POETICS OF WATER

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

Dhaka was built on the banks of the river Buriganga around 700 AD. Over the last 400 years, it has grown into one of the most densely populated cities in the world. Every year, Dhaka sees an influx of migrants, who move to the city in search of jobs and a better life. With this rapid growth in the population of the city, the urban fabric is also growing rapidly. Waterbodies are rapidly being filled up, canals are being fragmented, and economic disparities are becoming wider.

The city started because of the presence of water; water allowed its growth, and water created an agriculturally rich ground for farming and the livelihoods of the people of the country. Dhaka has been isolated from water by planners and developers. Every monsoon season, Dhaka suffers from severe flooding. Since the devastating flood of 1988, the western part of Dhaka has been surrounded by an embankment system. This embankment now causes waterlogging: the pumps and sluices built along the embankment cannot extract enough trapped water during the rainy season.

This thesis is an exploration of the relationship between the city and water. It attempts to reconnect land, water and people through urban, landscape, and architectural design. It proposes strategies for flood mitigation and water management in the city. Then, it proposes a design at a microscale that can act as a prototype for urban resilience and sustainable design. The aim of the design proposal at the end of this thesis is to suggest a means to connect the city and the people back to water.

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DEDICATION

To the people who were part of my childhood and youth in Dhaka – You are the reason I remember the city with so much love.

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0. Prelude

Legend has it that once upon a time, the Ganga,[1] the enormous river that flows from the Himalayas to the Bay of Bengal, made its approach to the sea through present-day Dhaka. Over the course of hundreds of years, the Ganga changed its trajectory, separating itself from the original river (Figure 0.1). This river that was left behind is called the Buriganga today. Buri ganga means Old Ganga.

The author could not verify this oral history with citation.

1 Ganga and Ganges are used interchangeably in this thesis.

Figure 0.1: Buriganga River and Padma River in relation to Dhaka

The following eight images (Figure 0.2 - 0.9) were photographed by Shamim Shorif Susom. He is a pilot, and as he flies over Bangladesh, he captures its beauty. These aerial photographs were published in the Guardian in 2016, and they are also available on his website.[2] They are reproduced here with permission.

When I first came across these photographs, they spoke to me, to this thesis, to what I am trying to convey. The following chapters talk about the destructive qualities of water and the devastation it causes. But water is not always destructive. It is flaws in our design, our desire to separate and isolate water from us, that have resulted in this situation. These images show the beauty and peacefulness of water.

2 Shamim Susom, "A Pilot's View of Bangladesh – in Pictures." The Guardian, 26 Aug. 2016, https://www.theguardian.com/global-development-professionals-network/gallery/2016/aug/26/pilots-aerial-view-bangladesh-in-pictures.

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MEMORIES AND NOSTALGIA

I stood on the balcony waiting. The wind against my face was getting stronger and stronger. There were only a few meters between us and the opposite house, but with my eyes closed, it felt like it was just me and nature. People were running to their rooftops, gathering the clothes they had hung there to dry. The rickshaws on the streets were stopping on the side, taking out thin pieces of plastic from under the seats to use as covers for the passengers. The vendors on the street started wrapping up the colorful bangles, the handmade clay potteries, the flowers, the little toys. People in their homes could be seen at the windows and on balconies looking up into the sky. Everyone was excited. Day was turning as dark as night. The north-western wind was getting stronger and stronger. After the long summer days, it was the first sign of cool for all – the people living in the slums in single rooms with their entire family, the little child running along the roads trying to sell some peanuts, the mother carrying bricks in the hot sunny afternoon, the father in the crammed bus coming back from work. It was a sign of blessing from the sky. The first storm was always special. This storm was so strong: so much wind and so much rain – the Bengalis call it "Kal Boishakhi Jhor."

The months following the first rain of the season are not the same. Bengalis have not adapted to the monsoon. We have accepted it, yes, but it terms of resilience and adaptability, we have a lot to learn. Houses are wrecked, roads are flooded, thousands of people become homeless every monsoon. The media portray the rain as the enemy of the people. People see the rain as their enemy. We forget that water is not our enemy–it is what gives us life.

Figure 0.10 is a collage I created in response to this memory.

-Author's personal entry
November 2017

Figure 0.10: Rainy Day.

WATER IN BENGALI POETRY

To start the exploration of the connection between water and the city the literature of Tagore is used. Rabindranath Tagore was a Nobel Laureate from Bengal, and he wrote several poems about rain, river, and Baishakh. The English translations of his poems do not do justice to the emotions that he conveyed through his poems, but hopefully some of the essence carries through. The Bengali calendar starts on April 14th, and every year, people welcome the Bengali New Year, known as Pahela Boishakh, with processions, festivities, traditional food, and cultural performances. The following song is the most iconic song sung every year at every event to welcome the first day of Baishakh, the season of storms and rain. Figures 0.11 - 0.13 are photographs of the celebrations on this day.

এসো, এসো, এসো হে বৈশাখ
তাপসনশ্বিাসবায়ে মুমূর্ষুরে দাও উড়ায়ে,
বৎসররে আবর্জনা দূর হয়ে যাক
যাক পুরাতন স্মৃতি, যাক ভুলে যাওয়া গীতি,
অশ্রুবাষ্প সুদূরে মিলাক।
মুছে যাক গ্লানি, ঘুচে যাক জরা,
অগ্নস্নিানে শুচি হোক ধরা
রসরে আবশেরাশি শুষ্ক করি দাও আসি,
আনো আনো আনো তব প্রলয়রে শাঁখ
মায়ার কুজ্ঝটজিাল যাক দূরে যাক।[3]

Welcome, welcome, welcome O Baishakh
Dust away all that's dying with your ascetic breath
Let the year's dross go.
Let go old memories, let go forgotten melodies,
Let mists of the eye thin far away into dissolution.
Let weariness be erased, infirmity cease,
Hallowed be the Earth to bathe in your fire
Come and dry all the sap of slush,
Bring forth and sound your conch of annihilation.
Let the foggy mesh of illusion be gone.[4]

3 Rabindranath Tagore, *Geetobitan* (Kolkata: Biswa Varati University, 2012).

4 Rabindranath Tagore, "Esho He Boishakh [O Boishakh, I Call on You]," trans. Sumana Roy, modified by author, accessed July 2 2019, https://free219467.wordpress.com/2017/06/08/esho-he-boishakh-o-boishakh-i-call-on-you/.

Figure 0.11: People from all walks of life came together to create this hand painting (Alpona) in front of the National Parliament Building in Dhaka to commemorate Pohela Baishakh.

Figure 0.12: Procession carried out on the morning of Pohela Baishakh.

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The following poem is “Our Little River” by Tagore. Every child in every school in Bengal learns this poem in elementary school. We remember the poem into adulthood. The poem describes how people and river coexisted, how water and land coexisted. People and nature helped each other. When it rained and the river became full, it was an occasion for celebration. Figures 0.14 and 0.15 are photographs of the river mentioned in this poem.

আমাদের ছোট নদী চলে বাঁকে বাঁকে
বৈশাখ মাসে তার হাঁটু জল থাকে।
পার হয়ে যায় গরু, পার হয় গাড়ি,
দুই ধার উঁচু তার, ঢালু তার পাড়ি।
চিকি্ চিকি্ করে বালি, কোথা নাই কাদা,
একধারে কাশবন ফুলে ফুলে সাদা।
কিচিমিচি করে সেথা শালিকিরে ঝাঁক,
রাতে ওঠে থেকে থেকে শেয়োলেরে হাঁক।

আর-পারে আমবন তালবন চলে,
গাঁয়ের বামুন পাড়া তারি ছায়াতলে।
তীরে তীরে ছলে মেয়ে নাইবার কালে
গামছায় জল ভরি গায়ে তারা ঢালে।
সকালে বিকালে কভু নাওয়া হলে পরে
আঁচল ছাঁকয়িা তারা ছোটো মাছ ধরে।
বালি দিয়ে মাজেথালা, ঘটিগুলি মাজে,
বধূরা কাপড় কেচে যায় গৃহকাজে।
আষাঢে বাদল নামে, নদী ভর ভর
মাতিয়া ছুটয়িা চলে ধারা খরতর।
মহাবেগে কলকল কোলাহল ওঠে,
ঘোলা জলে পাকগুলি ঘুরে ঘুরে ছোটে।
দুই কূলে বনে বনে পড়ে যায় সাড়া,
বরষার উৎসব জেগে ওঠে পাড়া।।[5]

Our little river flows in graceful loops
On summer months water is knee high.
Cattle crosses, car crosses with ease,
Her banks are high, her depths are shallow.
The sand glitters, no mud to be seen,
On one side the white kash flowers shimmer.
Flocks of mynas chirp busily all day
And jackal calls arise at night

5 Tagore, *Geetobitan*.

This bank shelters sleepy hamlets in the shade
Of ranks of ancient mango and palm tree
At bath times, children swim and play
Splashing water at each other in noisy glee
Morning or afternoon as their bathing is done
They catch little fish in nets of cloth
With sand the wives wash their pots and pans
With water they wash their clothes then they go home
When the rains descend, the river swells fast
Rushing waters raise voice in happy uproar,
The muddy torrent spins in eddies and swirls
Both banks uniting in joyous clamor
Awake, to join in the festival of rain[6]

6 Rabindranath Tagore "Amader Chhoto Nodi Chole Bnāke [Our Little River]," trans. Unknown, modified by author, https://animikha.wordpress.com/2012/01/16/amader-chhoto-nodi-chole-bnake-bnakeour-little-river/.

Figure 0.14: Kopai River.

Kopai River flowing through Shantiniketan where Tagore established his school. The river is almost dry during dry seasons. Over the years it has lost its fullness and shrunk to a very narrow river.

Figure 0.15: Kopai River.

