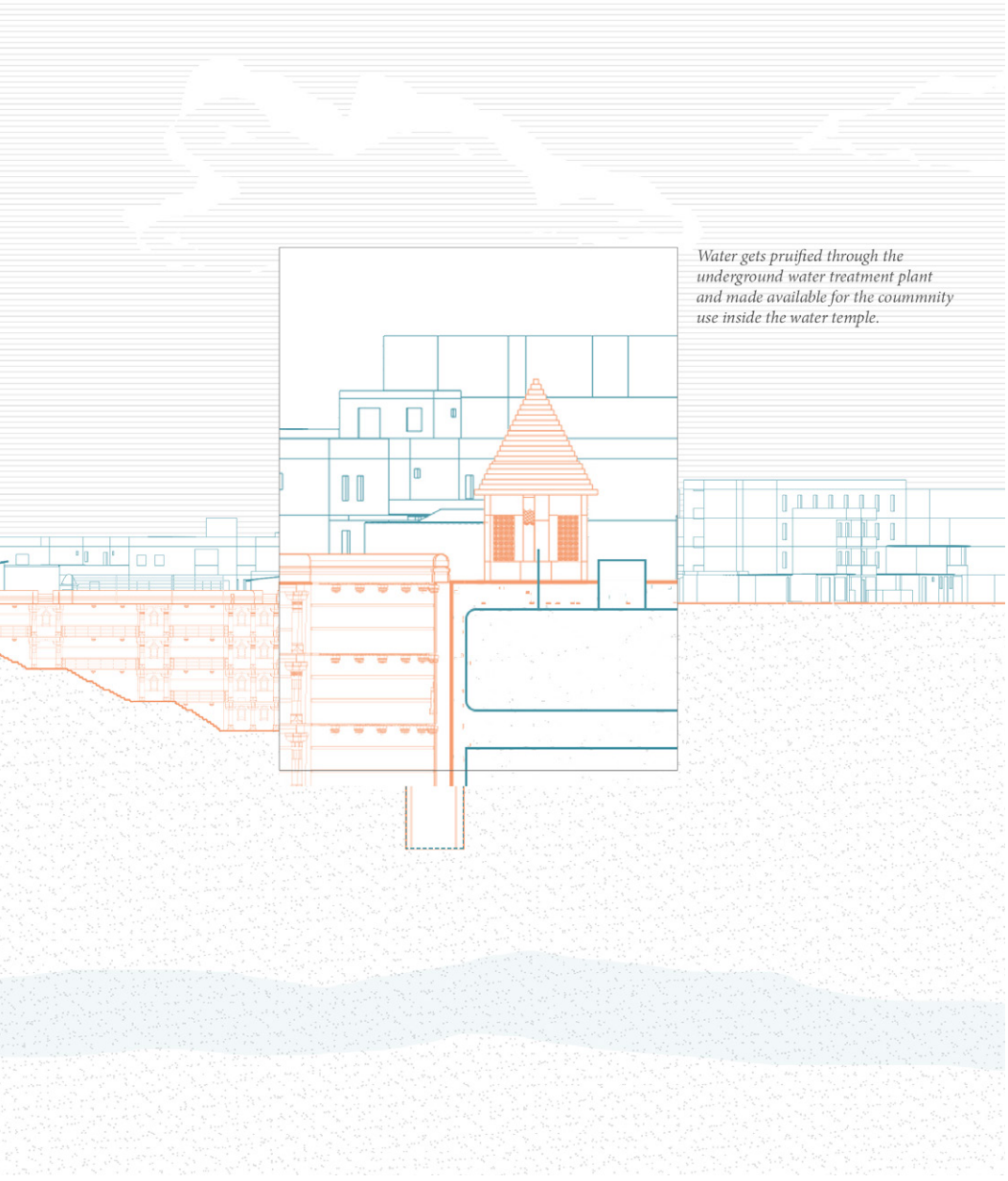


Fig 4.24 - Section highlighting the water temple. The water from the stepwell is filtered and made available for the community inside the water temple.



Water gets pruified through the underground water treatment plant and made available for the coummnity use inside the water temple.

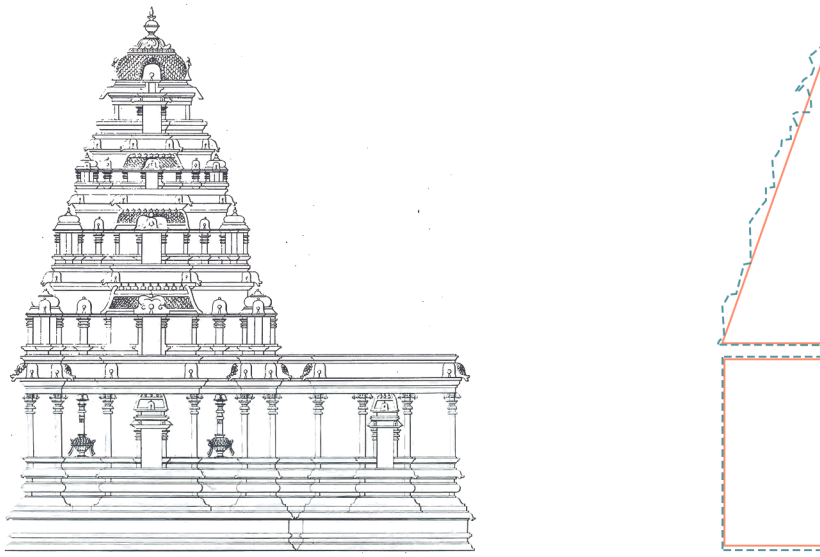
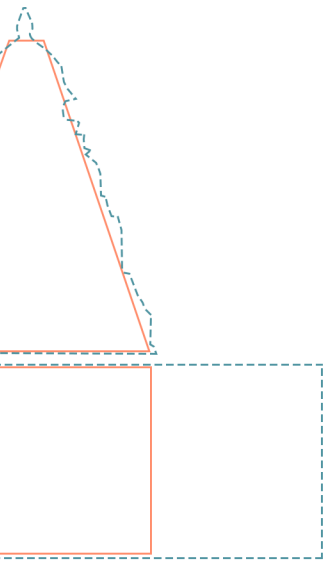
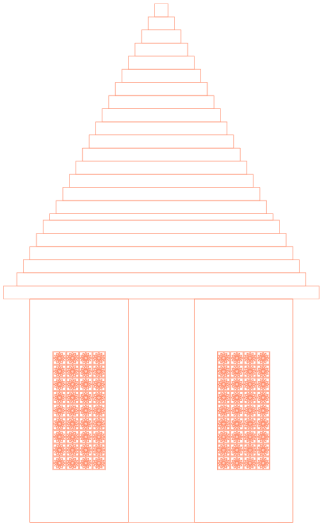


Fig 4.25 - The form of the exposed brick water temple inspired by historical temple architecture.





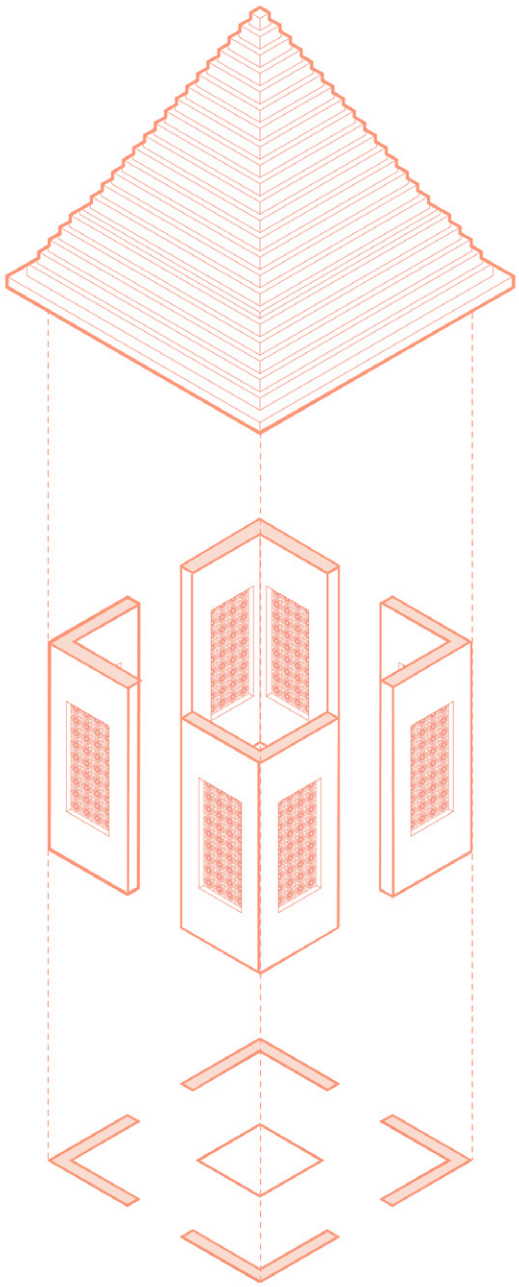


Fig 4.26 - Water temple, a place for sourcing clean water for the local community.

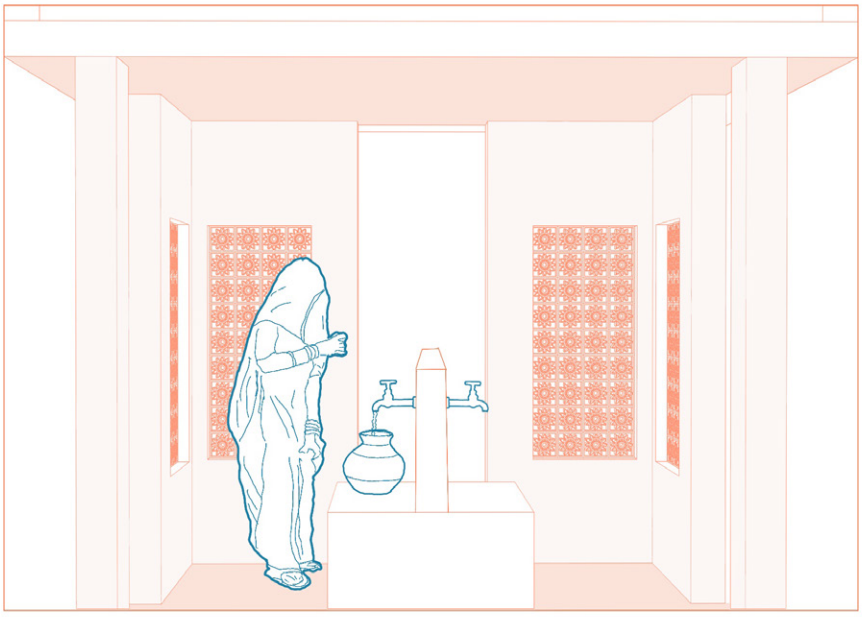


Fig 4.27 - View of woman fetching clean water from the water temple.



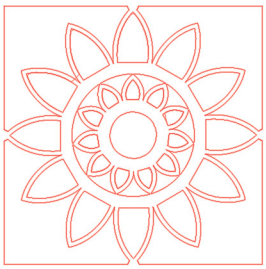
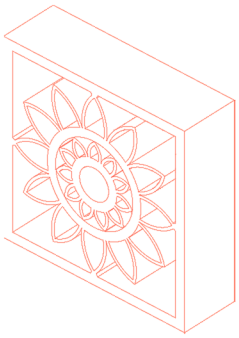
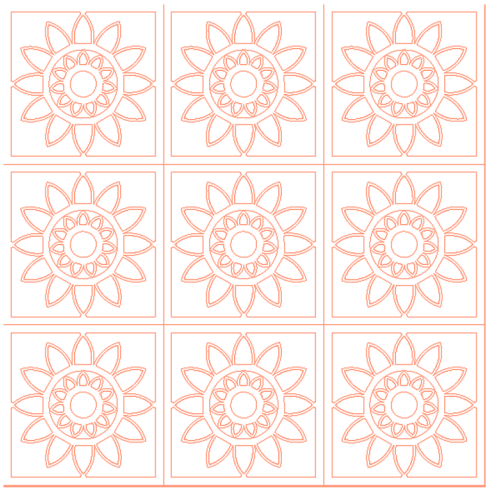


Fig 4.28 - Abstraction of Jali pattern (clay lattice screen) from the intricate niche motifs of the existing stepwell.





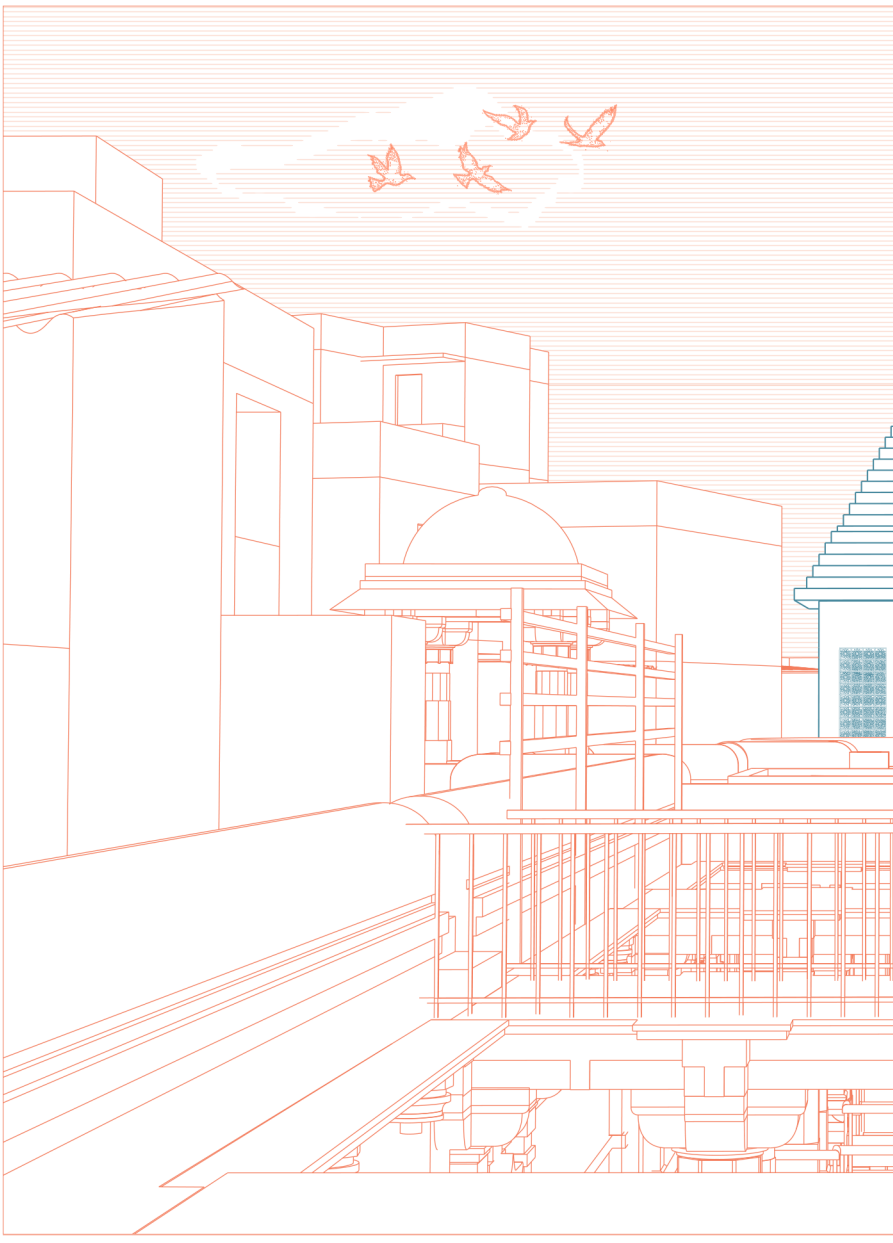
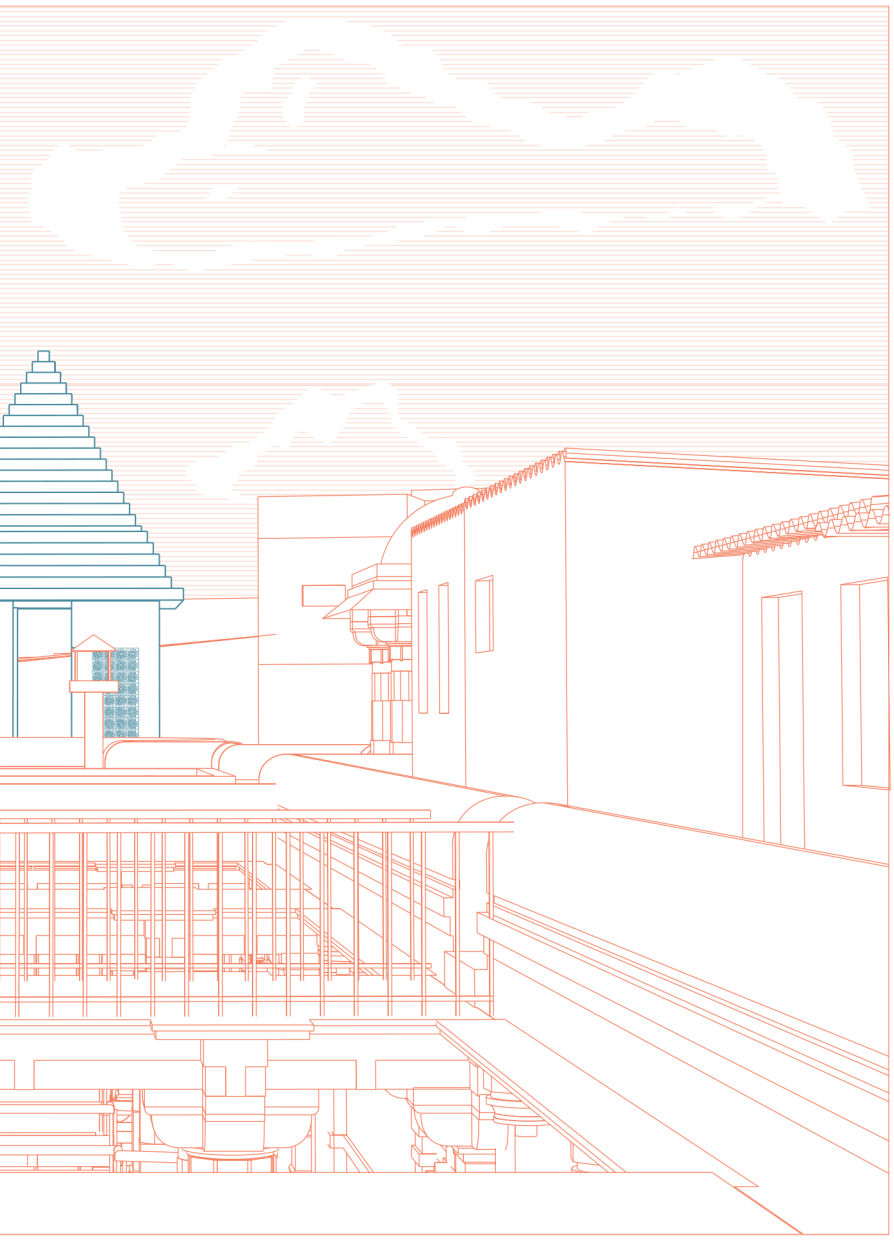


Fig 4.29 - View of the water temple from the entrance of the stepwell. The elongated roof structure helps in locating the subterranean stepwell in the urban context.



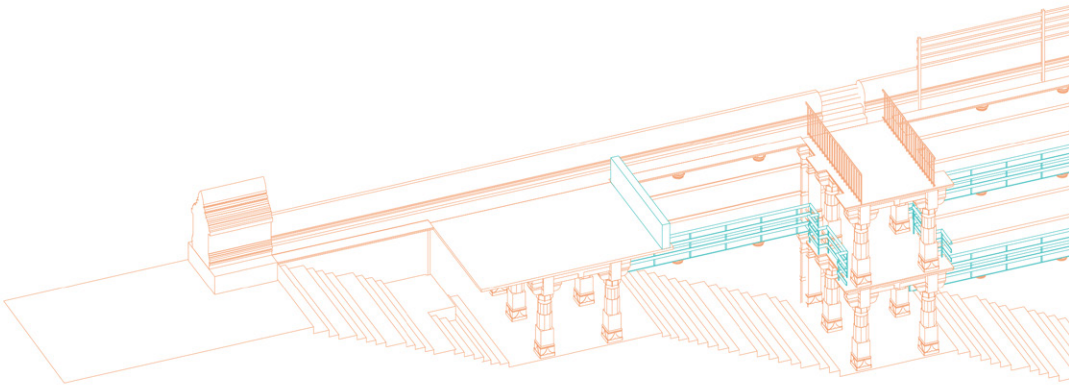
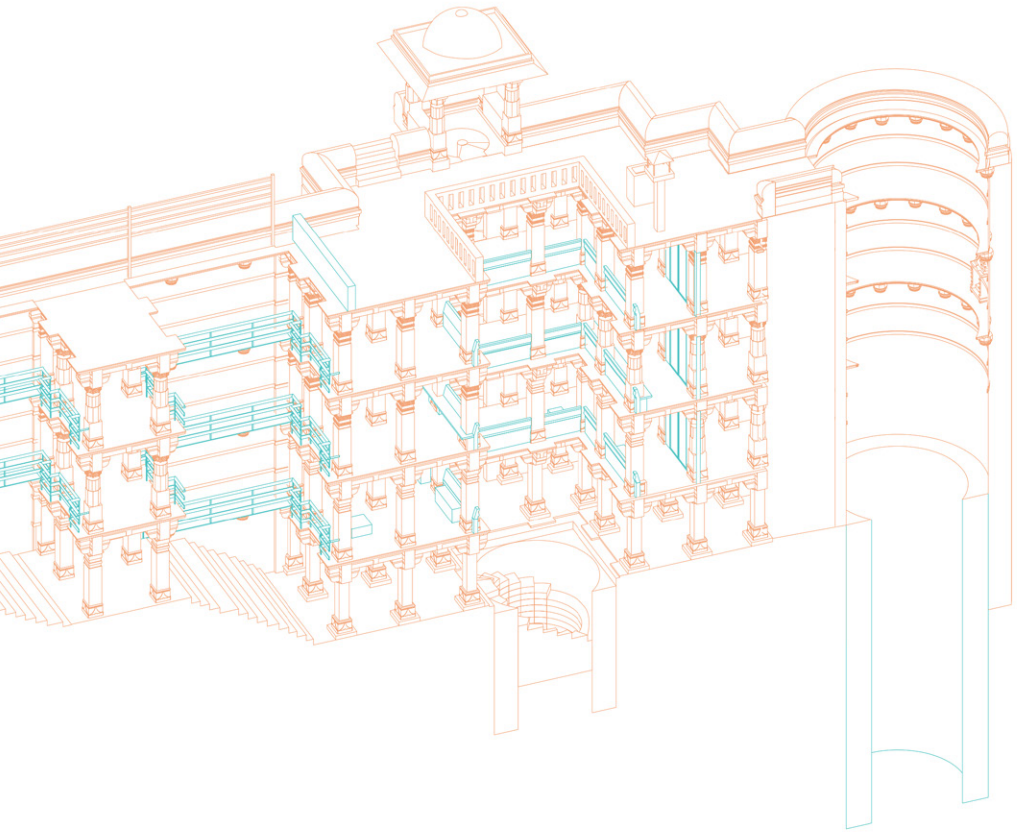


Fig 4.30 - View highlighting the additions made to the existing stepwell to make it useable for the public.



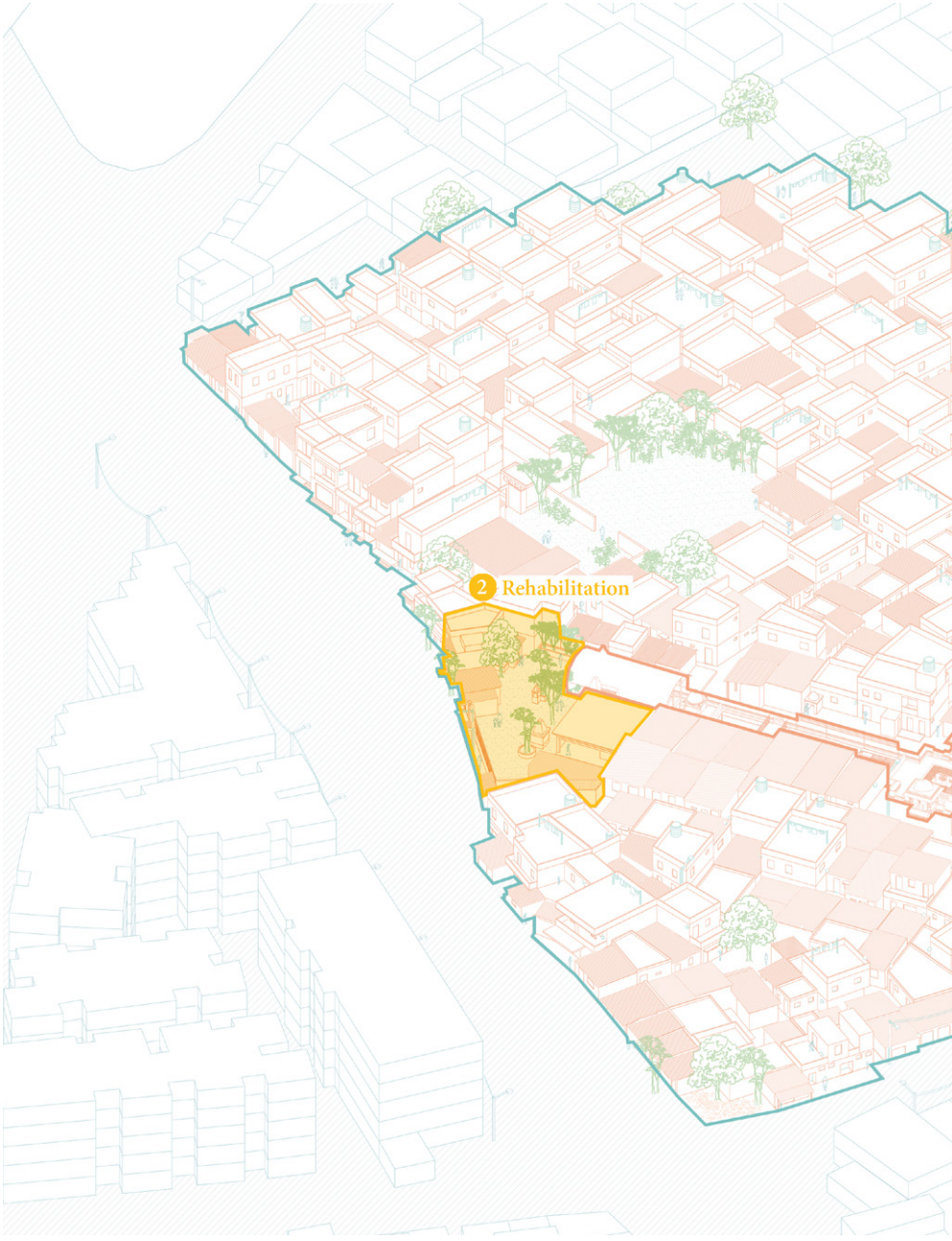
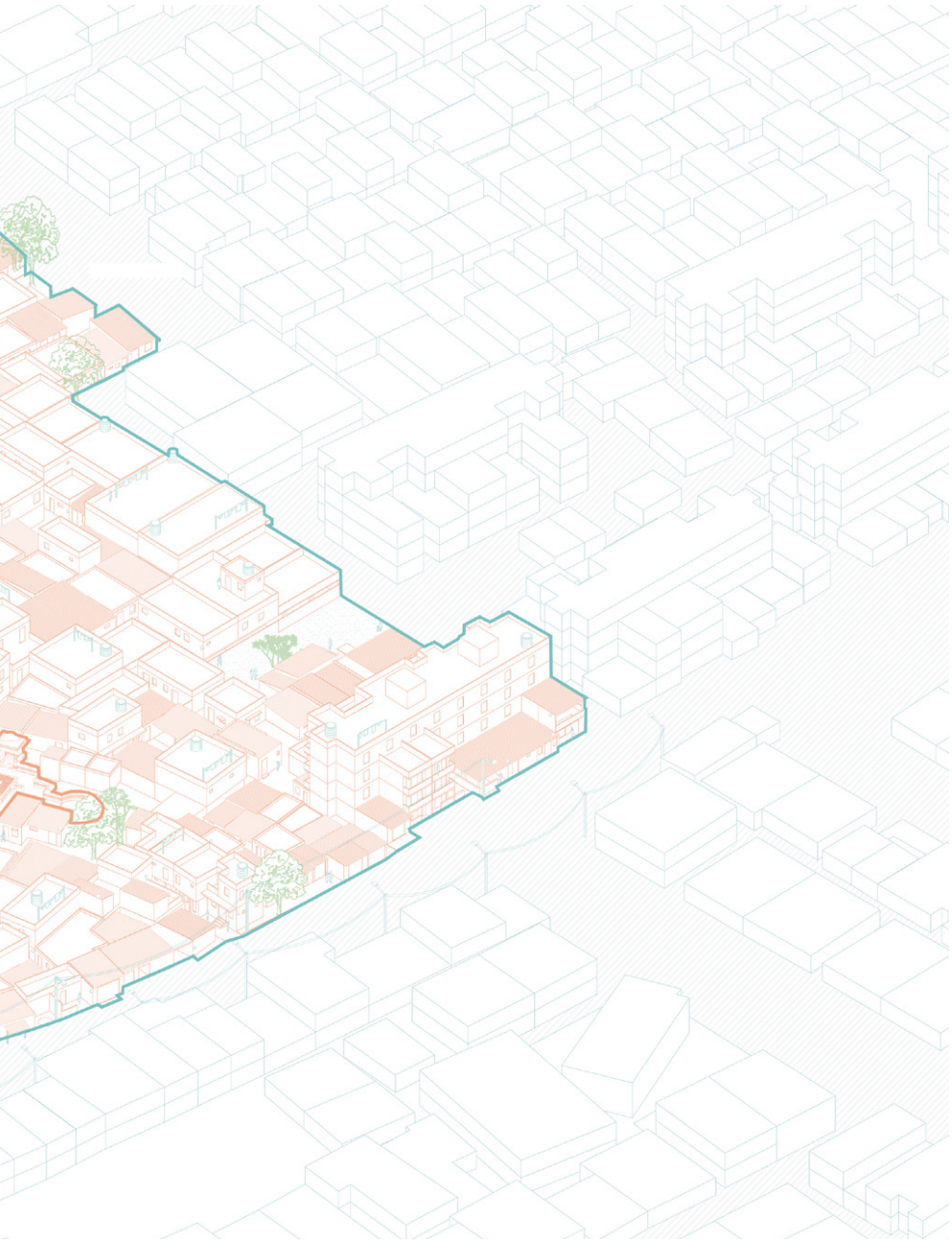


Fig 4.31 - Zone 2 - Rehabilitation



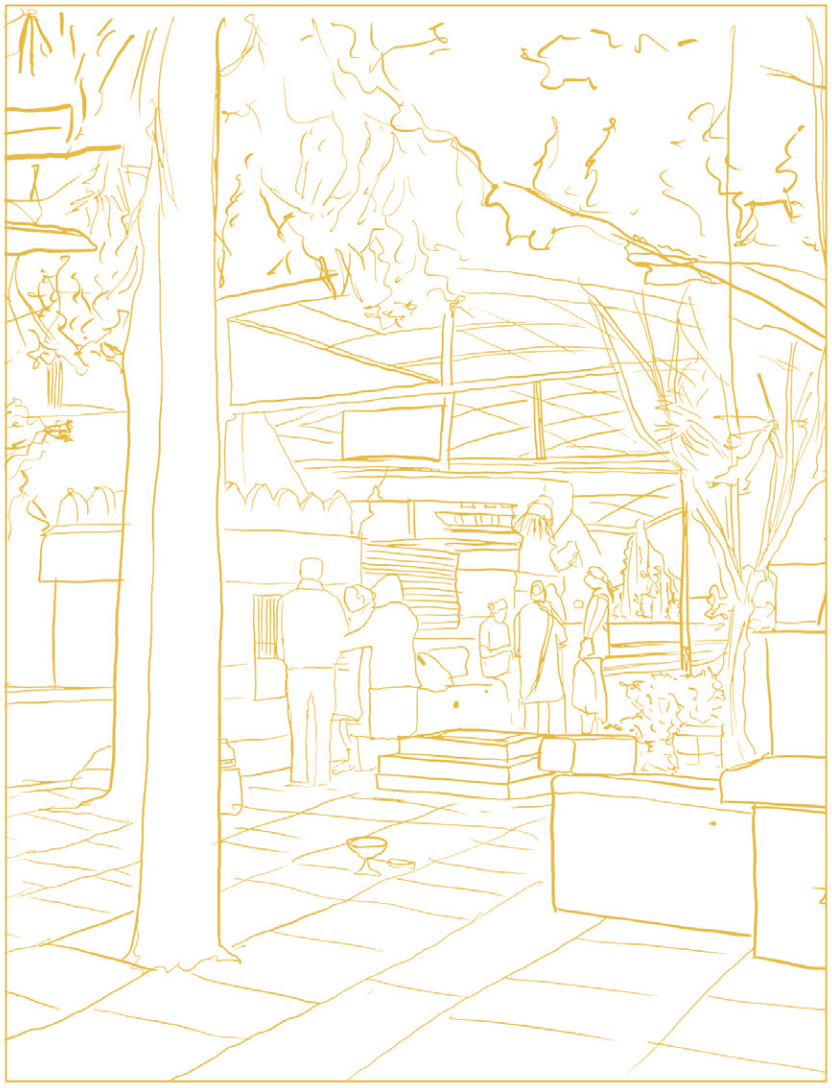


Fig 4.32 - View of the existing temple complex in front of the stepwell.

The Ashapura Mata Stepwell is hidden in the bustling residential community. It makes it difficult for the user to navigate towards the entrance of the stepwell. The rehabilitation of the front plaza opens up the space for public movement creating a visual connection from the street. The front plaza is redeveloped to provide activities required for a historical site. The existing commercial and residential buildings are relocated to other parts of the colony to open up the space for a visitor center.

The primary function of the visitor center is to provide all the basic amenities required for tourists visiting a historical site. The building layout is designed to reshape the entrance to the stepwell and make it visible on the street front. It comprises a gift shop, information desk, seating space and restrooms. The gift shop promotes the work of women from the local community.

The architectural style of the building is inspired by the modern architectural style of Ahmedabad. The use of exposed brick and laying it in different patterns creates a subtle yet dynamic focus on the building. The roof of the building uses a local vernacular technique of filler slabs filled with clay pots. The use of clay pots helps with reducing concrete and improves thermal comfort within the building. The central courtyard with shrines and trees is kept intact.