Kopai river which inspired many literature once is now a narrow tickling river during the peak of summer.

Tagore always celebrated the beginning of his favorite season – the monsoon with Barsha Mangal. It was the festival that welcomed the first of rain in June. Tagore, however, did not ignore the ferocity of rain in his writing. Figures 0.16 and 0.17 are photographs representing the darkness of the storm.

নীল নবঘনে আষাঢ়গগনে তলি ঠাঁই আর নাহিরে।
ওগো, আজ তোরা যাস নে ঘরের বাহিরে।।
বাদলরে ধারা ঝরে ঝরো-ঝরো, আউষরে ক্ষতে জলে ভরো-ভরো,
কালমিখা মেঘে ও পারে আঁধার ঘনয়িছে দেখ্ চাহিরে।।

ওই শোনো শোনে পারে যাবে বলে কে ডাকিছে বুঝি মাঝিরে।
খয়ো-পারাপার বন্ধ হয়েছে আজিরে।
পুবে হাওয়া বয়, কূলে নেই কেউ, দু কূল বাহিয়া উঠে পড়ে ঢেউ--
দরো-দরো বেগে জলে পড়ি জল ছলো-ছল উঠে বাজিরে।
খয়ো-পারাপার বন্ধ হয়েছে আজিরে।।

ওই ডাকে শোনো ধেনু ঘন ঘন, ধবলীরে আনো গোহালে
এখনি আঁধার হবে বলোটুকু পোহাল।
দুয়ারে দাঁড়ায়ে ওগো দেখ্ দেখি, মাঠে গেছে যারা তারা ফিরিছে কি,
রাখালবালক কী জানি কোথায় সারা দিন আজি খোয়ালে।
এখনি আঁধার হবে বেলাটুকু পোহালে।।

ওগো, আজ তোরা যাস নে গো তোরা যাস নে ঘররে ঘরের বাহিরে।
আকাশ আঁধার, বলো বেশি আর নাহিরে।
ঝরো-ঝরো ধারে ভিজিবে নিচোল, ঘাটে যেতে পথ হয়েছে পছিল--
ওই বণুবন দোলে ঘন ঘন পথপাশে দেখ্ চাহিরে।।[7]

Sullen clouds are gathering fast over the black fringe of the forest.
O child, do not go out!
The palm trees in a row by the lake are smiting their heads against the dismal sky; the crows with their dragged wings are silent on the tamarind branches, and the eastern bank of the river is haunted by a deepening gloom.
Our cow is lowing loud, tied at the fence.
O child, wait here till I bring her into the stall.
Men have crowded into the flooded field to catch the fishes as they escape from the overflowing ponds; the rain-water is running in rills through the narrow lanes like a laughing boy who has run away from his mother to tease her.

7 Tagore, *Geetobitan*.

Listen, someone is shouting for the boatman at the ford.
O child, the daylight is dim, and the crossing at the ferry
is closed.
The sky seems to ride fast upon the madly rushing rain; the
water in the river is loud and impatient; women have hastened home
early from the Ganges with their filled pitchers.
The evening lamps must be made ready.
O child, do not go out!
The road to the market is desolate, the lane to the river is
slippery. The wind is roaring and struggling among the bamboo
branches like a wild beast tangled in a net.[8]

8 Rabindranath Tagore, "The Rainy Day," trans. Unknown, https://www.poemhunter.com/best-poems/rabindranath-tagore/the-rainy-day-2/.

Figure 0.16: A storm is coming.

Figure 0.17: Dhaka before rain.

THE RIVERS FLOWING THROUGH BANGLADESH

Bangladesh is located on the flood plain of three major river systems - Ganges, Brahmaputra and Meghna - along with two hundred and thirty-seven rivers that make up their tributaries. Fifty-seven of these rivers cross several countries and ultimately flow through Bangladesh to reach the Bay of Bengal. About 1000 cubic kilometers of water is carried by these rivers to Bangladesh every year; 85 percent of this water flows during the monsoon season. [9]

Figure 0.18 shows the location of Bangladesh and Figure 0.19 is a map of Bangladesh in relation to the surrounding mountains, rivers and the Bay of Bengal.

The three river system drains water from a catchment area that is 1.72 million square kilometers; 7 percent of this catchment area is within Bangladesh. The placement of these rivers poses some serious issues for Bangladesh both during monsoon and summer. The countries surrounding Bangladesh, mainly India, have the power to control the water upstream. Since the level of water flowing into Bangladesh is controlled by other countries, during wet season, Bangladesh has excess water and has to deal with flooding while in the winter, lack of water creates a problem for irrigation and agricultural productivity.

Brahmaputra originates in Tibet and is called Yarlung Tsangpo there. It flows through China and India (where it is called Brahmaputra) and enters Bangladesh from the north. Upon entering Bangladesh, the river continues south and is called Jamuna. Jamuna plays an important role in irrigation and transportation.

Ganges river originates in India, and enters Bangladesh from the west. Ganges joins Jamuna to become Padma.

Meghna river originates in Bangladesh. It is formed by the confluence of other rivers originating in Eastern India. Meghna river joins Padma, becoming Lower Meghna river, and eventually makes its way to the Bay of Bengal.

9 "Bangladesh Water Resources." AQUASTAT - FAO's Information System on Water and Agriculture. Food and Agriculture Organization of the United Nations. Accessed February 20, 2020. http://www.fao.org/nr/water/aquastat/countries_regions/Profile_segments/BGD-WR_eng.stm.

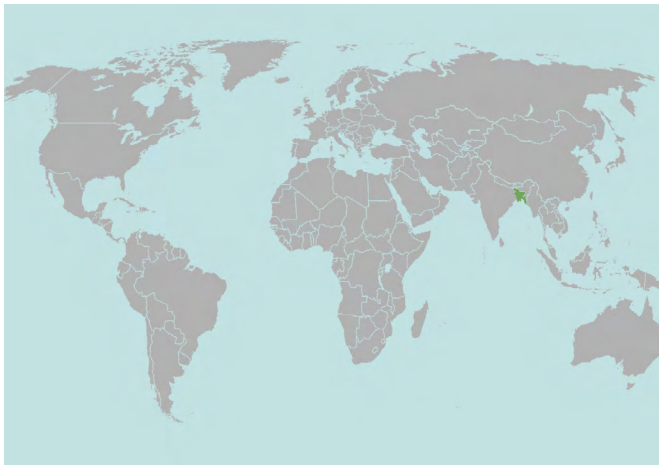


Figure 0.18: Location of Bangladesh. (Top)

Figure 0.19: Bangladesh in relation to its surroundings. (Bottom)

WATER AND THE CITY

Anuradha Mathur and Dilip da Cunha ask, "When water is everywhere, why do we see it somewhere?" They refer to rivers on maps.[10] The lines that we see in these maps are drawn by humans – at some point in time they saw the river following a path, and they decided that is where the water would always remain. We need to consider that river water is only one form of water, and that it is specific to that time and season. In the winter, the river can be drier; during the monsoon, it can be fuller. We cannot expect the river to stay in just one place. Major rivers flow through Nepal, India, and Bangladesh – Ganges and Brahmaputra. On maps, they are shown as starting in the Himalayas. Rain falls everywhere; then why are rivers drawn as starting from the Himalayas? Mathur and Cunha point out that this confinement of rivers on maps is an act of design and not documentation.[11] We cannot design nature; we have to live with nature. Figure 0.20 shows how the course of the rivers flowing through Bangladesh changed over the years.

This thesis explores the relationship between water and land in Bangladesh. It is a response to my 18 years in the beautiful city of Dhaka. It is a response to nostalgia. It is a homage to the rainy days and the knee-high rain, the stalling cars, the gusts of wind during evening tea, the unbearable traffic, the beautiful smile of the flower girl taking advantage of the cars stalled by traffic. This thesis brings up many problems and shortcomings of the city. I talk about the hardships of the people and the injustices that many face. At the core of it all is the desire to contribute to Bengali society – to understand the problem and to come up with possible solutions. I want to learn about the issues, and I want to ask, what can we do?

Flooding is one of the biggest problems in Bangladesh, and there are constant studies, research, and developments on this topic. However, research information are often not readily available in Bangladesh, and throughout my research, I have found that much of the available data were inconsistent. For this thesis, I have used my best judgment in determining the most reliable source, and I have based my research on the materials that were available and on my experience in living in the city for the first eighteen years of my life.

10 Anuradha Mathur and Dilip Cunha, "In the Terrain of Rain." YouTube. Nov 17, 2016. https://www.youtube.com/watch?v=I7A8Sz-yEWQ&t=917s.