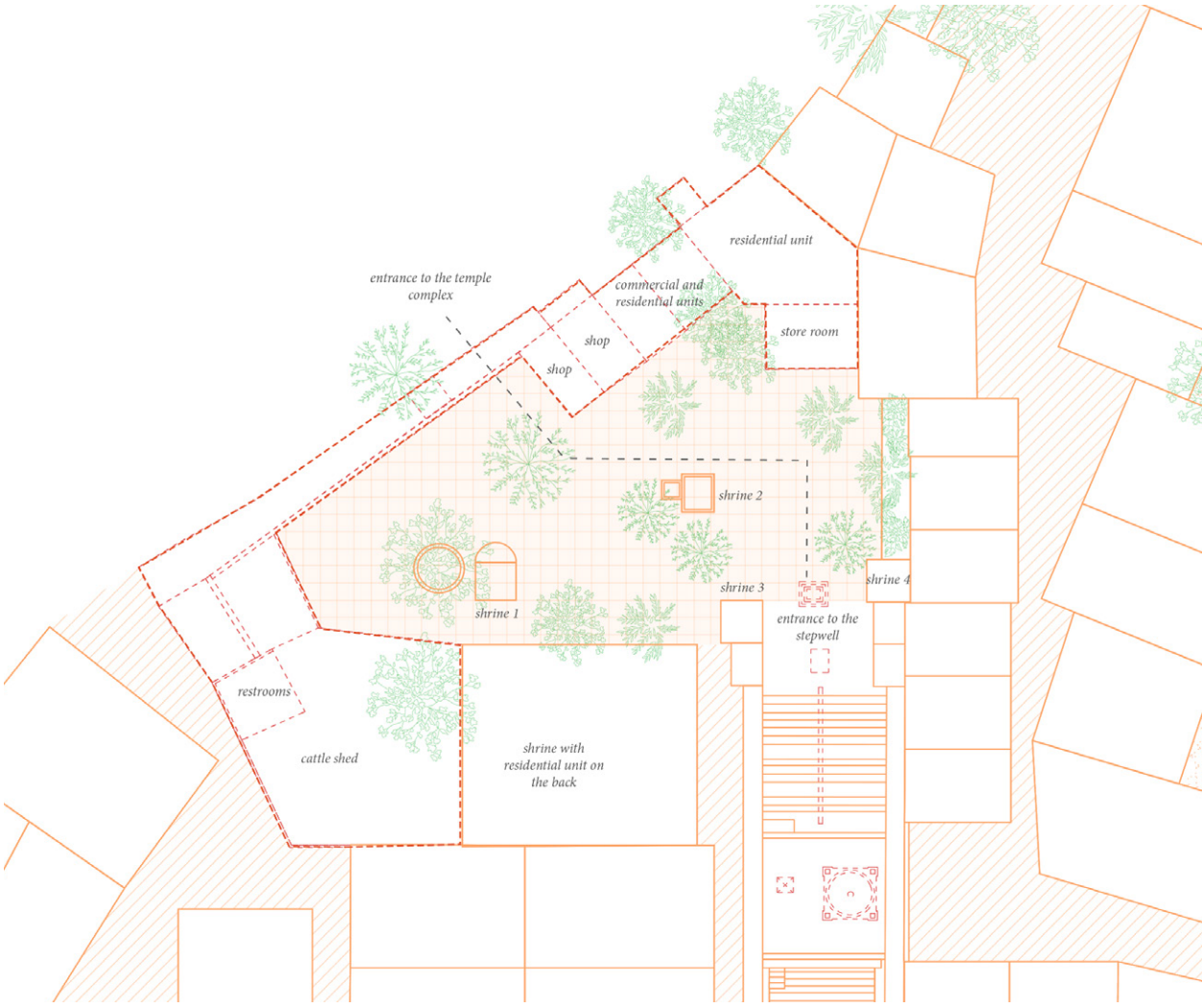


Fig 4.33 - Plan of the existing temple complex.

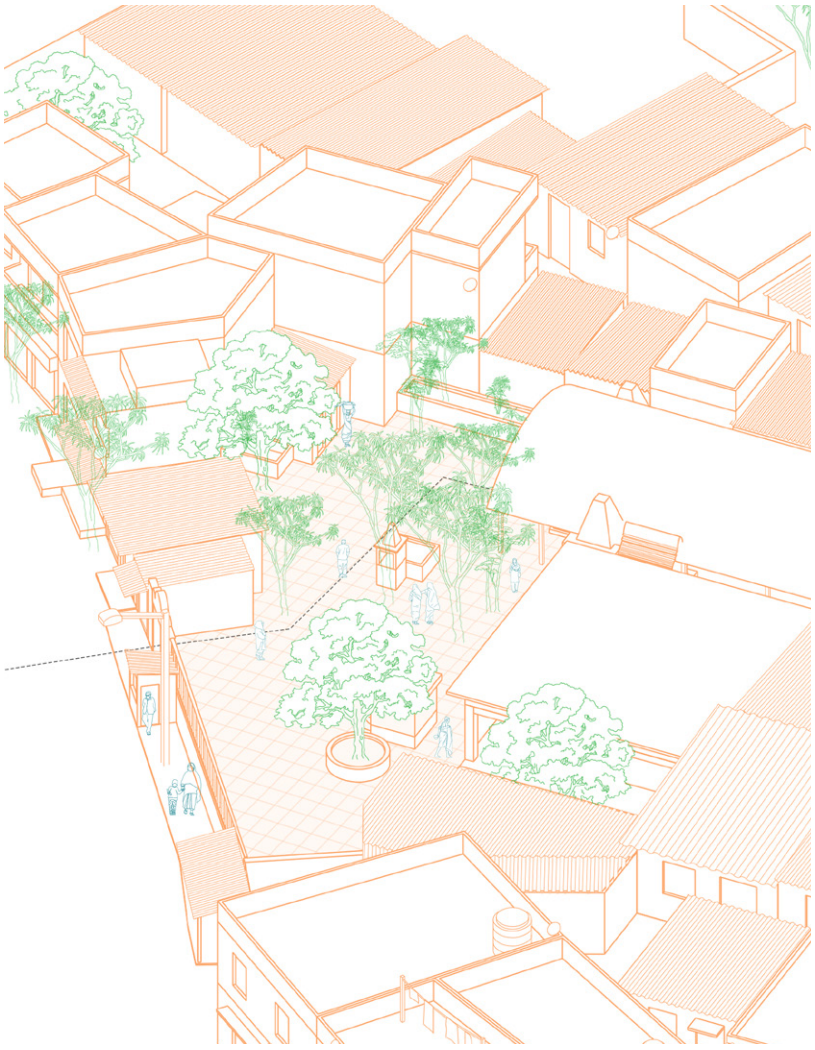


Fig 4.34 - View of the existing temple complex. As there is no defined axis to the stepwell, it remains hidden behind the temple.

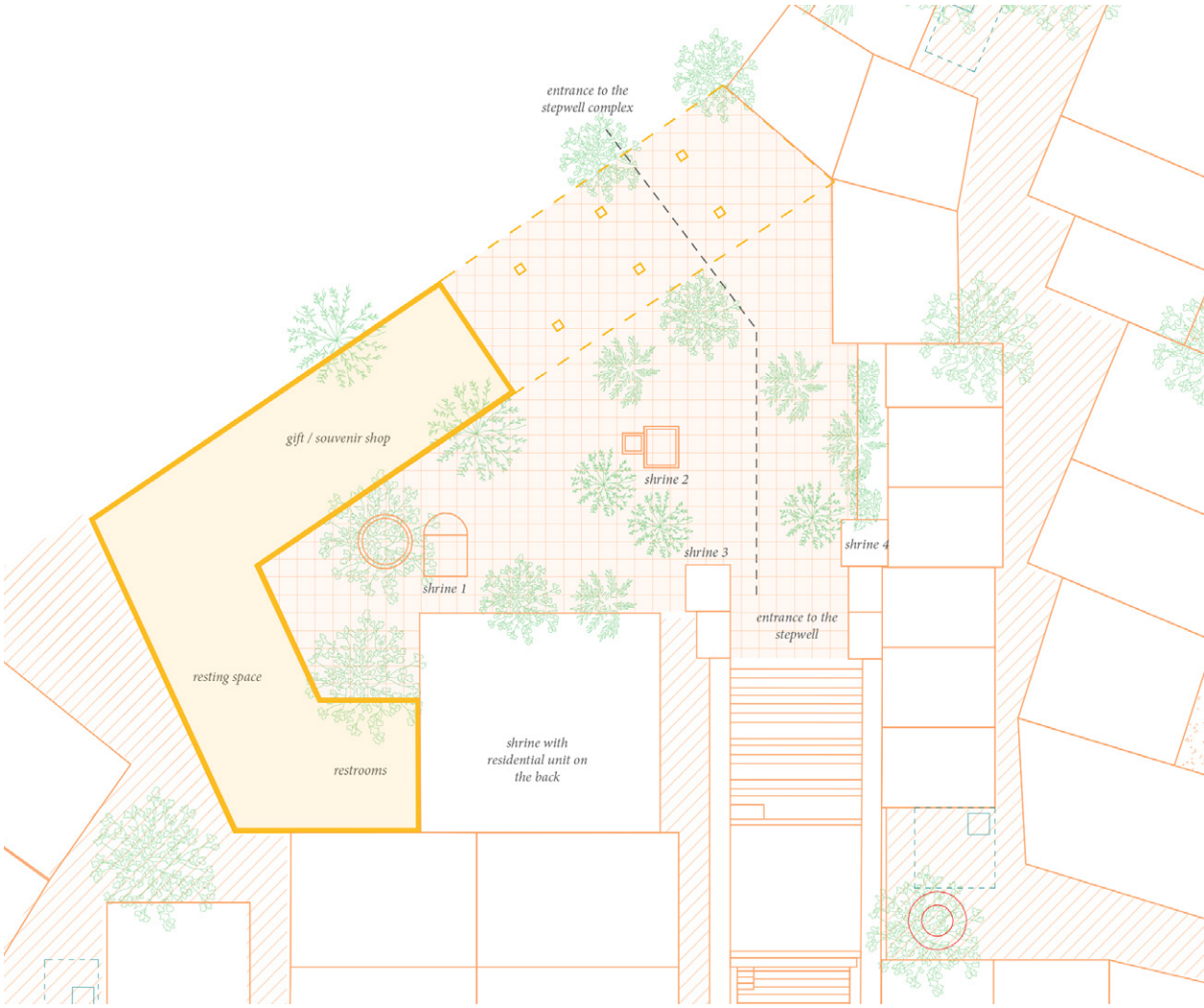


Fig 4.35 - Proposed plan for the front plaza of the stepwell.

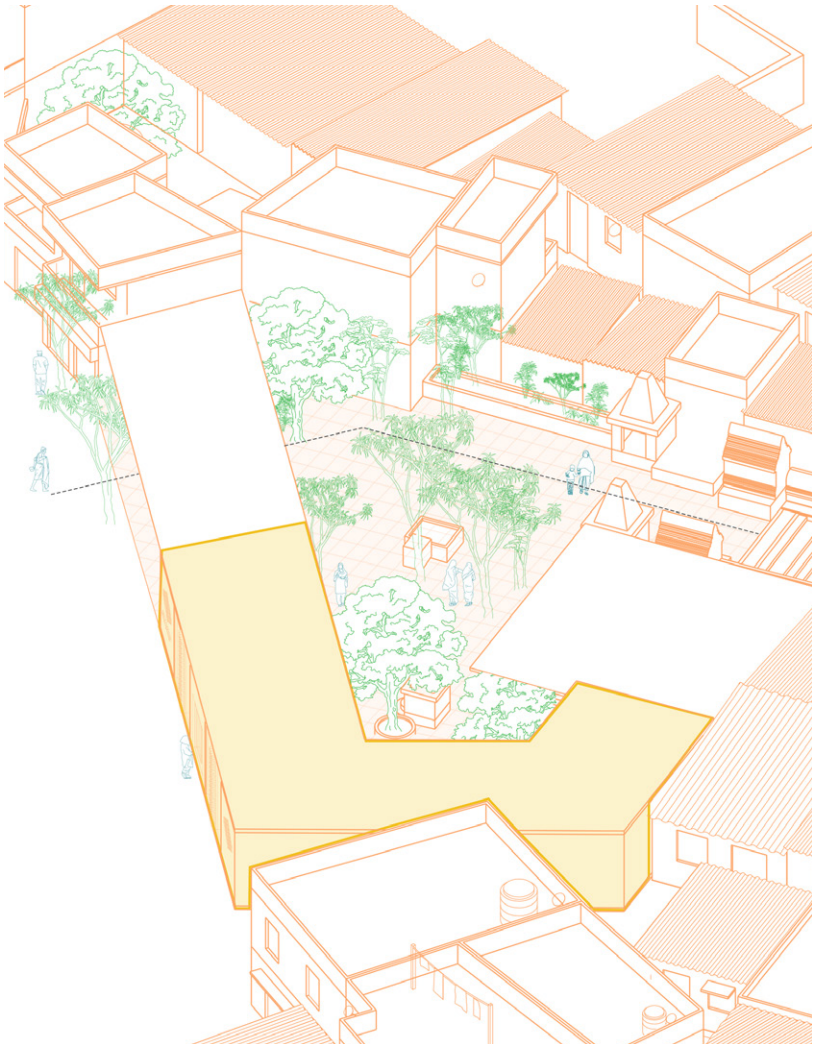


Fig 4.36 - View of the proposed visitor center for the stepwell.

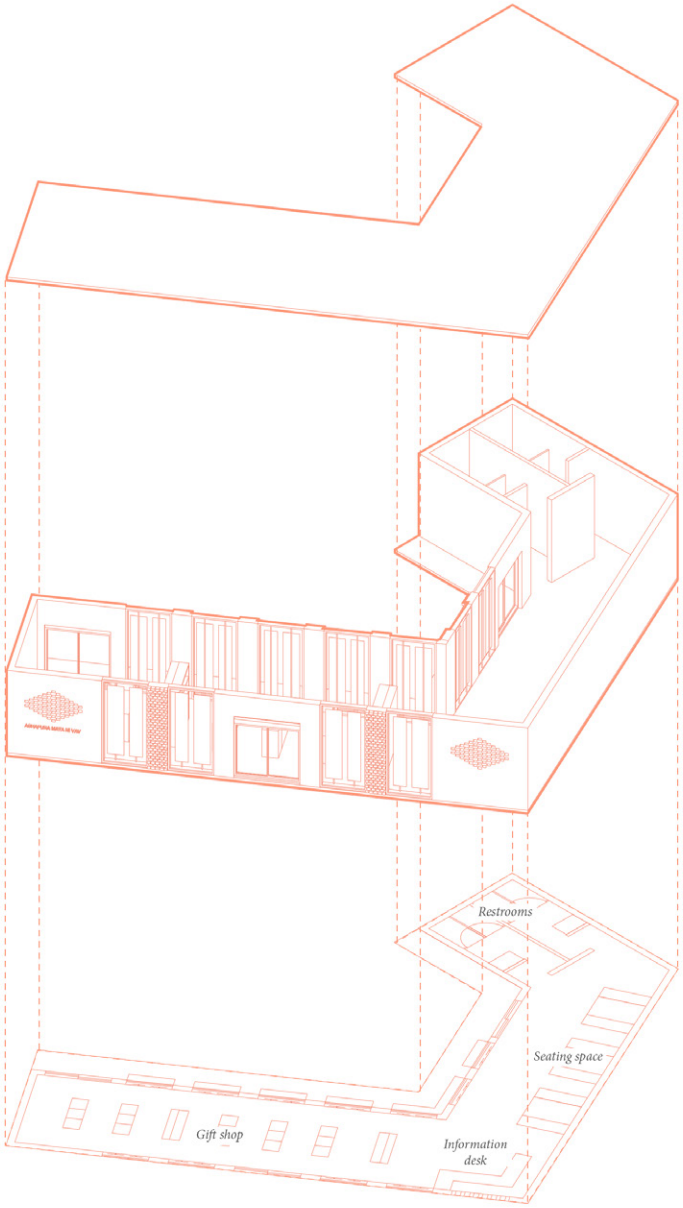


Fig 4.37 - Ashapura Mata stepwell visitor center.

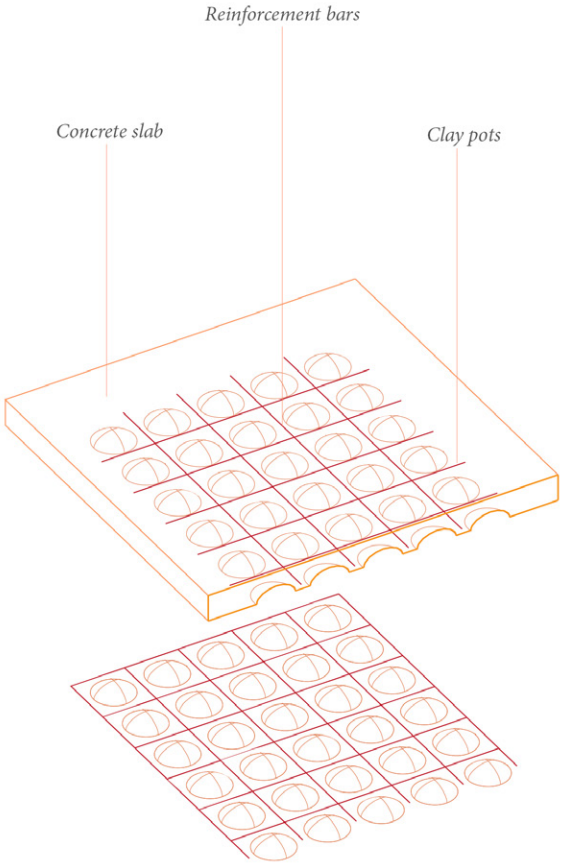


Fig 4.38 - Filler slab with clay pots roof detail.

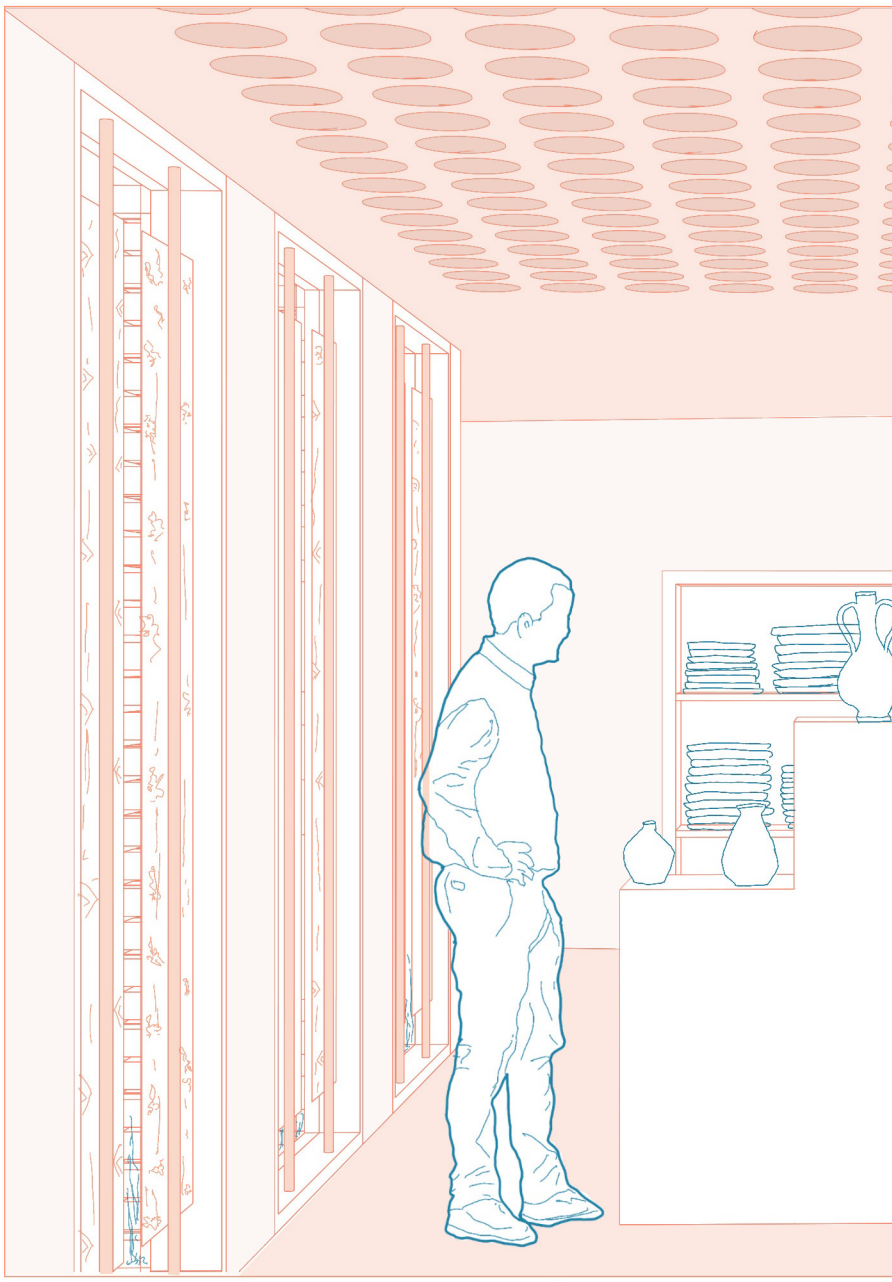


Fig 4.39 - Interior view of the visitor center.





Fig 4.40 - Exterior view towards the courtyard of the front plaza.



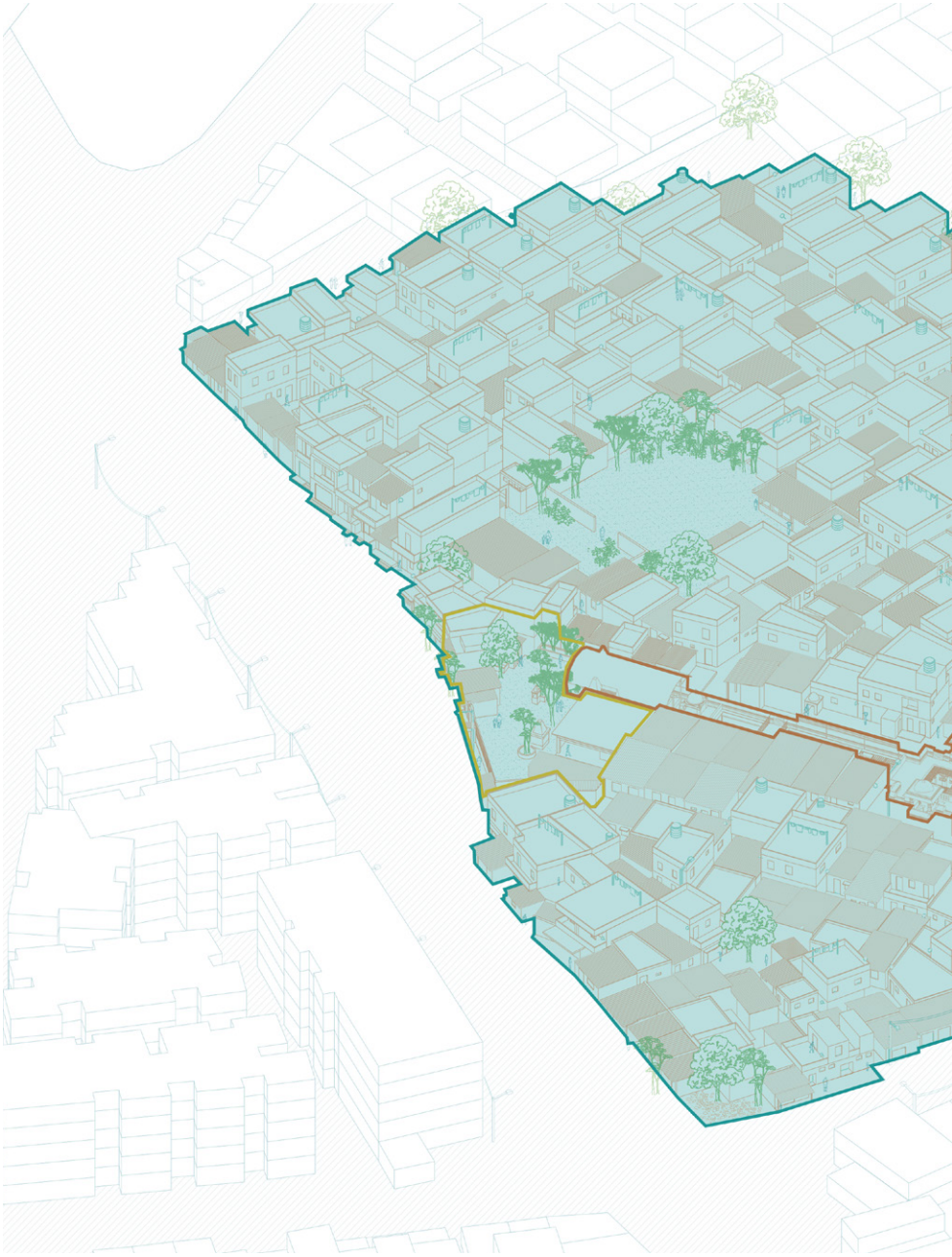
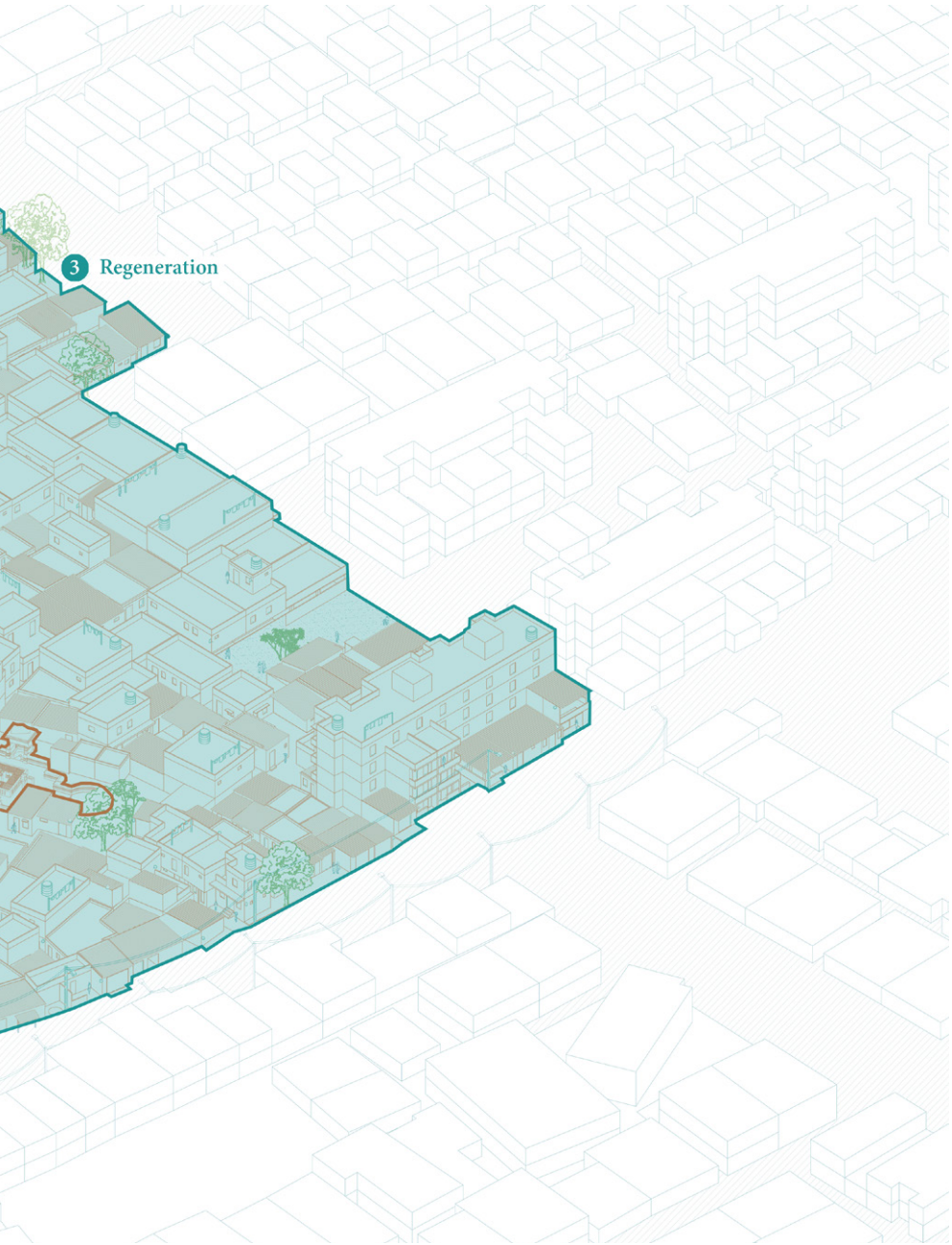


Fig 4.41 - Zone 3 - Regeneration


3 Regeneration

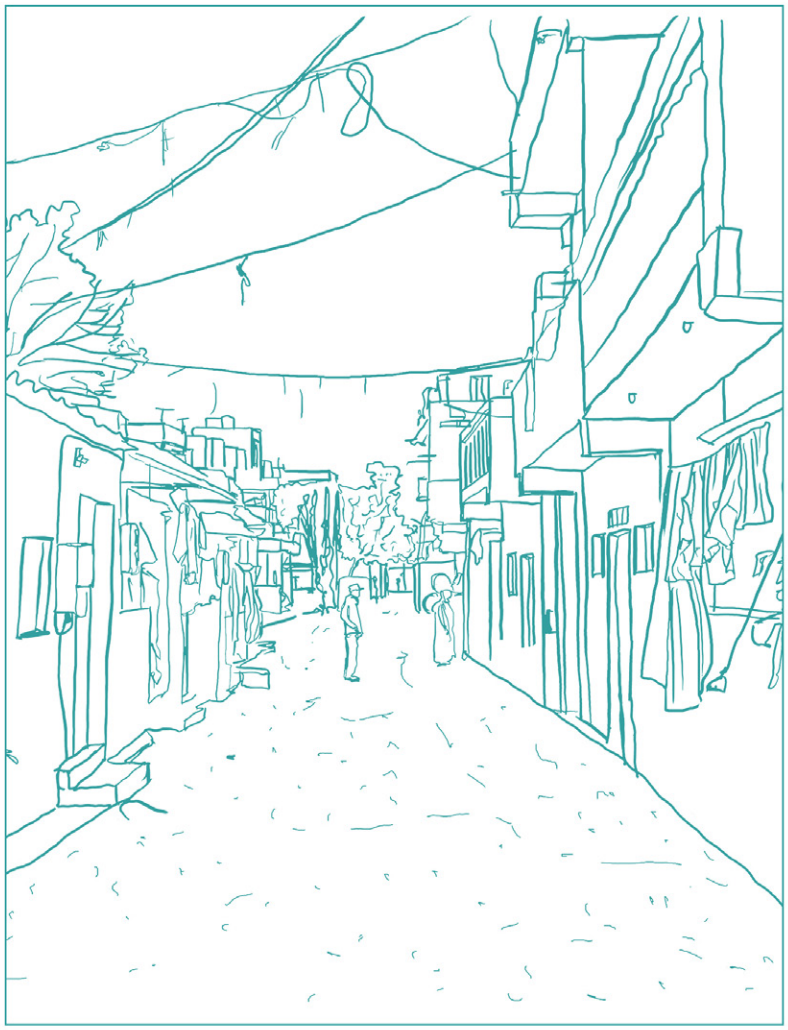


Fig 4.42 - Existing view of the residential community.

Local community engagement is crucial for the regeneration of groundwater. Considering the existing condition of the community, urban-scale interventions are proposed to recharge the aquifers. Rainwater harvesting is used to recharge groundwater. Due to weak infrastructure and poor water management, rainwater gets wasted. Providing community-scale intervention enables the harvest of rainwater and redirect it to recharge the aquifers.

With the adaptation of current government policies for rainwater harvesting, the temporary roof structures within the site are replaced with sturdy rainwater harvesting roof systems. These are further connected to recharge pits. Recharge pits follow the reverse principle of a borewell thereby recharging the aquifers. A series of recharge pits are strategically placed within the site to collect roof runoff and recharge groundwater. Since the streets within the site are already paved, changing them to permeable pavement blocks will promote efficient absorption of rainwater in an urban setting.

Along with these strategies, planting native groundwater retention trees will not only help with recharging groundwater but also provide shaded spaces within the community. Formal and informal seating spaces are provided to promote outdoor engagement in the community.

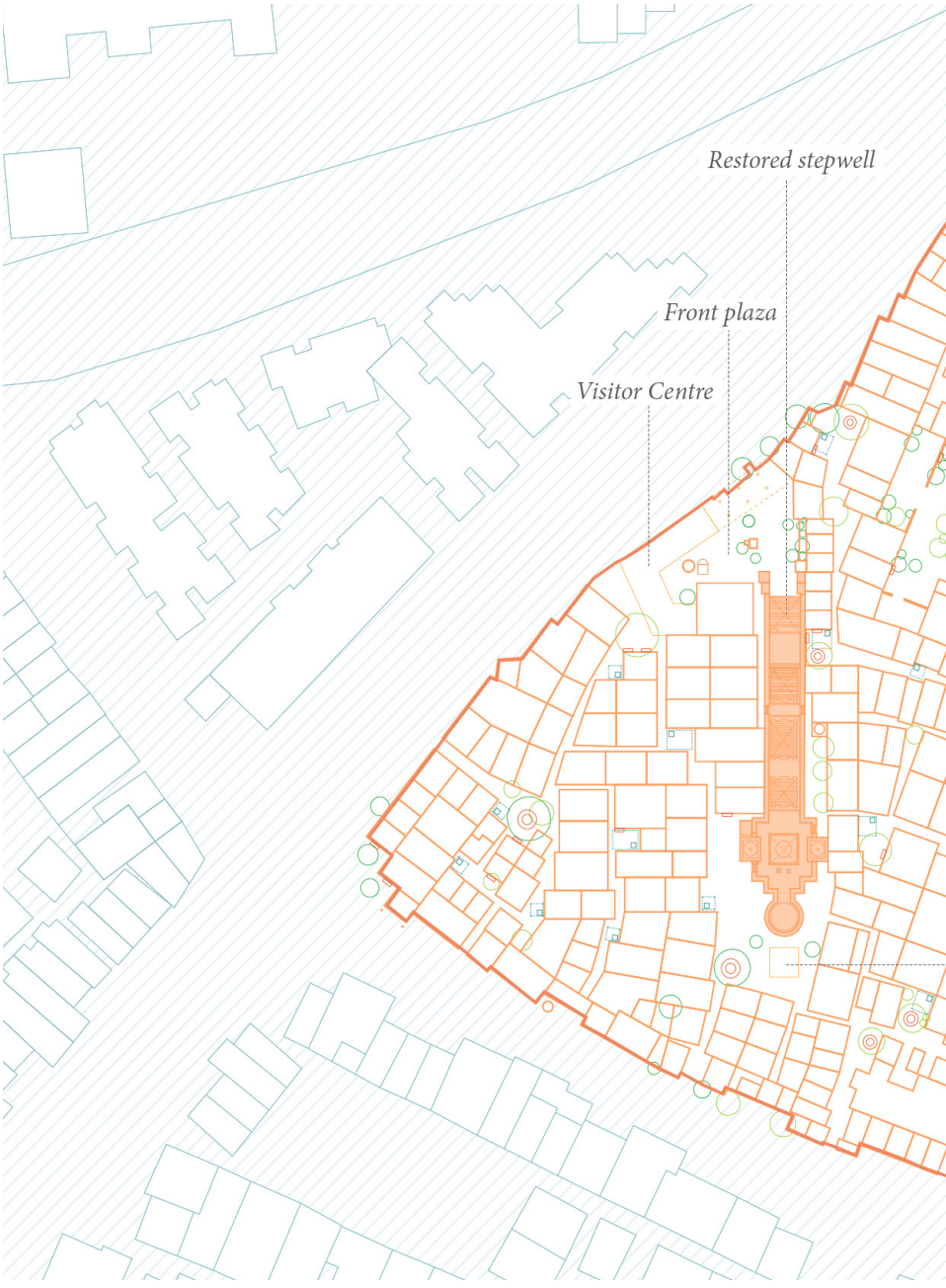


Fig 4.43 - Masterplan with regeneration strategies.