11 Ibid.

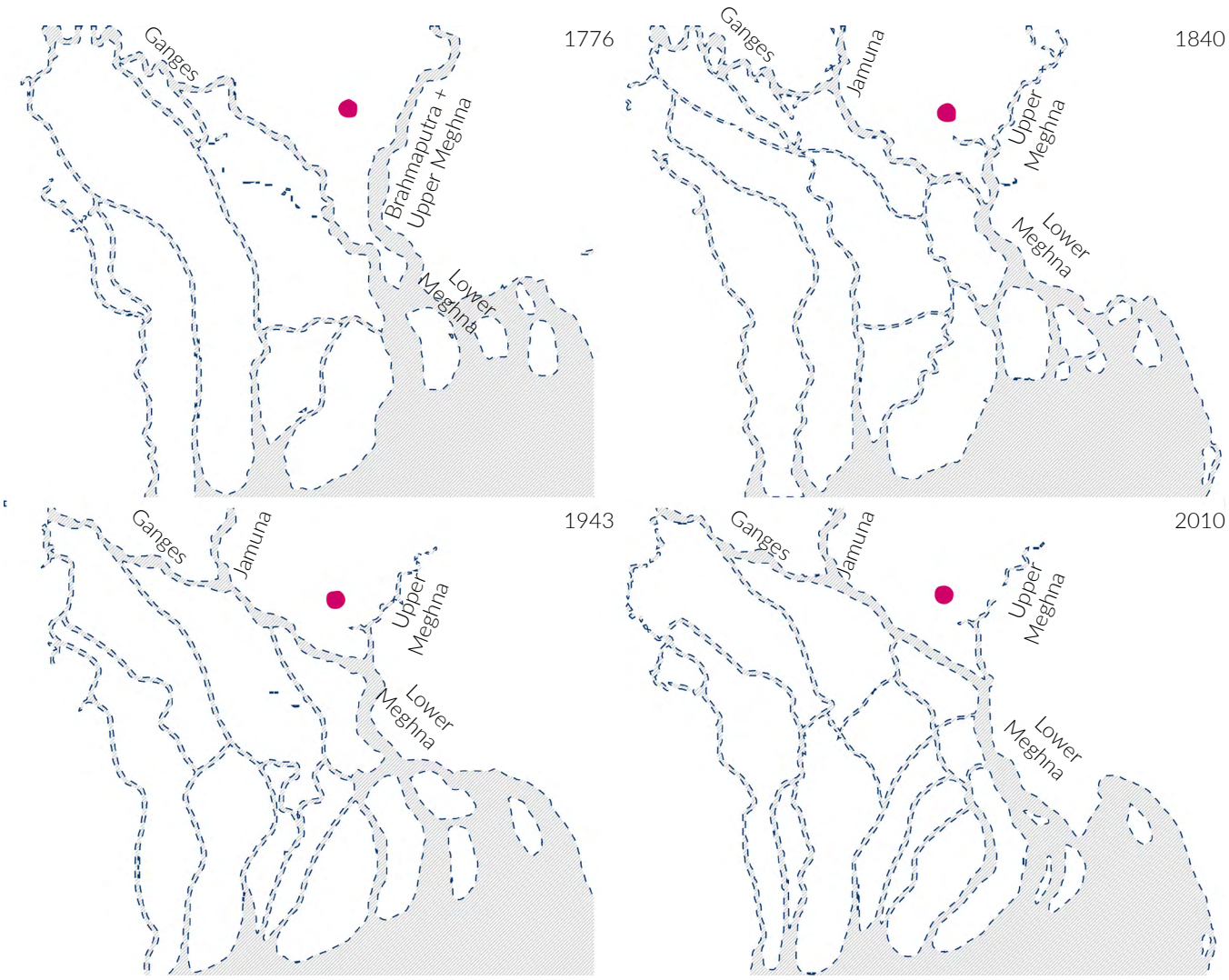


Figure 0.20: Chronological development of the main rivers of Bangladesh.

The site for this thesis is Dhaka, Bangladesh. It is home to 17 million people living in an area of 265 square kilometers. Flood is one of the biggest problems the people of Dhaka face every year. Typically, the country is most susceptible to flooding between June and October.[12] Two of the biggest contributing factors for flood in the city are monsoon rain and the overflowing of the Buriganga river at the edge of the city. Relief rainfall and melt water from the Himalayas are also contributing factors.[13] Last, the loss of wetland and the embankment constructed in 1988 have given rise to urban flooding.[14]

Bangladesh has 237 rivers. Two major rivers flow from the Himalayas and surrounding countries, meet in Bangladesh, and they drain into the Bay of Bengal. Dhaka is surrounded by rivers and canals.[15] During the monsoon, they overflow. The melting ice cap of the Himalayas combines with increased rain during the monsoon season, leading to frequent flooding in Bangladesh. The capital of Bangladesh is Dhaka, which is the urban center of the country, and it lies north of the enormous River Ganges (called Padma in Bangladesh).

Every year, thousands of people migrate to Dhaka. This is leading to an increase in population. The infrastructure of Dhaka is not expanding as fast as the population, leading to a housing crisis and infrastructure problems. This, combined with climate change, is affecting the people of Dhaka, and it is causing displacement every year. The floods in the city can be divided into two categories: urban floods and river floods. During heavy rainfall, the west side of the city floods due to poor infrastructure and drainage problems, and the east of the city floods due to the overflowing of the river.[16]

The city of Dhaka developed in the Bengal Delta.[17] The Bengal Delta runs from the Himalayas through West Bengal and Bangladesh, and it ends at the Bay of Bengal. Rivers from Bhutan, Tibet, and Nepal also drain into this

12 Mizanur Rahman, Amirul Hossain, and Amartya Bhattacharya, "Flood Management in the Flood Plain of Bangladesh," Academia.edu, Accessed March 3 2019, https://www.academia.edu/702051/Flood_Management_in_the_Flood_Plain_of_Bangladesh.

13 Pawel Prokop and Adam Walanus, "Impact of the Darjeeling-Bhutan Himalayan Front on Rainfall Hazard Patterns," Natural Hazards 89, no. 1 (2017): 387-404, https://doi-org/10.1007/s11069-017-2970-8.

14 Kazi Ashraf, "Water as Ground," in *Design in the Terrain of Water*, edited by A. Mathur and D. D. Cunha (Philadelphia: Applied Research + Design Publishing with the University of Pennsylvania School of Design, 2014), 91-97.

15 Rahman, Hossain, and Bhattacharya, "Flood Management," 1.

16 Ibid.

17 Ashraf, "Water as Ground," 91 - 97.

delta. It is the largest delta in the region, and this was the reason for the development of some of the most prominent regional cities there.

Today, the city and the delta are increasingly seen as separate entities.[18] Dhaka is developing at an unprecedented pace. Wetlands, lowlands, and flood plains are rapidly being covered by developers. To keep out the water, embankments were built in 1988, following a series of devastating floods. Kazi Ashraf, in his "Water as Ground," suggests that these embankments be redesigned to allow the passage of water and that the embankments be redefined as edges.[19] Instead of treating them as barriers, he suggests that these embankments be developed into an integral landscape, with boulevards, terraces, drainage systems, and water reservoirs. He also suggests that controlled fractures and openings be used to allow water to flow from both sides into agricultural parks, retention ponds, wetlands, and reservoirs.

Mathur and Cunha, in "Water Everywhere," write, "Is it that we privilege a moment in time, a wishful moment perhaps, when the earth's surface presents itself as divided between land and water?"[20] Water is everywhere, particularly during the monsoon season in Dhaka in the form of floods. Much of Dhaka is only a few meters above sea level, and during floods, these areas are almost completely immersed in water. Dhaka's average rainfall is close to 2,000 mm per year.[21] Poor city planning and a lack of proper infrastructure to drain out water are causing many parts of the city to become clogged with water. In recent years, Dhaka has been through some disastrous floods. Some 85 % of Dhaka was engulfed by water during the flood of 1988.[22] In 1998, 56% of the city was affected by flood, and in 2004, 40% of the city was affected.[23]

Figure 0.21 is an early painting of Dhaka City.

18 Ibid.

19 Ibid.

20 Anuradha Mathur and Dilip Cunha, "Waters Everywhere," in *Design in the Terrain of Water*, edited by A. Mathur and D. D. Cunha, 1st ed. (Philadelphia: Applied Research + Design Publishing with the University of Pennsylvania School of Design, 2014), 1 - 11.

21 Subhendu Roy et al., *Urban Flooding of Greater Dhaka in a Changing Climate* (Washington, DC: World Bank Publications, 2015), 1, https://doi.org/10.1596/978-1-4648-0710-7.

22 Ibid.

23 Ibid.

Figure 0.21: Dhaka City across the Buriganga River. Painting by Frederick William Alexander de Fabeck, 1861.

> Many of the current crises of Dhaka stem from the inability to incorporate the language of a dynamic aquatic landscape into planning mechanisms and policies.[24] - Kazi Ashraf

Dipesh Chakrabarty writes that "today's capitalism feeds off a large pool of migrants, often illegal, labor that is cast aside by many as 'surplus population' – a process that deprives these groups of the enjoyment of any social goods and services, while their labor remains critical to the functioning of the service sector in both advanced and growing economies."[25] Dhaka is no stranger to this. One of the biggest international business sectors that contributes to the economy is the garment industry, exporting its products to North America. This industry relies completely on the surplus population of Dhaka. Housemaids, caretakers, and cleaning services also use this population. These people most often live in slums and poorly constructed high-density housing in flood-vulnerable areas. Today 28%[26] of the people of Dhaka live below the poverty line. Those living in temporary, densely populated, informal settlements are most affected by floods.

The crises that Dhaka is facing right now include shortage of land, housing, and public space, in addition to its annual flood. The people of Dhaka are extremely resilient to this flooding, and their daily life does not and cannot stop in flood conditions. Often, they continue living in their houses with water up to their ankles or knees. Land is so scarce that when people can claim spaces in these unregulated settlements, they do not want to leave. Flood affects their income, and it damages their houses.

If we accept floods as just a natural process and we do not look at them as a disaster, we may be able to design better to accommodate and welcome this form of water and to live alongside it. However, by ignoring nature and expecting it to follow lines we have drawn very recently, we are making our cities unlivable.

---

24 Ashraf, "Water as Ground," 91 - 97.

25 Dipesh Chakrabarty, "Postcolonial Studies and the Challenge of Climate Change," *New Literary History* 43, no. 1 (2012): 1 - 18. http://muse.jhu.edu/journals/new_literary_history/v043/43.1.chakrabarty.html.

26 Barua and van Ast, "Towards Interactive Flood Management."

My thesis started with an exploration of ideas. In the beginning in trying to solve flooding, I was also trying to be pragmatic in my approach – avoiding relocation and accounting for spaces that will be taken over by squatters. I started by looking at Dhaka on different scales and from different perspectives. I explored housing designs, slum designs, and landscape designs. My initial design explorations led to major dilemmas. Any new design involved displacements. I also had no way of guaranteeing that the new design would actually mitigate flooding. Most design explorations require massive overhaul of land areas, none of which I felt comfortable proposing.