Formal gathering space
Water temple

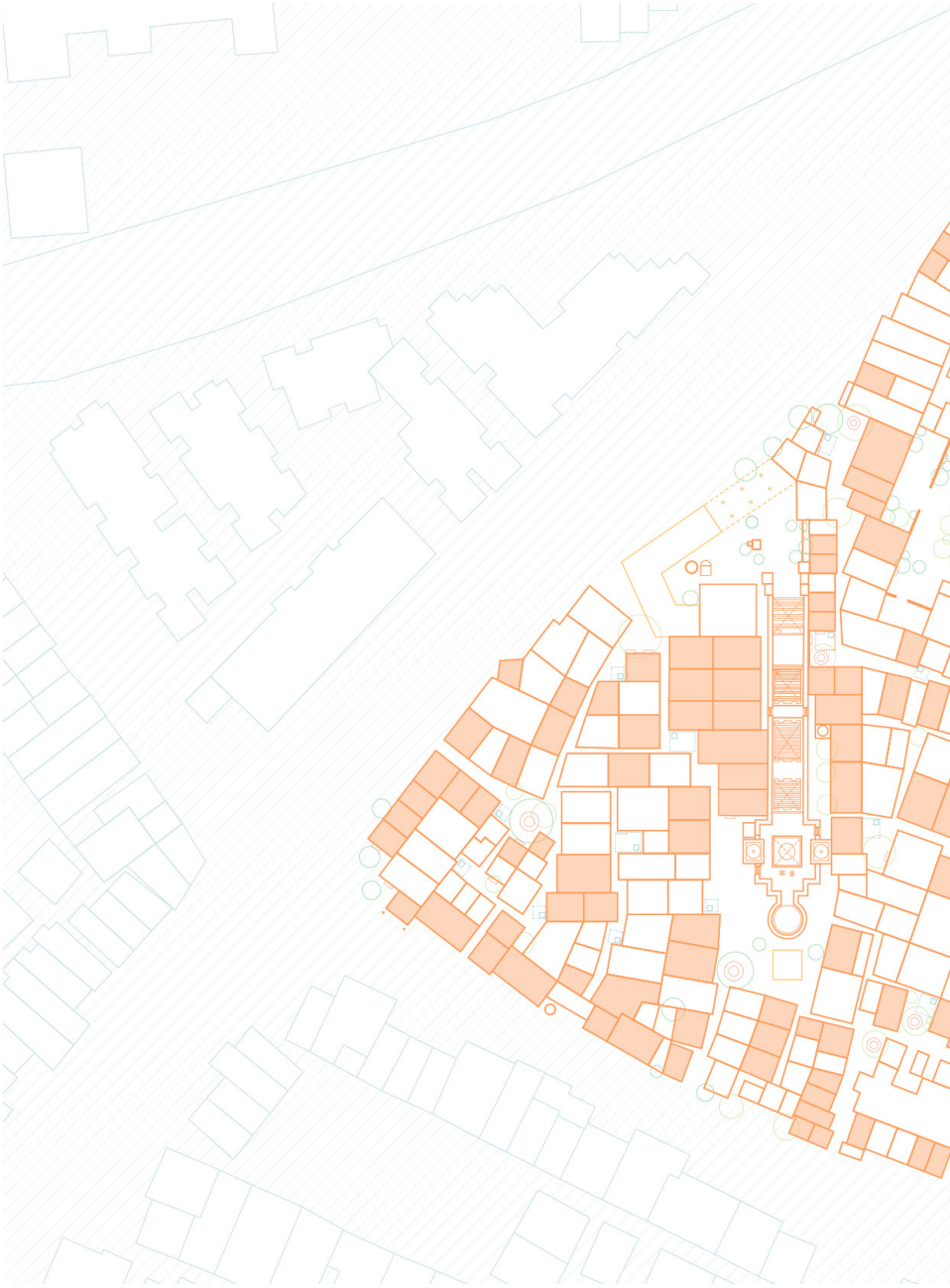


Fig 4.44 -Highlighted are the existing sloped roof structures within the site.



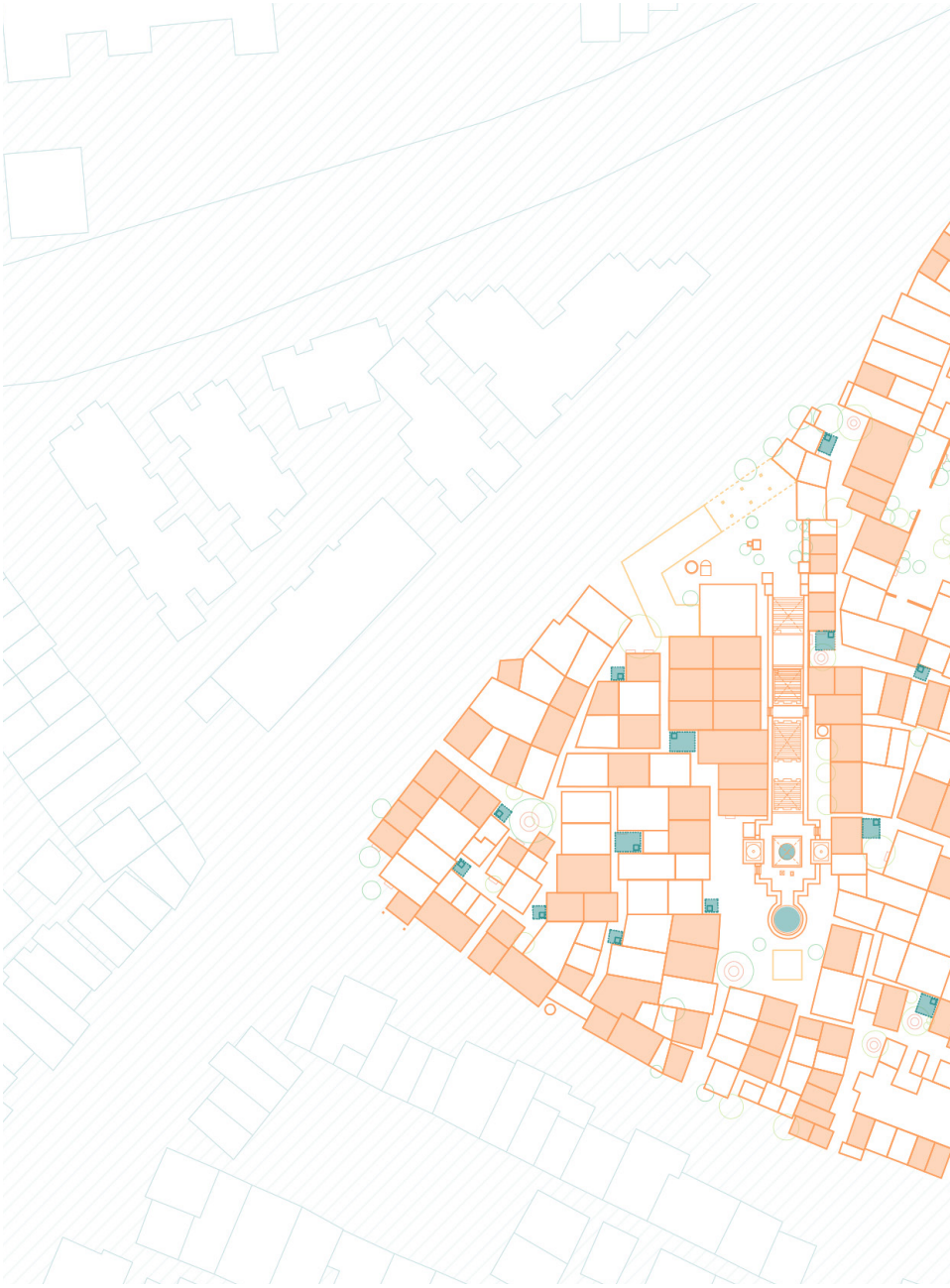
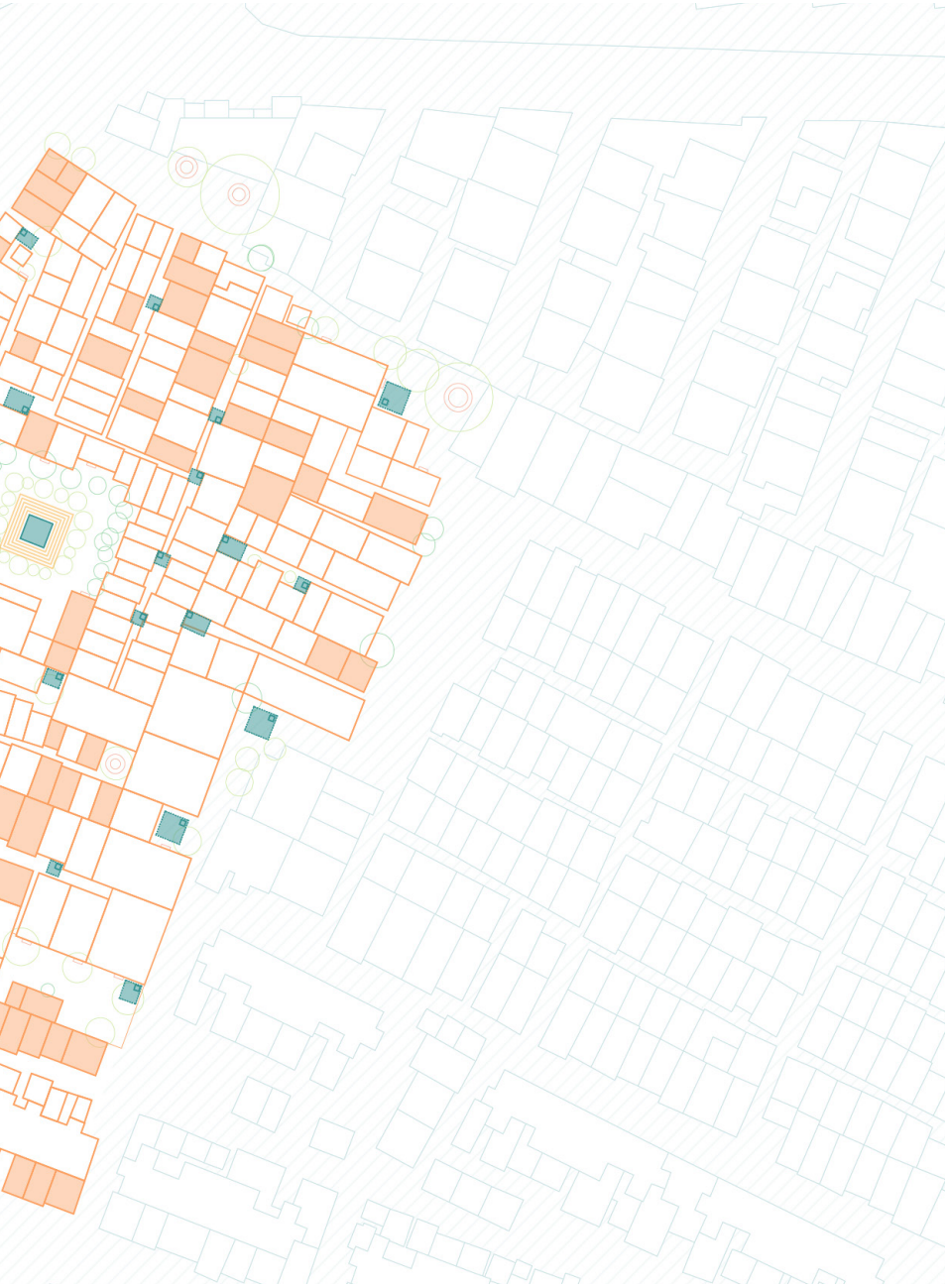
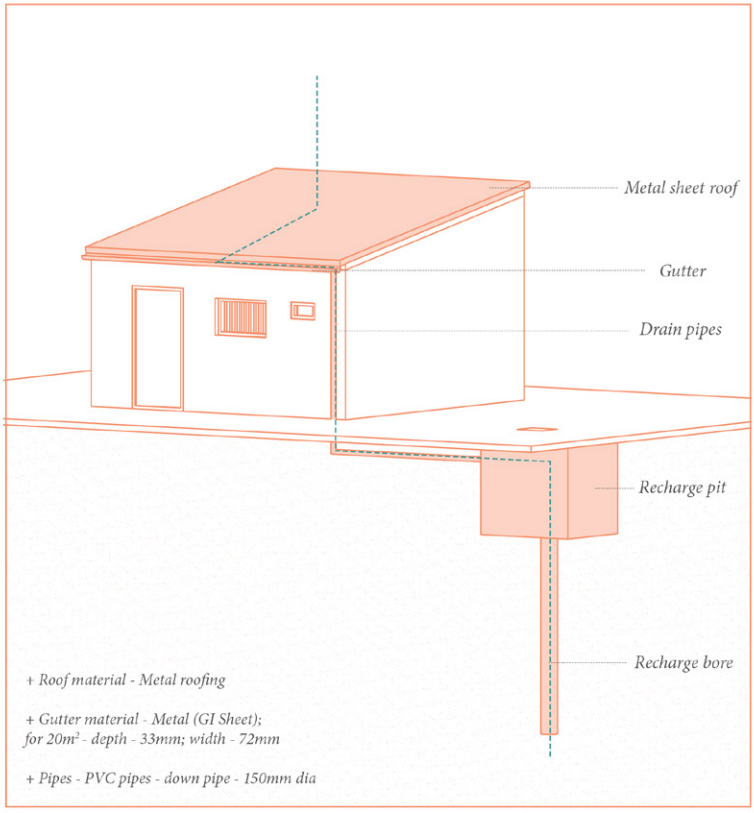


Fig 4.45 - Strategical placement of recharge pits to store rainwater and rejuvenate the aquifers.





A typical roof of a house in the neighbourhood - 20m²

Considering annual rainfall of 717mm for Ahmedabad

Water harvested for a flat roof - 12.8m³ = 3381 gallons

Water harvested for a sloped roof - 15.2m³ = 4015 gallons

There are approximately 350 - 400 units in the site;

Even if 50% of the houses harvested rainwater; it can help recharge upto 700,000 gallons of water in a year.

Fig 4.46 - Proposed Rainwater harvesting system.

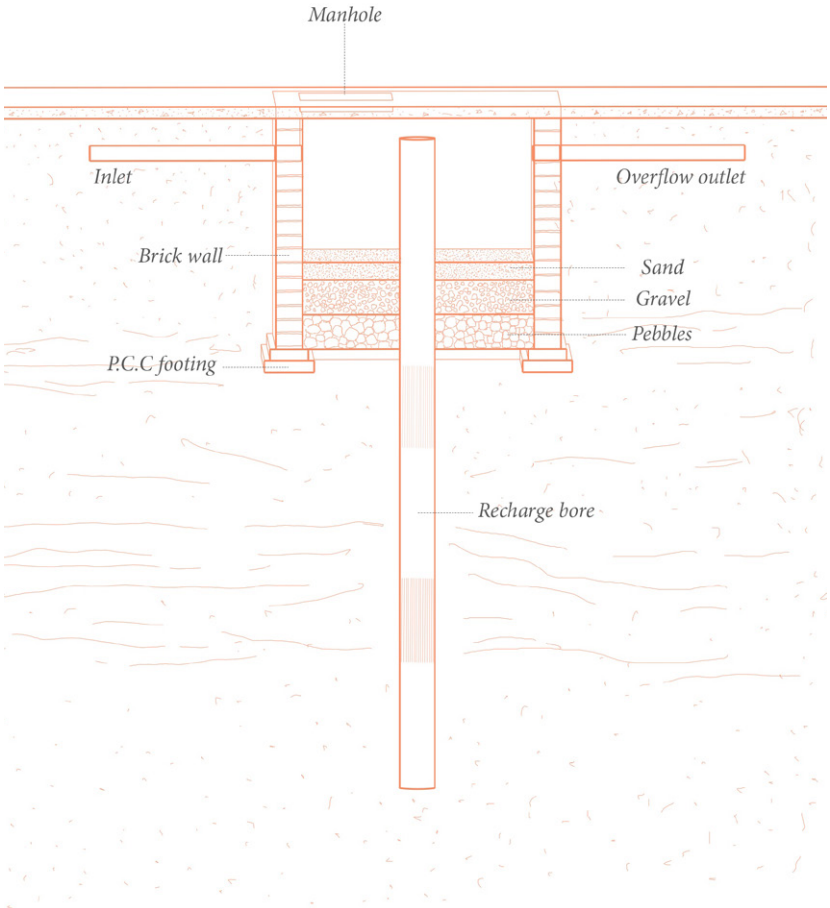


Fig 4.47 - Detail of Recharge pit.

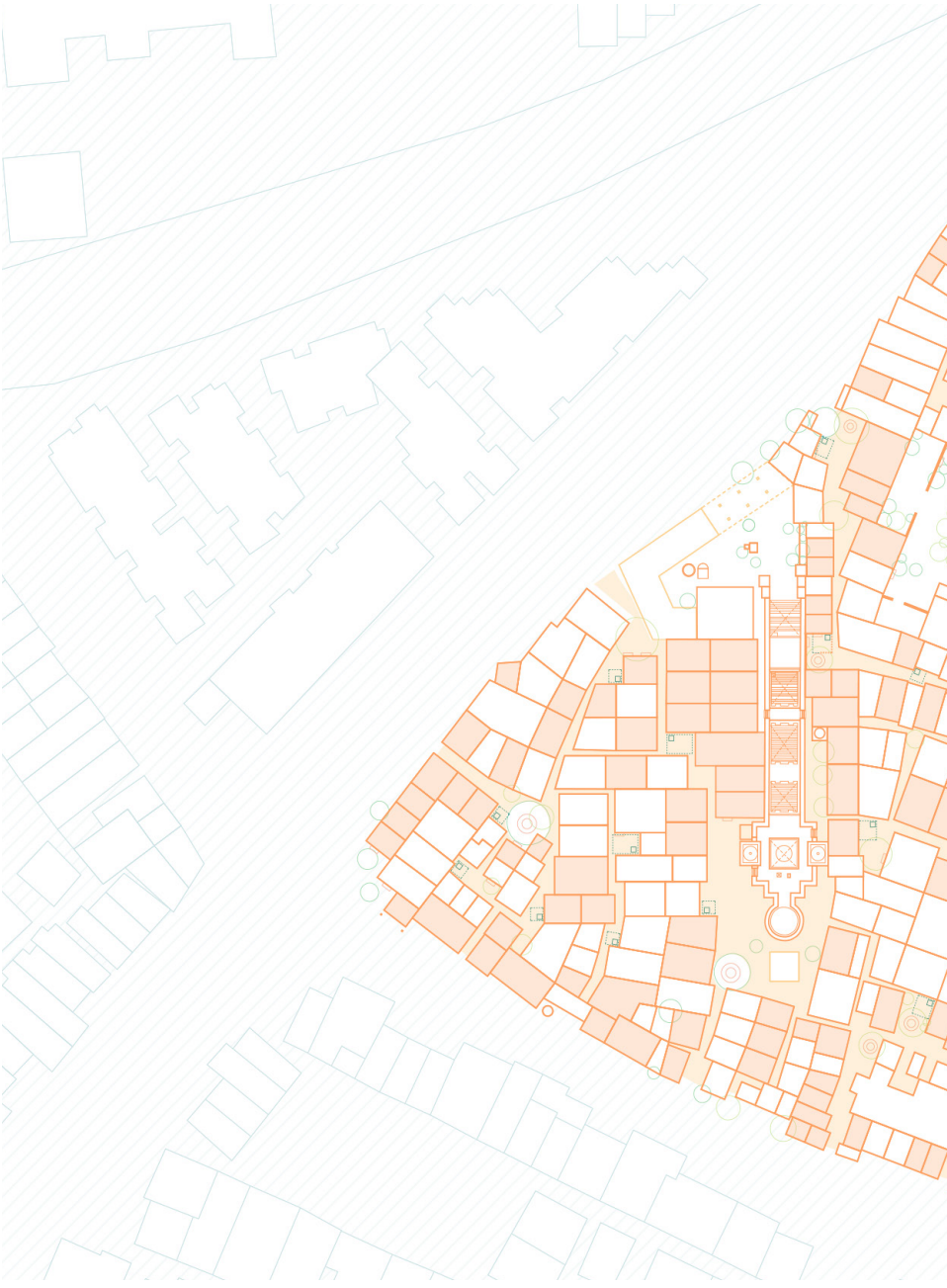


Fig 4.48 - Changing of existing pavement to permeable pavement to recharge groundwater.





Fig 4.49 - Proposed street view with permeable pavement blocks.



Fig 4.50 - Proposed street view with permeable pavement blocks.

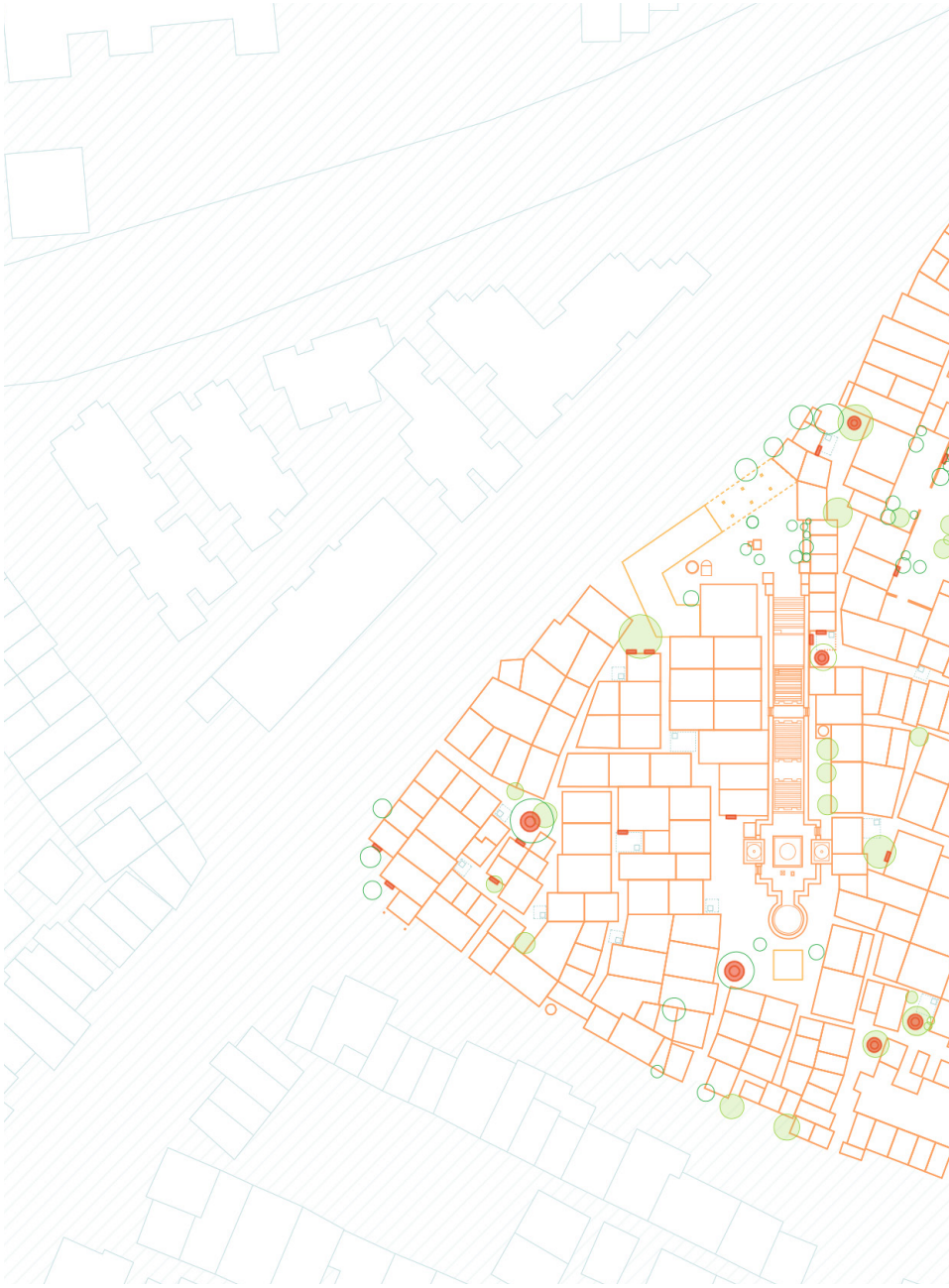
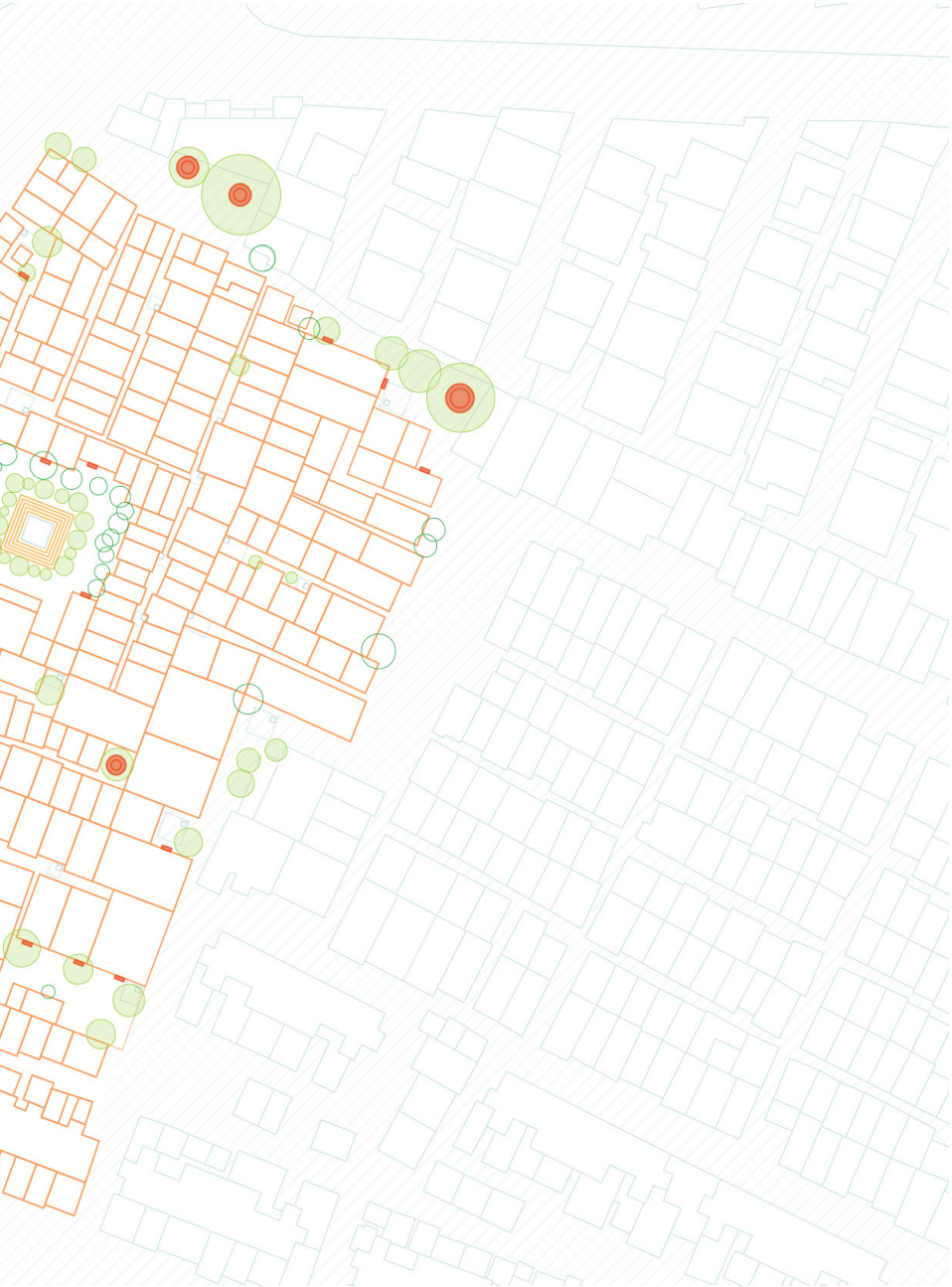


Fig 4.51 - Location of new plantation of groundwater retaining trees and formal and informal gathering spaces.



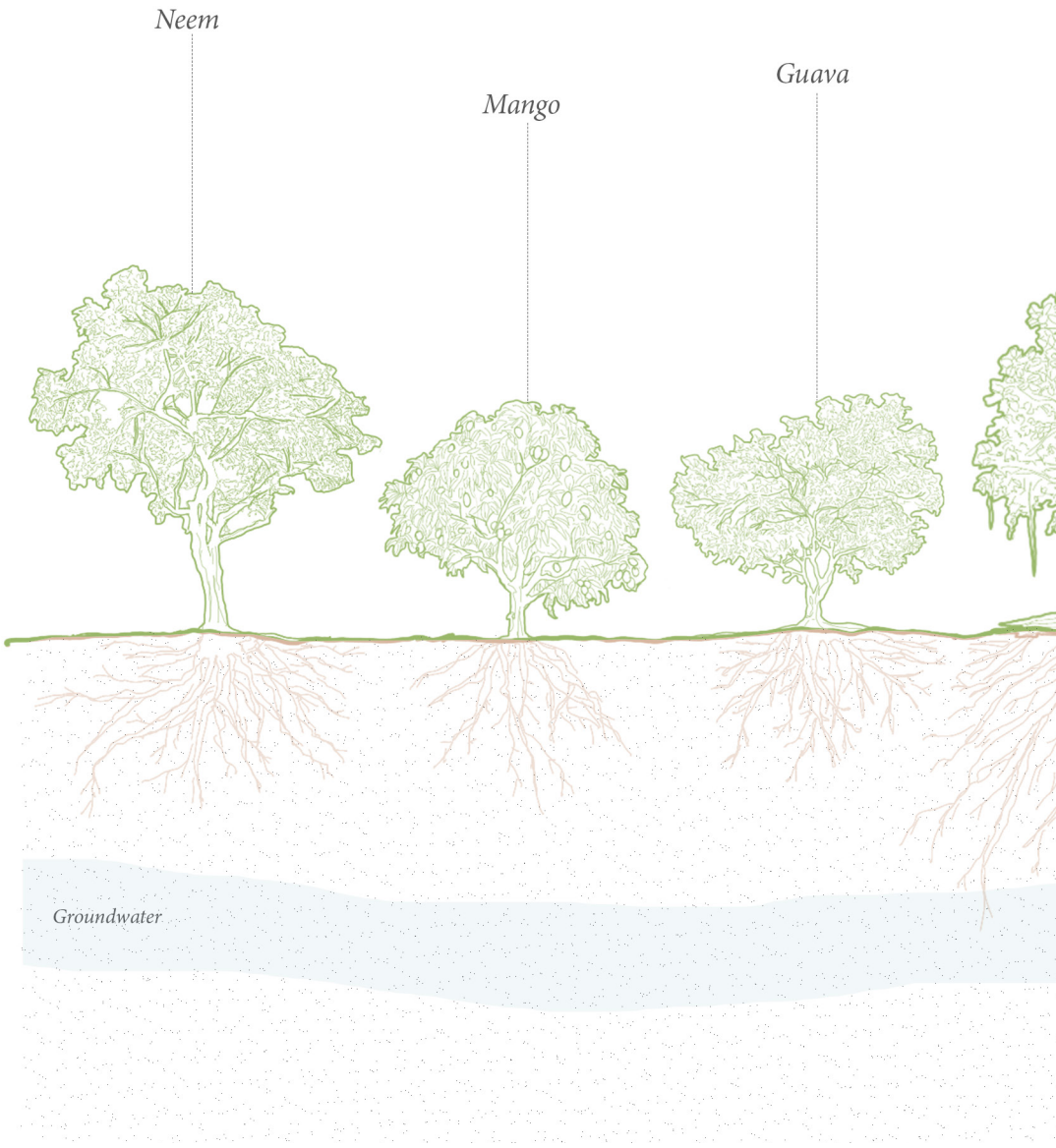
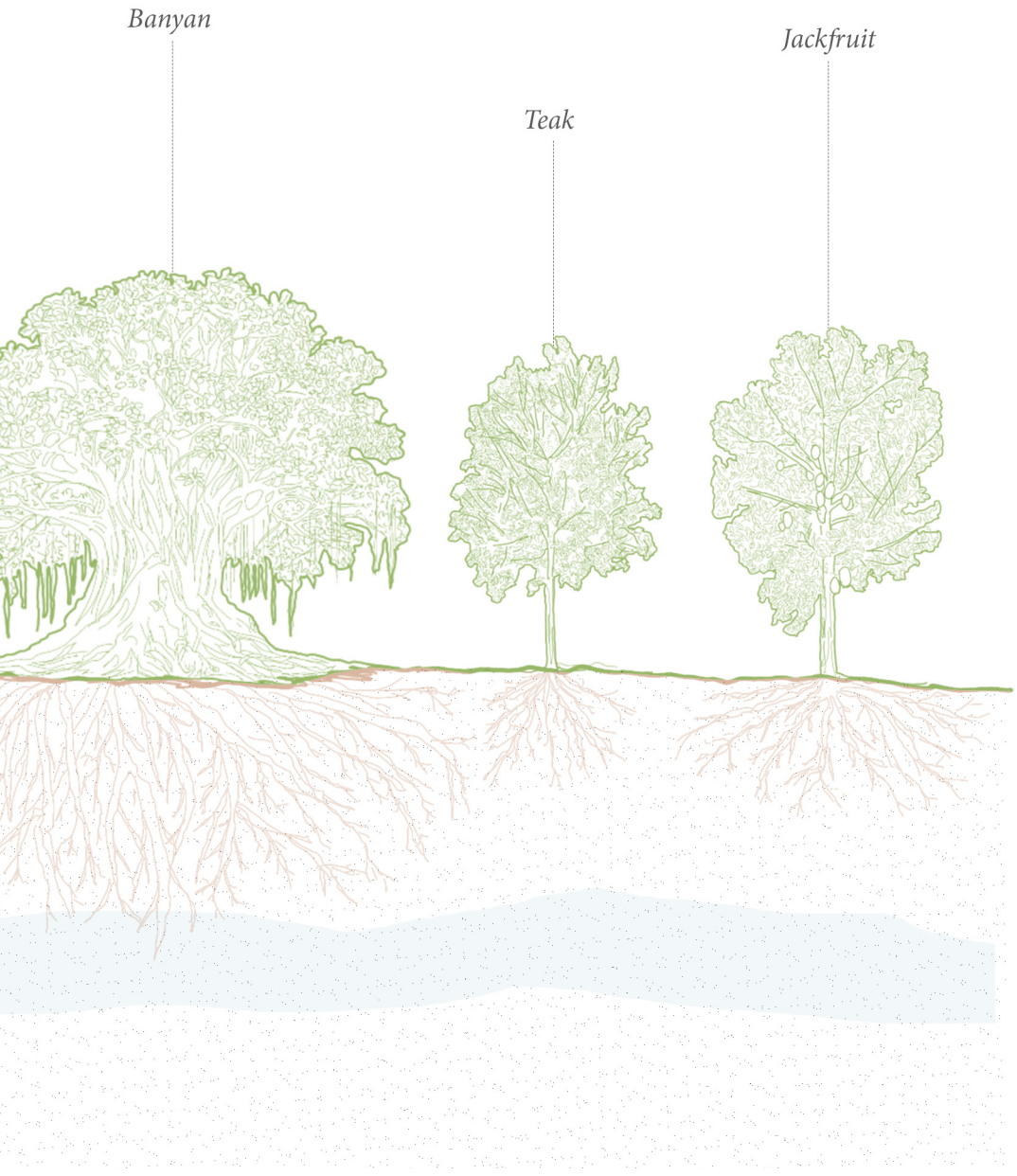


Fig 4.52 - Groundwater retaining trees locally grown in India.