Solving the problem of flooding in the city, particularly in a city like Dhaka with a very dense urban fabric, very few open spaces, and limited resources, was beyond the scope of this thesis. What I intend to do in this thesis is to contribute to the conversation on breaking boundaries – boundaries between land and water and boundaries between people. I intend to contribute to the conversation on resiliency and adaptability in Dhaka – the ability for the city to immerse itself in water and to bounce back from it. I propose four strategies[27] *that can be implemented throughout the city. Some of the strategies are small scale, but they will need to be adopted by a large number of people for them to have significant effects. In the final part of the research, the strategies were implemented on the site I had chosen for the small scale intervention: the intersection of Banani Lake (canal) and Karail Basti. The site has buildings with affluent users on one side and informal settlements on the other side. The design proposal was to connect the water bodies currently separated by the informal settlement, connecting the different social classes and connecting the ground to the water. I was not looking to solve the problem of flooding – instead, I proposed a prototype that took account of the problems with the intention of creating an example of how the city can change if it adopts a model of resiliency, sustainability, and adaptability. The design was intended to create a working landscape and an urban center that can improve the quality of water in the canal, promote interaction between social classes, raise the consciousness of individuals of their actions in relation to water, and stitch the urban environment to the canal.*

27 The strategies are
1. Water-retention sunken plazas.
2. Blue and green features.
3. Reconnecting canals for stormwater management.
4. Connecting the city via walkways.
They are elaborated on the strategies section of the thesis starting on page 93.

A NOTE ABOUT METHODOLOGY

I started this thesis not knowing what I wanted the end result to be. What I knew was that I cared about the country I grew up in, the country with countless memories, and I wanted to contribute to its development. Once I established that my thesis would be about flood mitigation, my first step was to get to know Dhaka. I researched the current condition of the city, the flood problems, and possible solutions. One of the biggest challenges I faced during my research was the lack of or inconsistency in data about Dhaka and Bangladesh. For example, I did not find a 100-year flood map (or any reliable flood map), or the exact population of my site. Different sources published different numbers, and in many cases, I used my best judgment, prior knowledge, and experience in living in the country.

Flooding is a big problem for the people and economy of Bangladesh, and therefore it is a very popular topic for researchers, academics, and students in the region. However, the resulting documents are not readily accessible on research databases and in libraries in Canada.

The strategies I suggested were developed from projects and precedents I learned about during my research – later, I came across papers that suggested similar strategies, which strengthened my confidence that my design ideas have the potential of working.

1. Water

GLOBAL PERSPECTIVE ON FLOOD

Geological evidence shows that flood has been one of the most powerful natural events throughout the past. The period we currently live in is termed the quaternary period, and it started 2.5 million years ago. The largest known flood of this period was caused by the breakage of ice dams formed during the ice ages.[1] The ice sheets disrupted large-scale drainage systems, and they led to ice-age floods. These floods all occurred at times of extreme change in the hydrological conditions. Other reasons for flooding were volcanism, breaches of dams, sudden releases of water from ice jam breaks, and floods from rainfall and snowmelt.

Flooding is not new for the world. What is new is the relationship of water to the cities we have built today. Extreme change in the climate and the hydrological cycle is happening again, thus increasing the number of flood-related events and putting vulnerable low-lying countries at risk more than ever. To put the situation into perspective with numbers, between 1995 and 2015, there were 3,062 disaster[2] related flood events worldwide.[3] This made up 43% of all natural events. In the past twenty years, flooding killed 157,000 people and affected 2.3 billion people worldwide. Locations most affected by floods between 2001 and 2016 are highlighted in Figure 1.1.

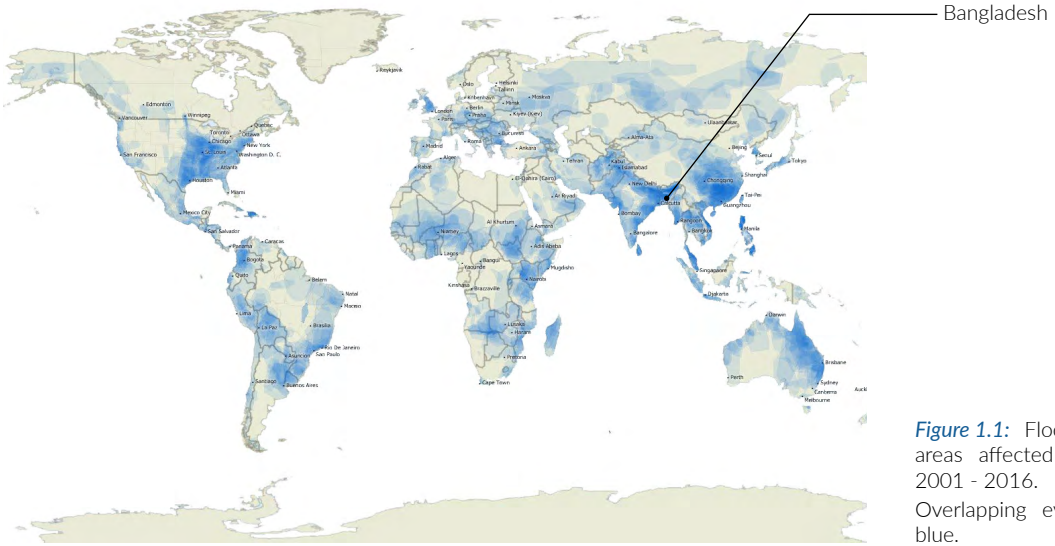


Figure 1.1: Flood Map showing areas affected by flood between 2001 - 2016.
Overlapping events are in darker blue.

1 Jim E. O'Connor and John E. Costa, *The World's Largest Floods, Past and Present their Causes and Magnitudes* (Reston, VA: US Geological Survey, 2004), http://hdl.handle.net/2027/umn.31951d02189484z.

2 Human choices and their pattern of settlement turn hazardous events such as floods into disasters.

3 Richard Davies, "UN – 1995 to 2015, Flood Disasters Affected 2.3 Billion and Killed 157,000," http://floodlist.com/dealing-with-floods/flood-disaster-figures-1995-2015.

BANGLADESH IS A FLOOD PLAIN

Flood plains (Figure 1.2) are low-lying areas adjacent to rivers, and they are important in terms of both flood protection and food production. The fertility of the soil due to its proximity to the river creates farming opportunities, thus attracting human habitats. This creates a contradiction – on one hand flood plains act as low-elevation areas to accommodate floods, thus protecting higher ground, and on the other hand they encourage the formation of cities and infrastructure, industrialization, and urbanization, thus requiring protection from floods themselves.[4]

Bangladesh is on the Ganges-Brahmaputra flood plain. The Ganges-Brahmaputra plain has one of the most agriculturally rich soils in the world, and it is subject to intensive agricultural production. The water in the river carries highly fertile sediments, and it deposits them throughout the flood plain, making the soil suitable for agriculture. The prime profession of most people in Bangladesh is agriculture.

The Brahmaputra has distinct characteristics during the wet and dry seasons. During summer, when the rivers are full, the braided Brahmaputra forms one big waterbody. In contrast, they are small channels in the dry winter season. Figure 1.3 shows the difference between the Brahmaputra, which is a braided river system, and the Ganges, which is a meandering river system.

Figure 1.2: The characteristics of floodplain under cultivation in Tangail.

4 Thomas Hofer and Bruno Messerli, *Floods in Bangladesh – History and Dynamics and Rethinking the Role of the Himalayas* (New York: United Nations University, 2003), xix.