Banyan
Teak
Jackfruit

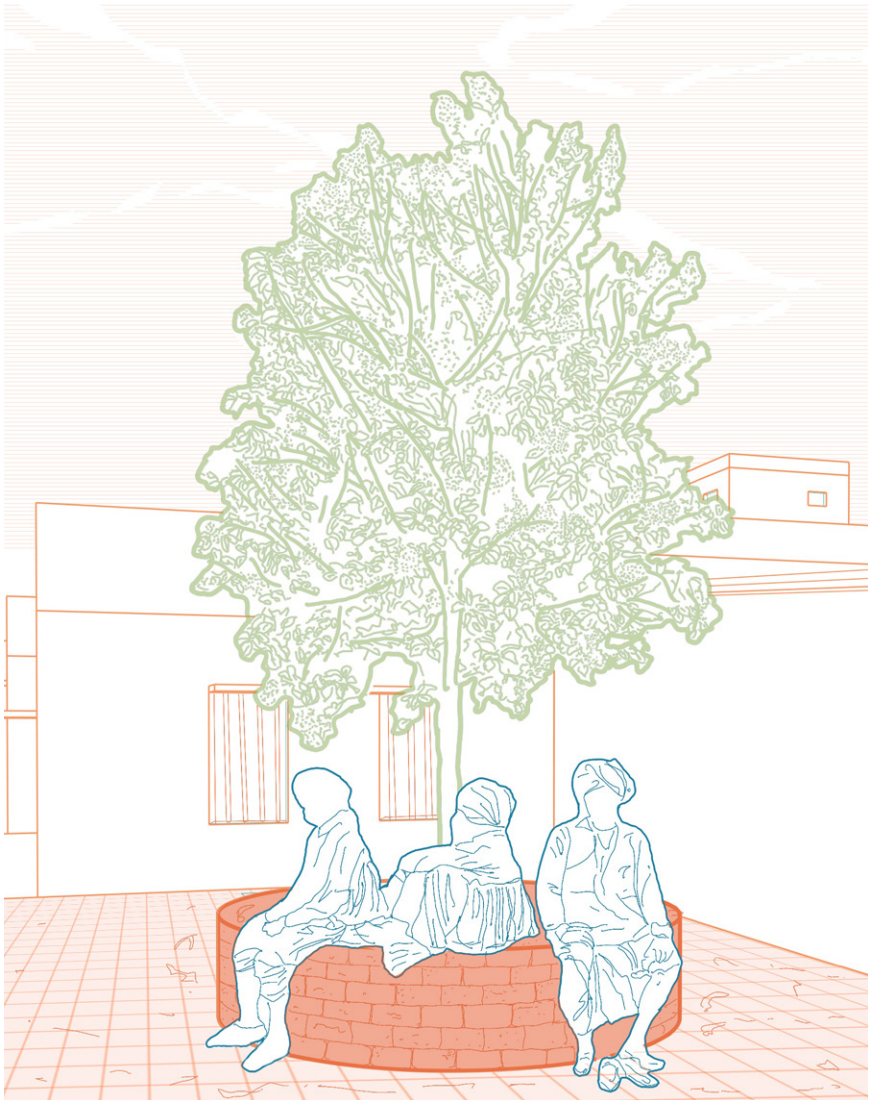


Fig 4.53 - View of informal seating space around existing and proposed trees.

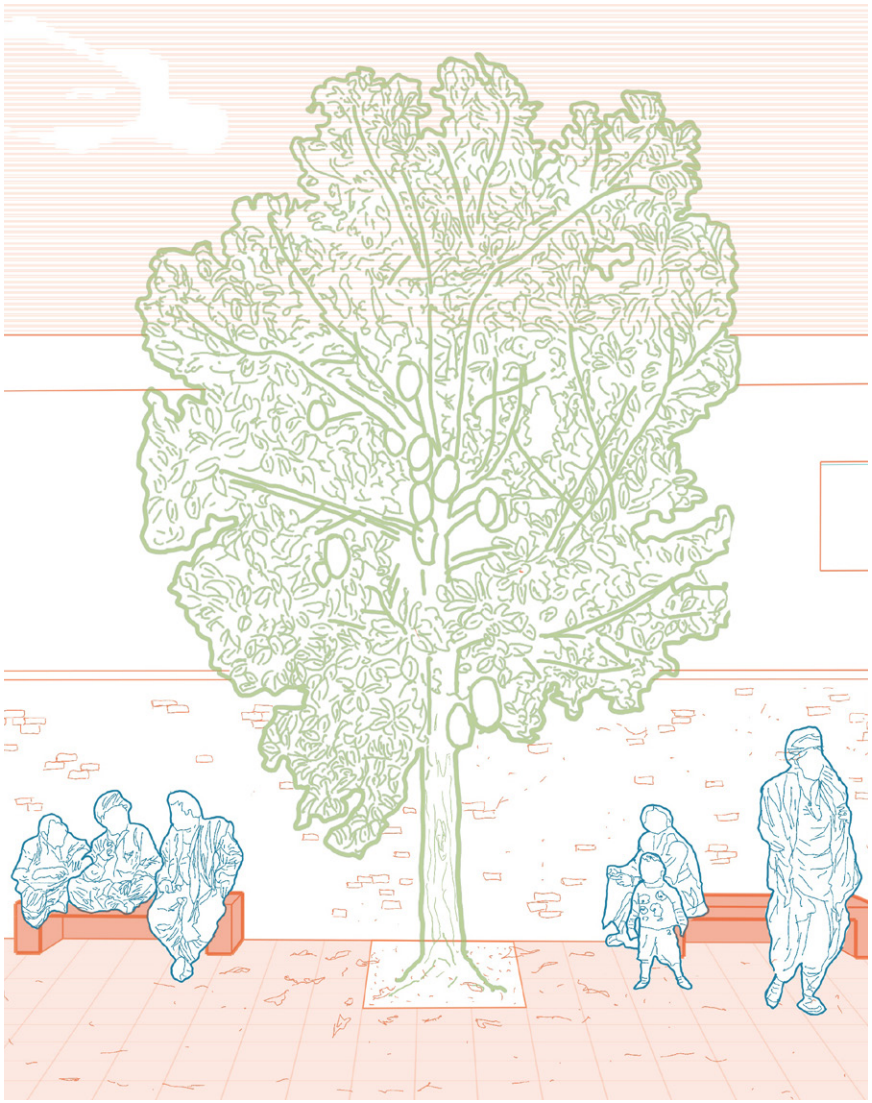


Fig 4.54 - View of informal seating insertions within the residential community.



Fig 4.55 - View of formal seating space designed around an open recharge pit.



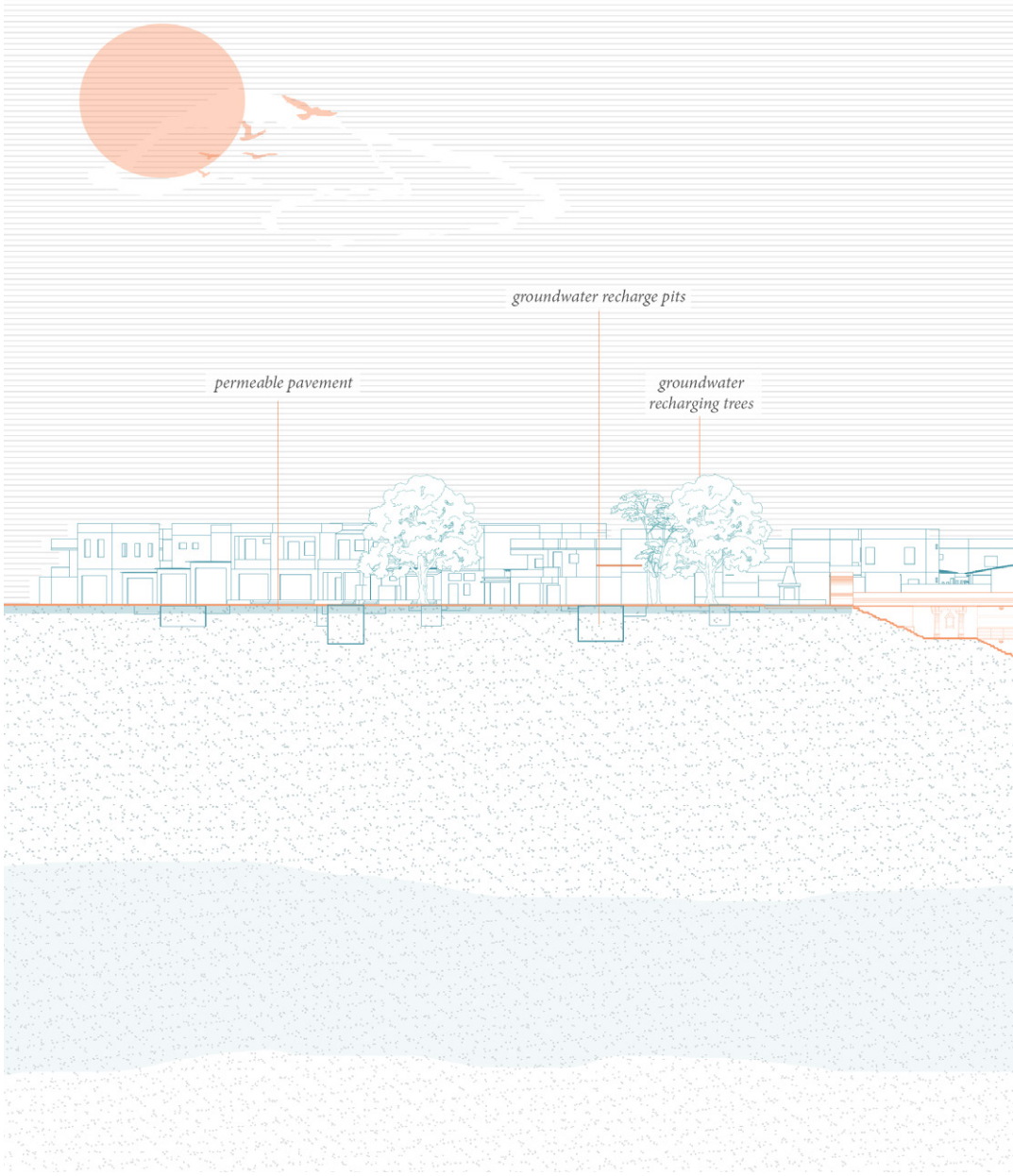
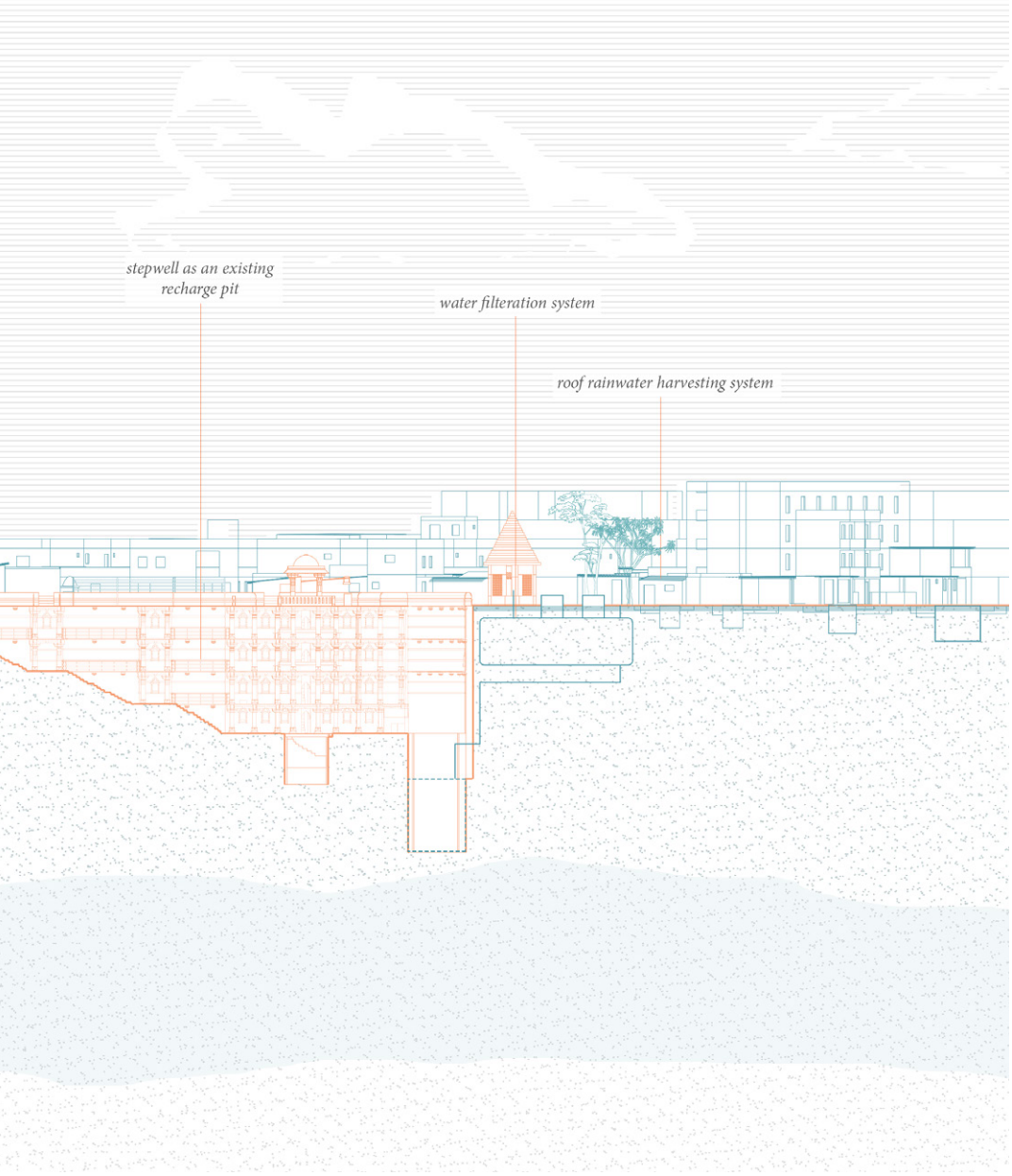
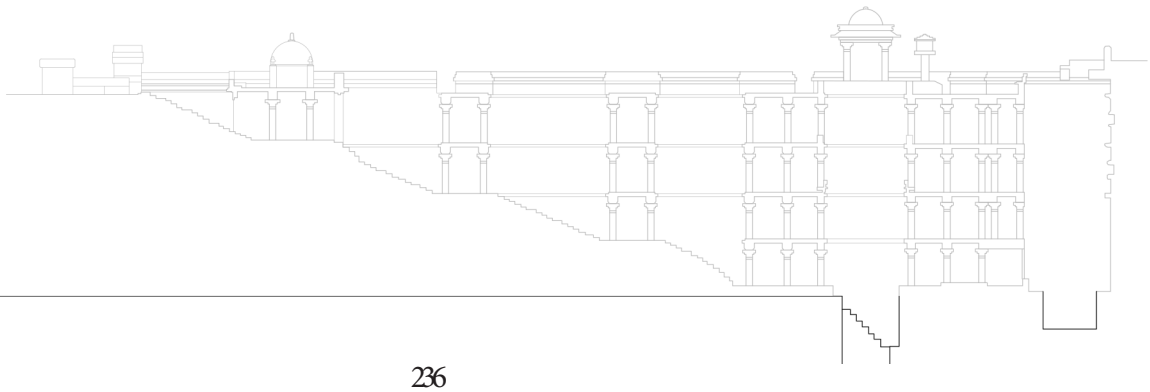