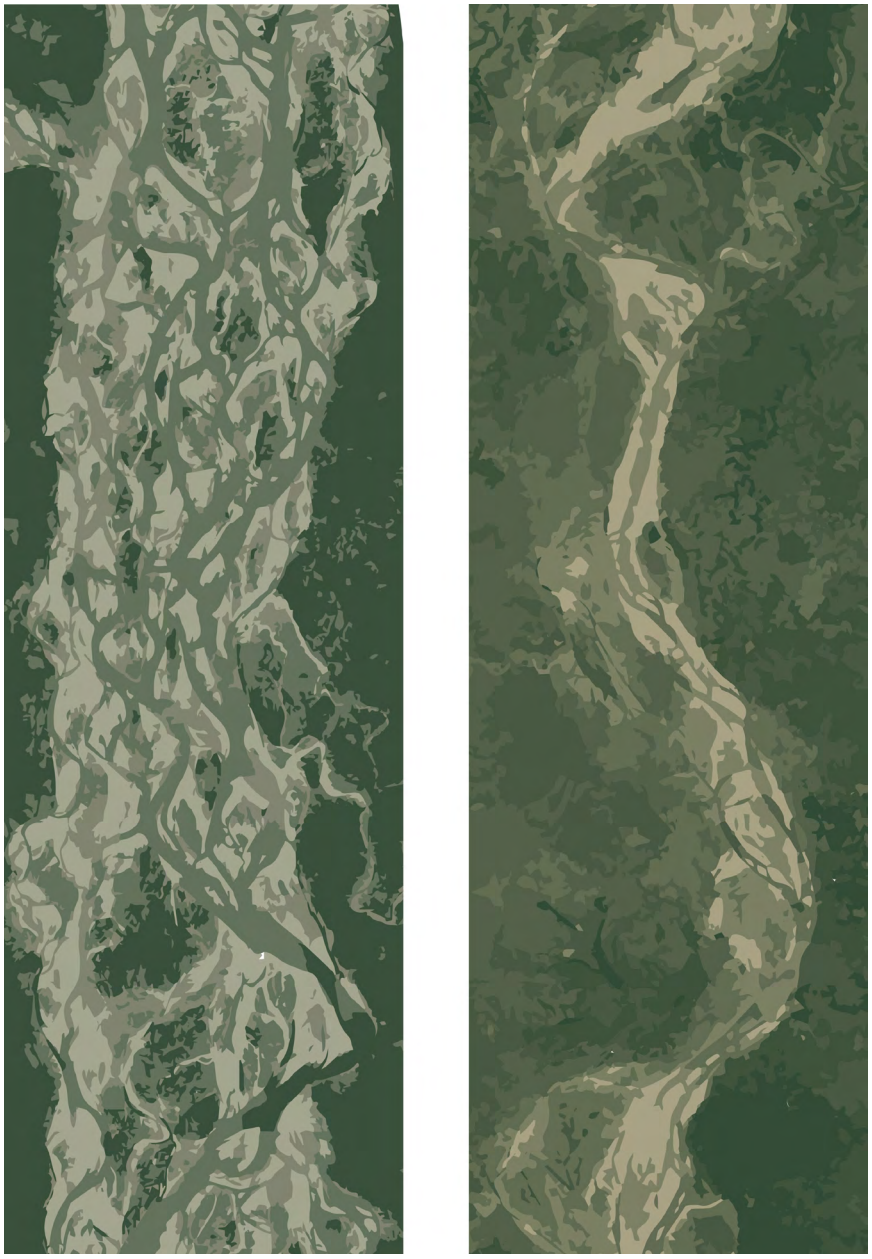


Figure 1.3: Braided Brahmaputra (left) Meandering Ganga (Right).

FLOODS IN BANGLADESH

As discussed in the previous section, Bangladesh has enormous rivers flowing through the country (Figure 1.4), contributing to its shifting landscape.[5] In addition, Bangladesh is very close to the Himalayas and the Bay of Bengal. This position makes Bangladesh an agriculturally rich country, but at the same time one of the most flood-prone countries in the world. Some 60% of the country is no more than 6 meters above mean sea level, and 70% of the country is susceptible to yearly floods.[6] The graph in Figure 1.5 shows the flooding events in Bangladesh between the years 1954 and 2004. According to the graph, every year a significant portion of the country is flooded.

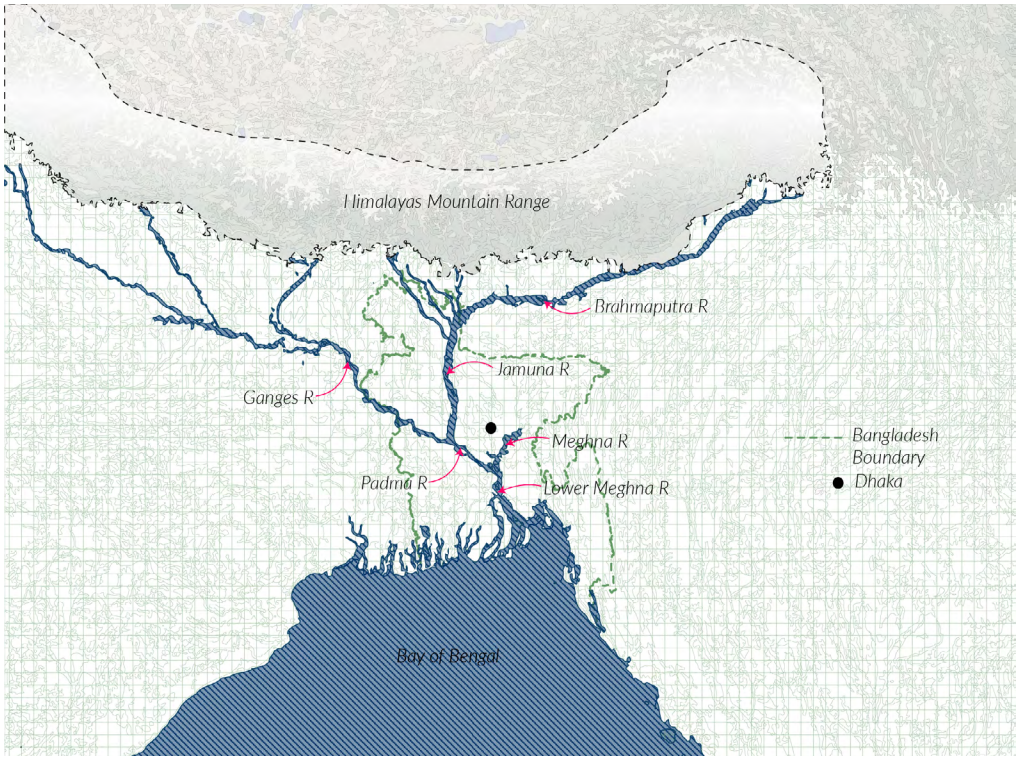
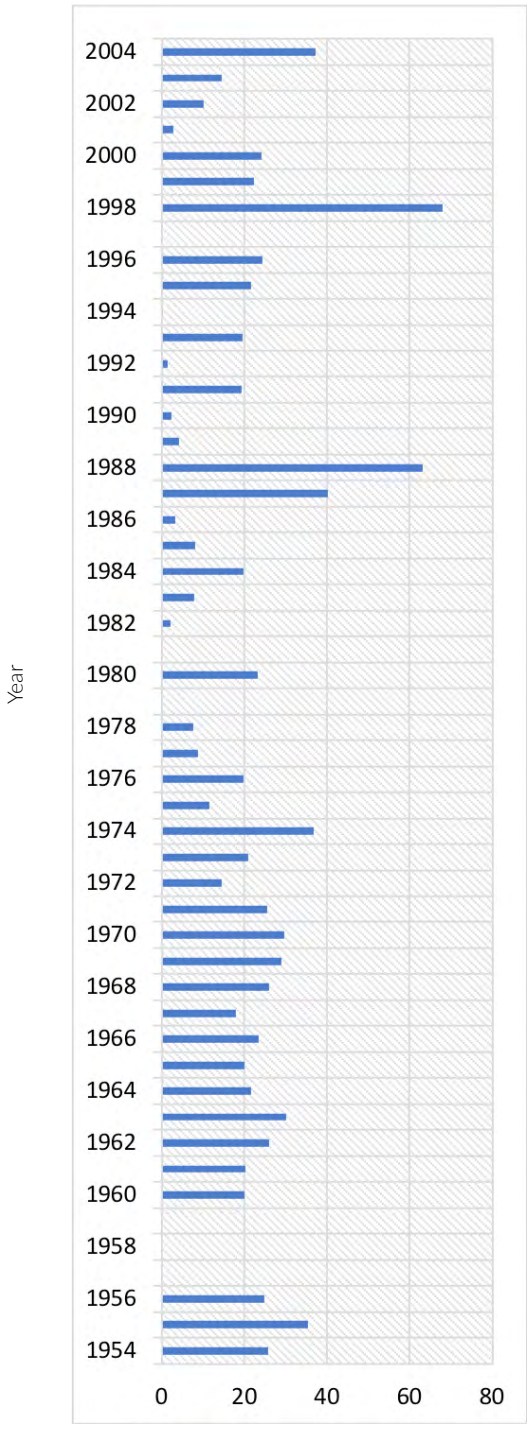


Figure 1.4: Map of Bangladesh in relation to the surrounding mountains, rivers and the sea. Diagram by author.

5 Ashraf, "Water as Ground," 91-97.

6 Gulshan Parvin, Annya Shimi and Chaitee Biswas, *Flood in a Changing Climate: The Impact on Livelihood and how the Rural Poor Cope in Bangladesh*, Vol. 4 (Kyoto: Climate, 2016).



The percentage of area in Bangladesh that is affected by flood.

Figure 1.5: The flood affected areas in Bangladesh. table by author. Source: Hoffer and Messerli_Floods in Bangladesh-History, dynamics and rethinking the role of himalayas pg 72.

The following flood types are identified in Bangladesh (Figure 1.6):

> Flash floods from hilly areas affect flood-prone areas at the foot of the hills in the Northeast and Southeast region as a result of intense, but short rainfall.
>
> River flooding occurs when the river overflows during monsoon seasons.
>
> Rain-fed floods occur in flood plain regions with disturbed natural drainage systems.
>
> Coastal floods (Tidal flooding) occur due to storm surges. Bangladesh has over 800 kilometers of coastline, and it has conical and funnel-like shapes in the eastern part of the country, resulting in higher than average storm surges.[7]

The main reason for flooding is the location of Bangladesh – its relation to the river, the mountains, and the sea. These could have been reasons for Bangladesh to prosper. However, due to detrimental human effects on the environment, these factors have become underlying causes for disasters in Bangladesh.

Some 237 rivers flow through Bangladesh, including the Ganges, Brahmaputra, and Meghna. The country is situated at the intersection of these rivers.[8] As mentioned before, because of this location and because of the rivers crossing different countries and political borders, Bangladesh finds itself burdened with dealing with not only river water of its own, but also water from neighboring countries.[9] During the monsoon season, Bangladesh does not have the ability or drainage infrastructure to cope with the large amount of water flowing through these rivers across borders. Figure 1.7 shows the different catchment basins for the rivers.

In March, melting snow in the Himalayas results in a rise of water in the Brahmaputra river: the first peak is reached in May, and again in August.[10] Heavy rainfall in the catchment areas increases the rise in water level. The Ganges reaches its peak in August, and it remains that way until mid-September. The Meghna reaches its peak in August and September. When the peaks of the Ganges and the Brahmaputra coincide, usually in August and September, severe flooding occurs.

---

7 Rahman, Hossain, and Bhattacharya, "Flood Management," 4; Hoffer and Messerli, *Floods in Bangladesh*, 31.

8 Barua and van Ast, "Towards Interactive Flood Management."

9 Parvin, Simi, and Biswas, *Flood in a Changing Climate*.

10 Rahman, Hossain, and Bhattacharya, "Flood Management," 4.

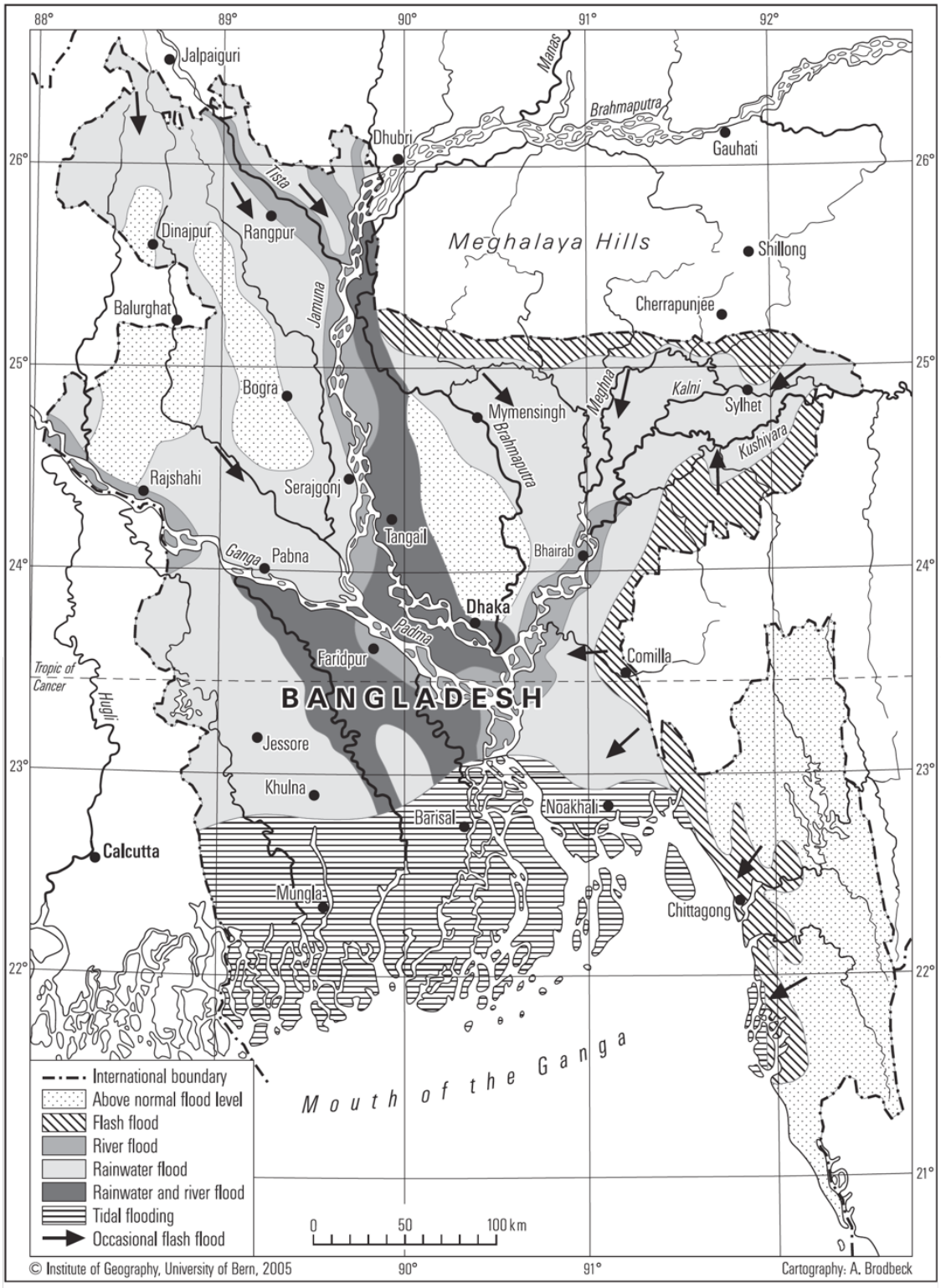


Figure 1.6: Different types of flooding in Bangladesh. Source: Hoffer and Messerli, Floods in Bangladesh-History, Dynamics and rethinking the role of Himalayas pg 31.

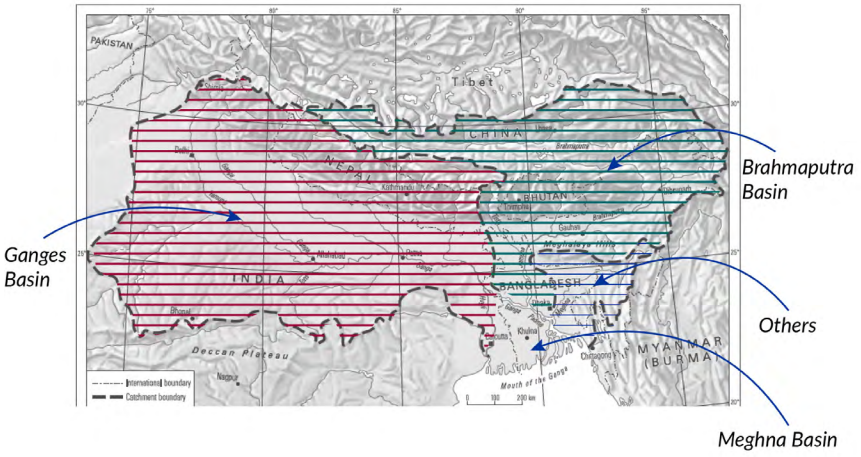


Figure 1.7: Catchment of the Ganges, Brahmaputra and Meghna Rivers. Diagram by author informed by Hoffer and Messerli.

Darjeeling-Bhutan and the Himalayas receive the most frequent heavy rain of up to 800 mm/day, and one of the highest annual rainfalls at 3,000 to 6,000 mm per year[11]. This kind of prolonged and intense rainstorm starts the processes of runoff, soil erosion, flood, debris flow, and landslide. This, combined with the heavy rainfall during monsoon season, causes the rivers to overflow.

The rural population of Bangladesh is the most affected by floods. While the landscape of the countryside is unaltered, with plenty of wetlands and very few buildings, its relationship to the rivers and the sea makes the lands susceptible to flooding. Most people in rural Bangladesh are dependent on water for their livelihood in a direct or an indirect way.[12] Fishing and farming are two common ways for the rural population to generate income, both of which require the right amount of water. Too little, and the crops and the fish will die, and too much water will also kill them. Some 60% of the villagers are fishermen or farmers. Settlements developed around the river in the early days, and they remain flood-prone. Since the population of the country is increasing and most of the country is in flood-prone areas, people have no option but to settle in low-lying areas.

Flood affects people by taking away their mode of living and taking away their resources to rebuild everything afterwards.[13] Food supplies and assets are both limited for the vulnerable population, which makes up a majority.

11 Prokop and Walanus, "Impact."
12 Parvin, Simi, and Biswas, *Flood in a Changing Climate*.
13 Ibid.

Research has found that in flood-prone areas, the income generated from agriculture goes down by 5% after seasonal flooding, and by 14% after extreme flood events.[14] Figure 1.8 shows average flood inundation depth in Bangladesh.

Numerous studies have been done on flooding. One such study demonstrates the effect of flooding in numbers. It was conducted on the vulnerable population in the Rajbari district, where 50% of the villagers were dependent on agriculture for their livelihood and 80% of the population lived under the poverty line.[15] After the flood, most people had to face a huge loss in their occupations and incomes. A third of farmers became jobless after the flood, and they switched to fishing or boating, becoming day laborers, or becoming rickshaw pullers. This group is most impacted by flooding and this susceptibility puts it in a cycle of going from poor to poorer with each flood cycle, and being unable to recover from the loss.[16]