Fig 4.56 - Overview of proposed groundwater recharge strategies.


stepwell as an existing recharge pit
water filteration system
roof rainwater harvesting system

Conclusion



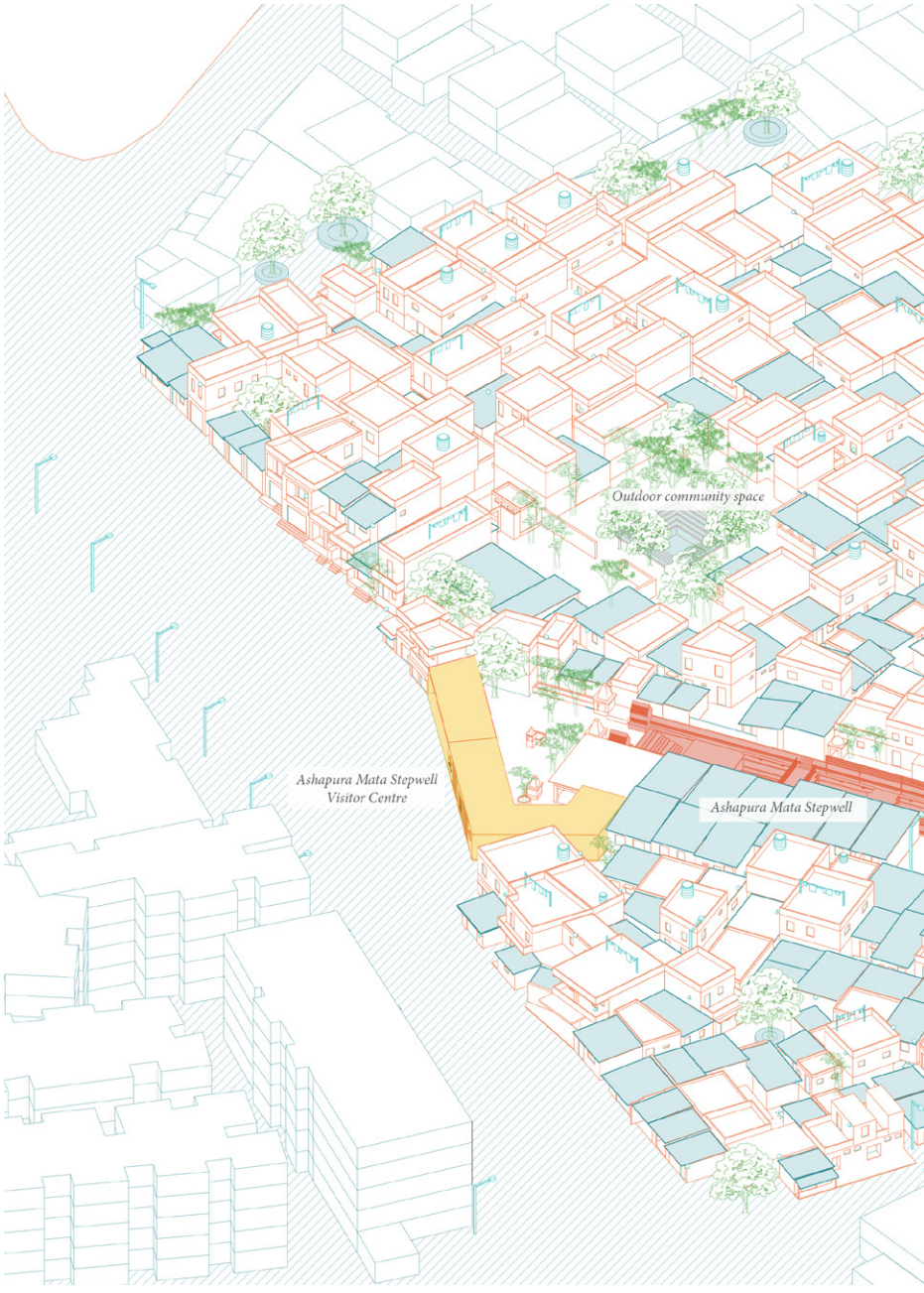
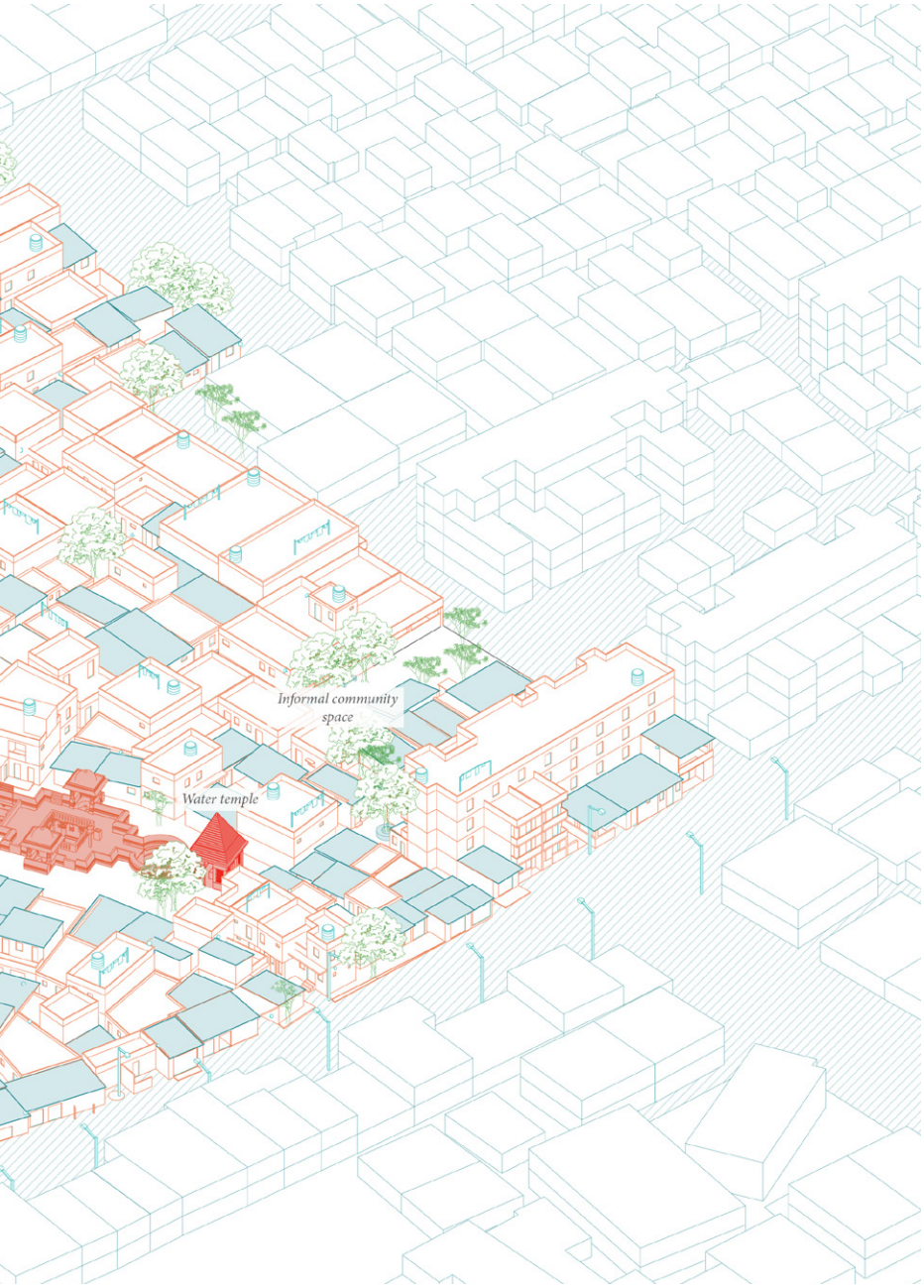


Fig 5.1 - Reimagined stepwell and its surrounding neighborhood.


Informal community space
Water temple

This thesis research observes the various aspects involved in the conscious restoration of historical sites. As stepwells have previously served as both utilitarian structures and communal gathering spaces, it became crucial to unfold the underlying layers of these urban artifacts. The design strategies proposed in this thesis are carefully crafted to bring back the cultural, social, and religious value of stepwells, making them a prominent architecture for society. Revival of the structure along with the historical past is a way to respect the heritage and honor the ancient wisdom of craftsmen.

The theories of Aldo Rossi on permeance laid out a critical framework for understanding the stepwell and the context as a collective entity. While the stepwells once displayed propelling permeance, most of them have become pathological sites now. Through the restoration of Ashapura Mata Stepwell, the idea of transforming a pathological site into a propelling site is demonstrated. The site not only restores stepwell as a space but the community as a whole. Opening the stepwell for the local community and the public enables the stepwell to become an icon of social life in the urban context.

In the urban setting of Ashapura Mata Stepwell, the activities and needs of the surrounding community are mirrored in the structure itself. Historically, stepwells served as communal gathering spaces, with the community acting as their primary caretakers. The restoration of the stepwell not only involved recharging groundwater but also repurposed it as a catchment zone for rainwater harvesting. The proposed design interventions at the community level further enhance the recharging of aquifers, making the well's water a valuable resource for residents. Each strategy in this thesis serves a dual purpose in revitalizing the site, emphasizing the importance of understanding the immediate context to develop effective restoration solutions.

The current government proposals for the restoration of stepwells focus solely on the stepwell alone. However, it is crucial to integrate strategies that replenish aquifers to ensure a sustainable water supply within the stepwells. The macro-level strategies proposed in this thesis should be enforced with the overall stepwell restoration plans and policies. Although groundwater recharge strategies are proposed only for the site, these strategies can be implemented anywhere in the city.

While water still plays as an indispensable necessity in human life it becomes crucial to use it consciously. When this resource becomes a personal commodity, its value becomes more apparent. Enhancing the engagement with the local community promotes the stewardship of the water resources. This way the local community calls for the embracement of sustainable alternatives.

In conclusion, this thesis research sets out as an example way to adopt the local context into the restoration plans. While there are several unprotected stepwells with similar contexts in the city of Ahmedabad, the strategies used in this project can be reflected in the restoration of other stepwells in the city and the country. This promotes the historical life of stepwells in cultural institutions and makes them the next space of cultural belonging.



Fig 5.2 - Reimagined Stepwell, safety ledges with railing provided to improve accessibility.





Fig 5.3 - Reimagined Stepwell, textile workshop space for women from the local community.





Fig 5.4 - Reimagined Stepwell, Sculpture gallery with ancient artefacts.

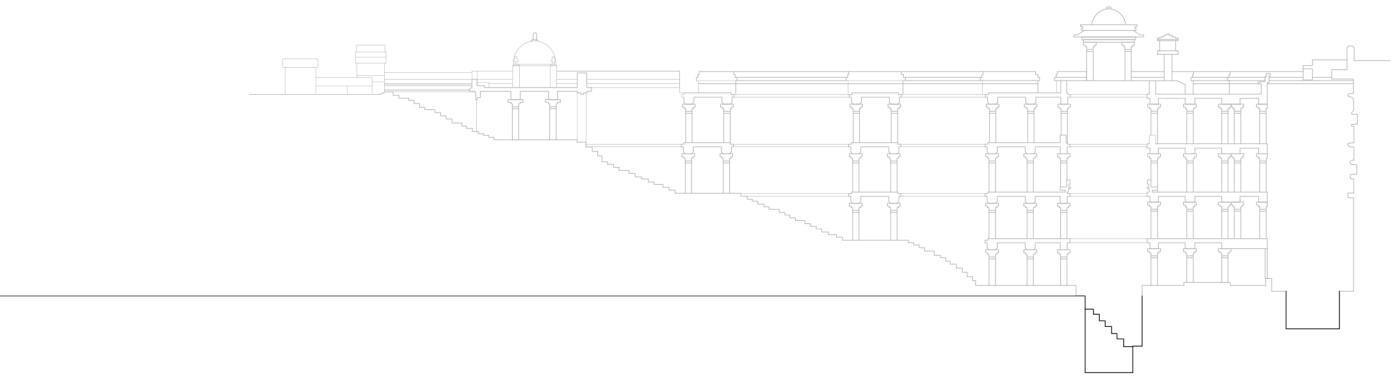




Fig 5.5 - Reimagined Stepwell, dedicated worship and ritual space on the bottom level connecting to water.



Bibliography



- Bhatt, Purnima Mehta, and Daniel del Solar. Her space, her story: Exploring the stepwells of Gujarat. Zubaan, 2014.

- Bhattarai, Nishan, David B. Lobell, Balwinder-Singh, Ram Fishman, William P. Kustas, Yadu Pokhrel, and Meha Jain. "Warming Temperatures Exacerbate Groundwater Depletion Rates in India." Science Advances 9, no. 35 (September 2023).
doi.org/10.1126/sciadv.adi1401.

- "Bengaluru Is Not Alone, Other Indian Cities Too Could Soon Face Water Crisis." Times of India, March 27, 2024.
www.indiatimes.com/news/india/bengaluru-is-not-alone-other-indian-cities-too-could-soon-face-water-crisis-630882.html.

- Hossain, Md Toukir. "Why Is Ahmedabad Considered a UNESCO World Heritage Centre." RTF | Rethinking The Future, April 3, 2023. https://www.re-thinkingthefuture.com/city-and-architecture/a8659-why-is-ahmedabad-considered-a-unesco-world-heritage-centre/.

- "How Much Water Is Needed in Emergencies." WHO WEDC. Accessed March 2024.
cdn.who.int/media/docs/default-source/wash-documents/who-tn-09-how-much-water-is-needed.pdf.

- Jain-Neubauer, Jutta. The Stepwells of Gujarat: in Art-Historical Perspective. 1st ed. New Delhi: Abhinav, 1981.

- Jansen, M. "Water Supply and Sewage Disposal at Mohenjo-Daro." World Archaeology 21, no. 2 (1989): 177–92.
www.jstor.org/stable/124907.

- Lautman, Victoria, and Divay Gupta. The Vanishing Stepwells of India. London; Merrell Publishers Ltd, 2017.

- Lesser-known stepwells in and around Ahmedabad and Gandhinagar region. Urban Management Center, February 2018.

- Livingston, Morna, and Beach. Steps to Water: The Ancient Stepwells of India. New York: Princeton Architectural Press, 2002.

- National Institute of Urban Affairs. "Impacts of Changing Climate on Water Resources – Consequences for Indian Cities." C-Cube Blog.

- News, Posted by AMERICAN. "The History of Water Infrastructure and What We Can Learn from It." American USA News, September 29, 2016.

- Padhmanaban, Vishnu, and Prachi Srivatsava. "Which Indian City Will Run out of Water First?" Mint, August 4, 2019.
www.livemint.com/news/india/which-indian-city-will-run-out-of-water-first-1564920315004.html.

- Pandey, Pooran Chandra. "India Has 16% of the Global Population but Only 4% of Total Water Resources, Resulting in Water Scarcity in Many Regions." Climate Scorecard, September 13, 2023.
www.climatescorecard.org/2023/09/india-has-16-of-the-global-population-but-only-4-of-total-water-resources-resulting-in-water-scarcity-in-many-regions/.

- *Parmara, Samirsinh P., and Debi Prasad Mishra. "Fractal Geometry in Water Conservation Structures: Step Wells and Tanks in India." Indian Journal of History of Science 55, no. 2 (September 2, 2020). doi.org/10.16943/ijhs/2020/v55i2/154675.*

- *Parmar, Jignesh. "AMC Plans to Drill More Borewells sans CGWB Nod amid Groundwater Crisis." Times of India, August 1, 2023. timesofindia.indiatimes.com/city/ahmedabad/amc-plans-to-drill-more-borewells-sans-cgwb-nod-amid-groundwater-crisis/articleshow/102294757.cms.*

- *"Policy for Rainwater Harvesting." Press Information Bureau, 2023. pib.gov.in/PressReleaseIframePage.aspx?PRID=1914351.*

- *Press Information Bureau. "Central Government has formulated National Action Plan for control of air pollution in urban and industrial areas." Accessed 30th April 2024. pib.gov.in/PressReleaseIframePage.aspx?PRID=1914351.*

- *Singh, Ram Kinkar. "Shortage of Tankers Add to Delhi's Water Woes amid Heatwave Conditions." India Today, 2024. w ww.indiatoday.in/cities/delhi/story/delhi-water-crisis-shortage-tanker-heatwave-summer-2554459-2024-06-17.*

- *"Stepwells of India (Jal Mandir)." Press Information Bureau, 2022. static.pib.gov.in/WriteReadData/specificdocs/documents/2022/jun/doc202262267001.pdf.*

- Tandon, Aakansha. "Groundwater Level in Ahmedabad Is Third Deepest across the Country, Rajya Sabha Told." Republic , August 2, 2021. h www.republicworld.com/india/groundwater-level-in-ahmedabad-is-third-deepest-across-the-country-rajya-sabha-told/?amp=1.

- Urbanet. "Urbanisation in India: Infographics." Urbanet, January 2, 2024. urbanet.info/urbanisation-in-india-infographics/.

- Vogt, Adolf Max. Aldo Rossi: The Architecture of the City. New York: Society of Architectural Historians, 1983.

- X, Science. "Pollution Risks Worsening Global Water Scarcity: Study." Phys. org, February 6, 2024. https://phys.org/news/2024-02-pollution-worsening-global-scarcity.html.