14 Ibid.
15 Ibid.
16 Ibid.

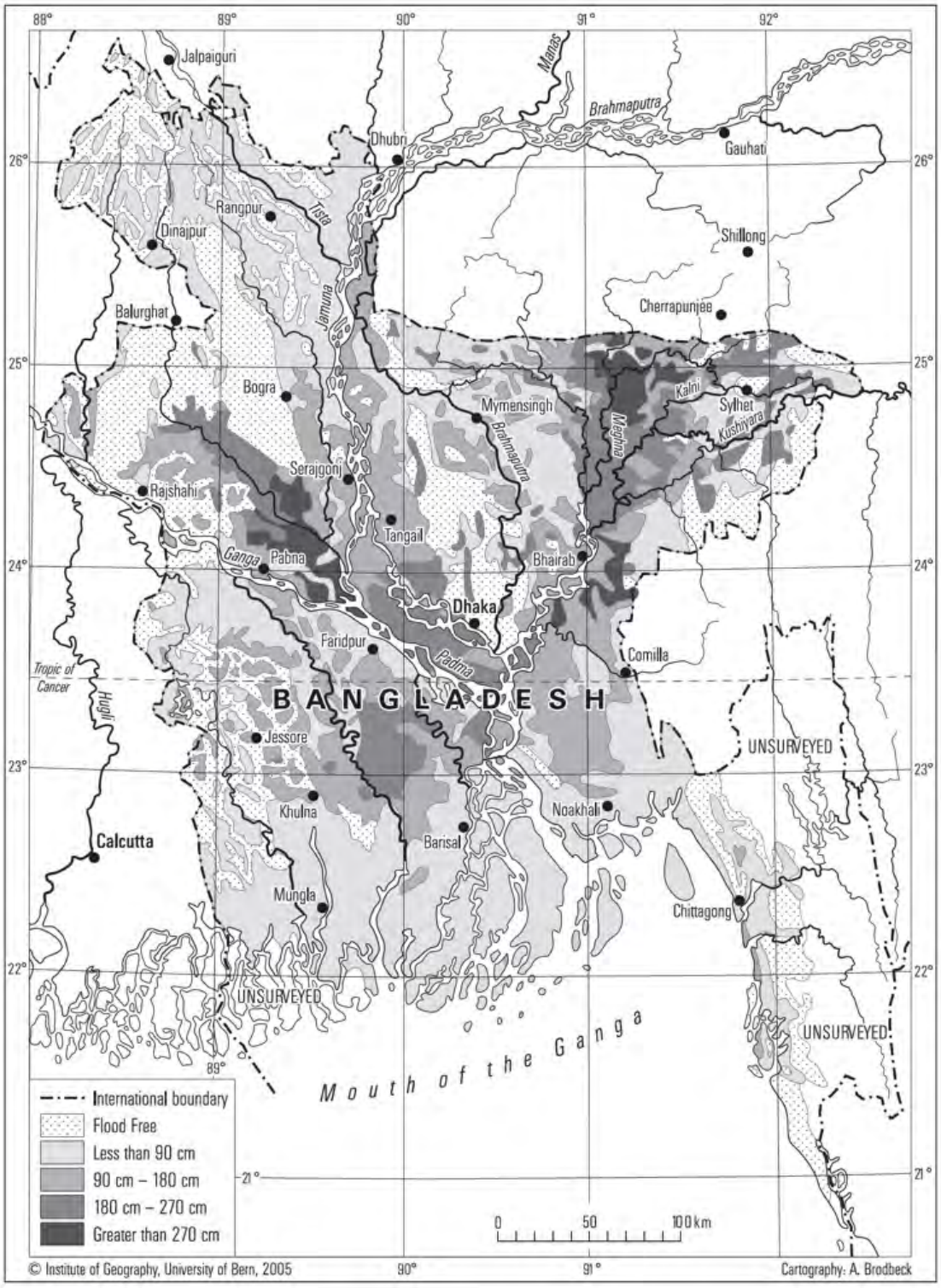


Figure 1.8: Average flood inundation depth in Bangladesh.

EDUCATION AND WARNING

One of the most crucial steps in flood management is educating the citizens. There are NGOs and agencies working with communities to improve awareness. Flood warnings through radio and television are used during high-risk periods to warn the residents in the affected areas.

FLOODPROOFING AND SHELTERS

In general, three types of flood shelter or flood-preventive housing are available in Bangladesh.[17] At an individual level, there are homesteads that are raised (usually of earth), and they are raised higher than the annual flood level, based on local knowledge (Figure 1.9). This kind of housing is usually found in villages and suburban areas. The second type of shelter is a community flood shelter, which is similar to a homestead, but the raised mound, in this case, accommodates a school and community centers (Figure 1.10). During monsoons, the school and the community centers are used for shelter. Their normal functions include education, playgrounds, fairs, etc. The third type is buildings on stilts (Figure 1.11). These buildings usually function as schools during the dry season and as shelters during floods.[18] Structural management includes placing highways and railways on higher ground. There are efforts at erosion control on rivers.[19]

Growing up, I never missed a school day or any other activities during the monsoon season. We went on with our life in the rain. Some roads would have higher water levels than others. I remember our car driver would ask my dad, should we proceed? My dad would say as long as it is not higher than the engine, go. Sometimes we would take the rickshaw. I would come out of school, jump on the makeshift bricks forming a raised path, and jump onto the rickshaw. Life does not stop for the people, but it poses many difficulties and health risks. Sewage and garbage mix with the water, and people are forced to keep on moving in that water.

-Author's personal entry
June 2018

17 Rahman et al., *A Comparative Analysis of Different Types of Flood Shelters in Bangladesh.* (Dhaka: Institute of Water Management BUET and Postgraduate Programs in Disaster Management BRAC University, 2010), 8.

18 Ibid.

19 Rahman, Hossain, and Bhattacharya, "Flood Management," 6.

Figure 1.9: Raised homestead.

Figure 1.10: Raised community homestead.

Figure 1.11: Government primary school that also doubles as shelter.

PAST FLOODS IN DHAKA

In this section, river flooding refers to the flooding in the city due to the overflow of the surrounding rivers. Waterlogging refers to rainwater trapped in the city due to its inability to either be absorbed into the soil or being drained away by the city's drainage system and pumps.

Dhaka was built in an unplanned manner, and it lacks resilience. It lacks the infrastructure to accommodate the changes in the environment without calamities. During floods, human lives and the city's infrastructures are both affected to a high degree, and it takes considerable time to recover. The following are some of the most catastrophic floods that Dhaka has faced.

In 1988, 85% of the city was flooded, with water reaching depths from 0.3 meters up to 4.5 meters.[20] The capital lost its connection with the rest of the country for 14 days due to a severe breach of water supplies, communication, and transportation.

In 1998, 56% of the city was flooded – the eastern side of the city flooded from the river, and the western side was affected by waterlogging.[21] The 1998 flood inundated 80% of the city, and it lasted for 10 weeks, with water depth reaching between 0.3 meters and 3 meters. The western part suffered because of the poor drainage capacity of the canals, and the flood damaged 66 kilometers of canals and 80 kilometers of stormwater drains. The breakdown of the sewage system resulted in water contamination and environmental conditions that threatened the general population's health.

In 2004, 43% of the city was flooded (map unavailable).[22] This flood was shorter than the previous two, but the water took longer to drain.[23] Gulshan and Baridhara were affected for a long time (this is where the Karail slum, to be introduced later, is located). The estimated damage to infrastructure and housing in these years was US$2.2 million in 1988, US$4.4 million in 1998, and US$5.6 million in 2004.

20 Roy et al., *Urban Flooding*, 3.

21 Ibid.

22 Ashraf Dewan and Yasushi Yamaguchi, "Land Use and Land Cover Change in Greater Dhaka, Bangladesh: Using Remote Sensing to Promote Sustainable Urbanization," *Applied Geography* 29 (2009): 392.

23 Roy et al., *Urban Flooding*, 4.

2007 and 2009 also saw heavy flooding, disrupting the housing, communication, and economy of the city and posing a serious threat to the public's health and wellbeing.[24]

Figure 1.12 shows the flood inundation in 1988, 1998, and 2007. It shows river flooding as opposed to waterlogging; thus, the western part of Dhaka appears to be flood-free in 1998 and 2007. However, from my personal experience and observation, and from other people's accounts, those areas have suffered from flooding in the form of waterlogging. (1.13 - 1.18).

24 Ibid.

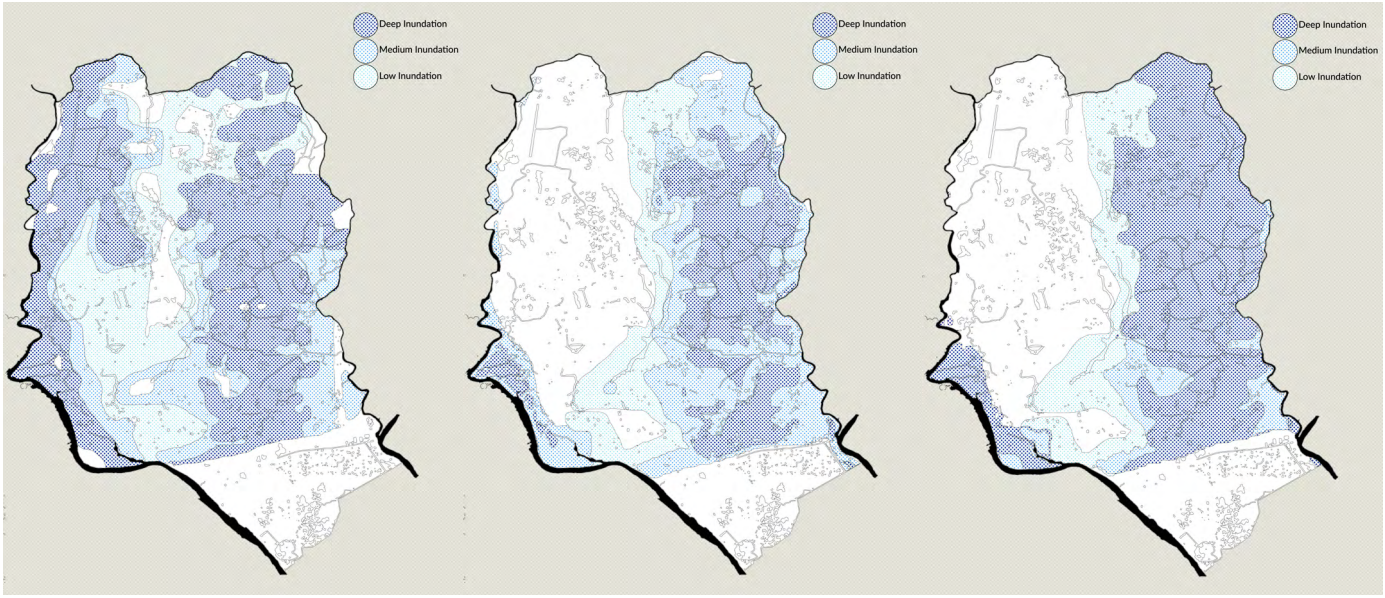


Figure 1.12: Flood inundation maps (left to right): 1988, 1998, 2007 . Inundation showing depth. Darkest areas had the deepest water. Due to lack of access to data, the exact depth could not be determined.

Figure 1.13: People going about their day in Rickshaws during a flood event.

Figure 1.14: People commuting by boat in the city.

Figure 1.15: Kneehigh water does not stop daily activities.

Figure 1.16: A student making her way to her exam, her papers and accessories in a water proof folder.

Figure 1.17: A child standing in flood water.

Figure 1.18: People on a "thela gari" (a transport usually used for moving furniture) during flood.

DHAKA FLOOD PROTECTION EMBANKMENT

> The process of sealing off the city from the rivers has to be reversed. The canals have to be allowed to meet the rivers.[25]
> - Prof. Nazrul Islam

Many of the earlier topics have elaborated contributors to the flooding of Dhaka – loss of wetlands, proximity to the river, proximity to the Himalayas, the heavy annual rainfall, and the unplanned growth of the city. One of the biggest problems the residents face today is waterlogging caused primarily by the flawed drainage system and the construction of the western embankment in 1988.

Although the embankment (Figure 1.19) was built to protect the city from flooding, it has done the opposite. Due to poor maintenance and the inadequacies of the sluices and pumps, whenever there is rainfall, water is trapped inside the embankment. Even when the water level in the river is lower, water inside the embankment cannot drain due to inadequate openings. Most of the problems related to flooding in the western part of Dhaka are due to waterlogging rather than river flooding.

The embankment has divided the city into two parts, and these two parts are affected by the monsoon in different ways. The embanked portion of the city is the west of Dhaka, and it suffers from intense rainfall, resulting in waterlogging due to limited drainage.[26] The east side of Dhaka does not have any embankment, and as a result, it suffers from overland flooding from the river during intense rain.[27]

There are plans (Figure 1.20) to build another embankment for the eastern part. My belief is that it should be built in a more resilient and sustainable manner for it to function properly.

Figure 1.21 shows the relationship between the embankment that keeps out water from the Buriganga River and the city. This section shows how waterlogging affects old Dhaka. Even when water levels in the river are not high, water is trapped on the other side due to the embankment. Figures 1.22 - 1.24 are street views from three points in the embankment system.

25 Nazrul Islam, "Where will the canal go?," *The Daily Star*, August 10, 2009, https://www.thedailystar.net/news-detail-100778

26 World Bank, *Flood Risk Management in Dhaka : A Case for Eco-Engineering Approaches and Institutional Reform* (Washington, DC: World Bank, 2015), https://openknowledge.worldbank.org/handle/10986/29348.

27 Ibid.

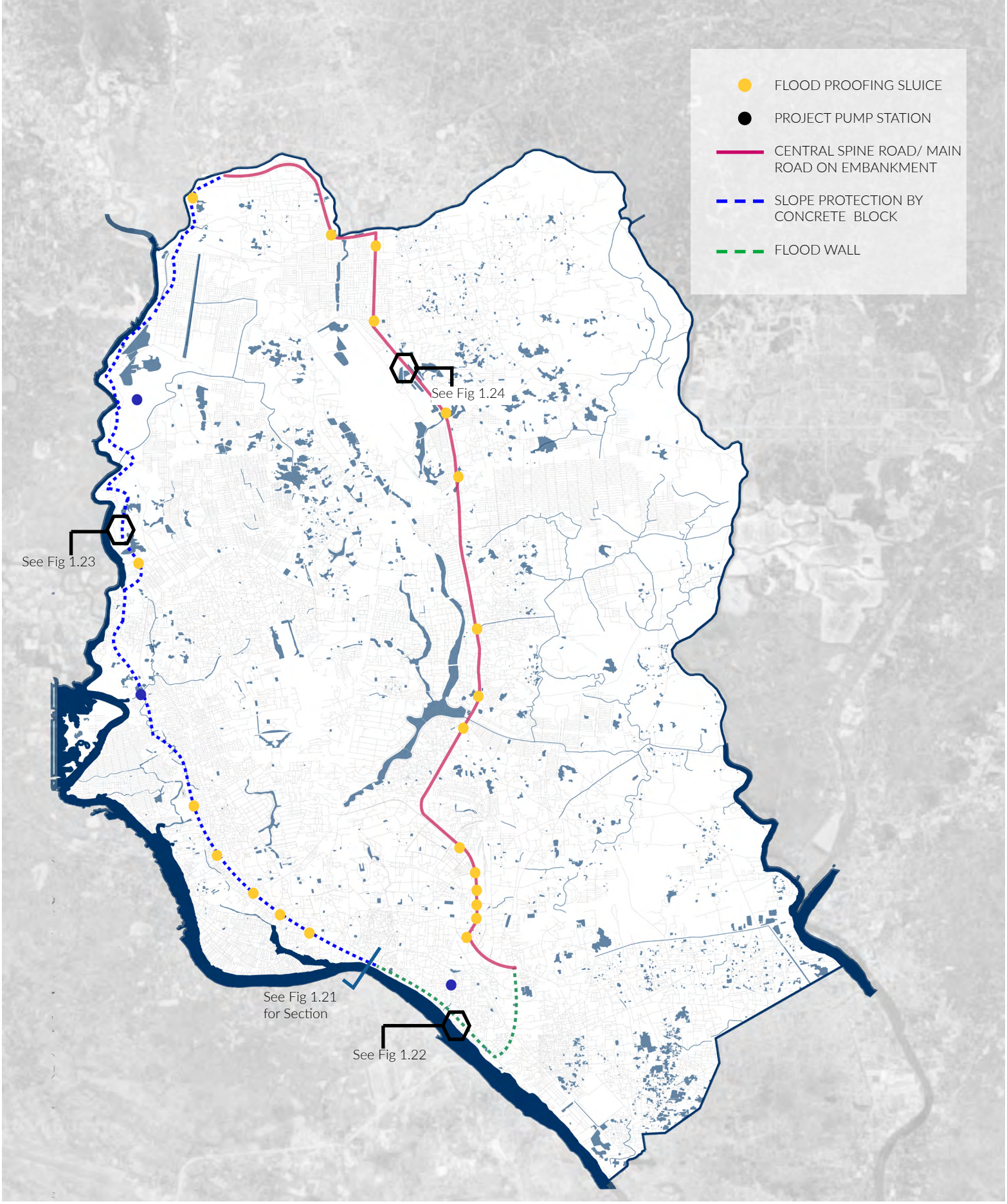


Figure 1.19: Dhaka Flood protection project 1988.

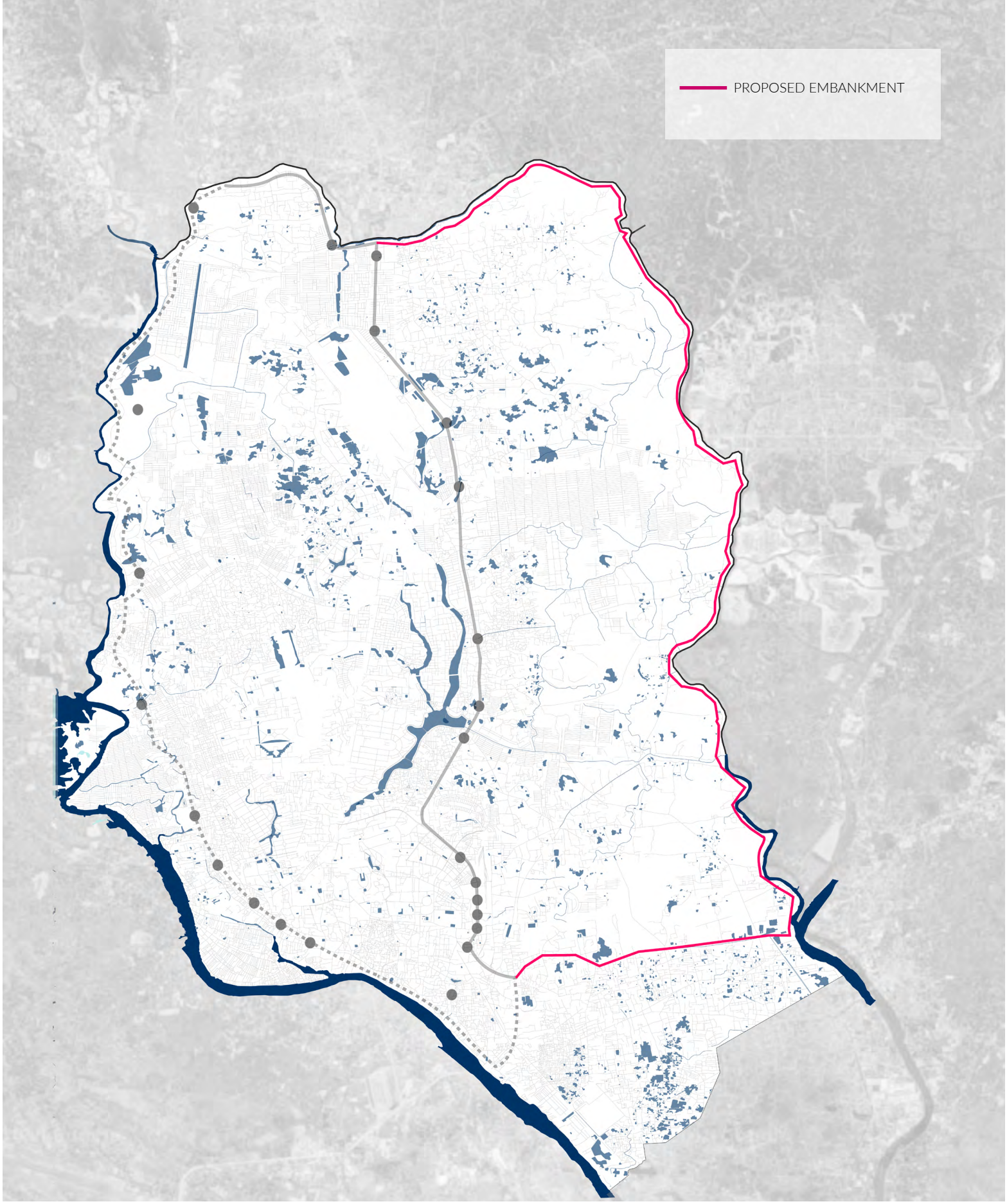


Figure 1.20: Proposed Eastern Embankment. The Proposal includes 28 kilometers of flood wall farther delinking the canals and blocking natural draingae system

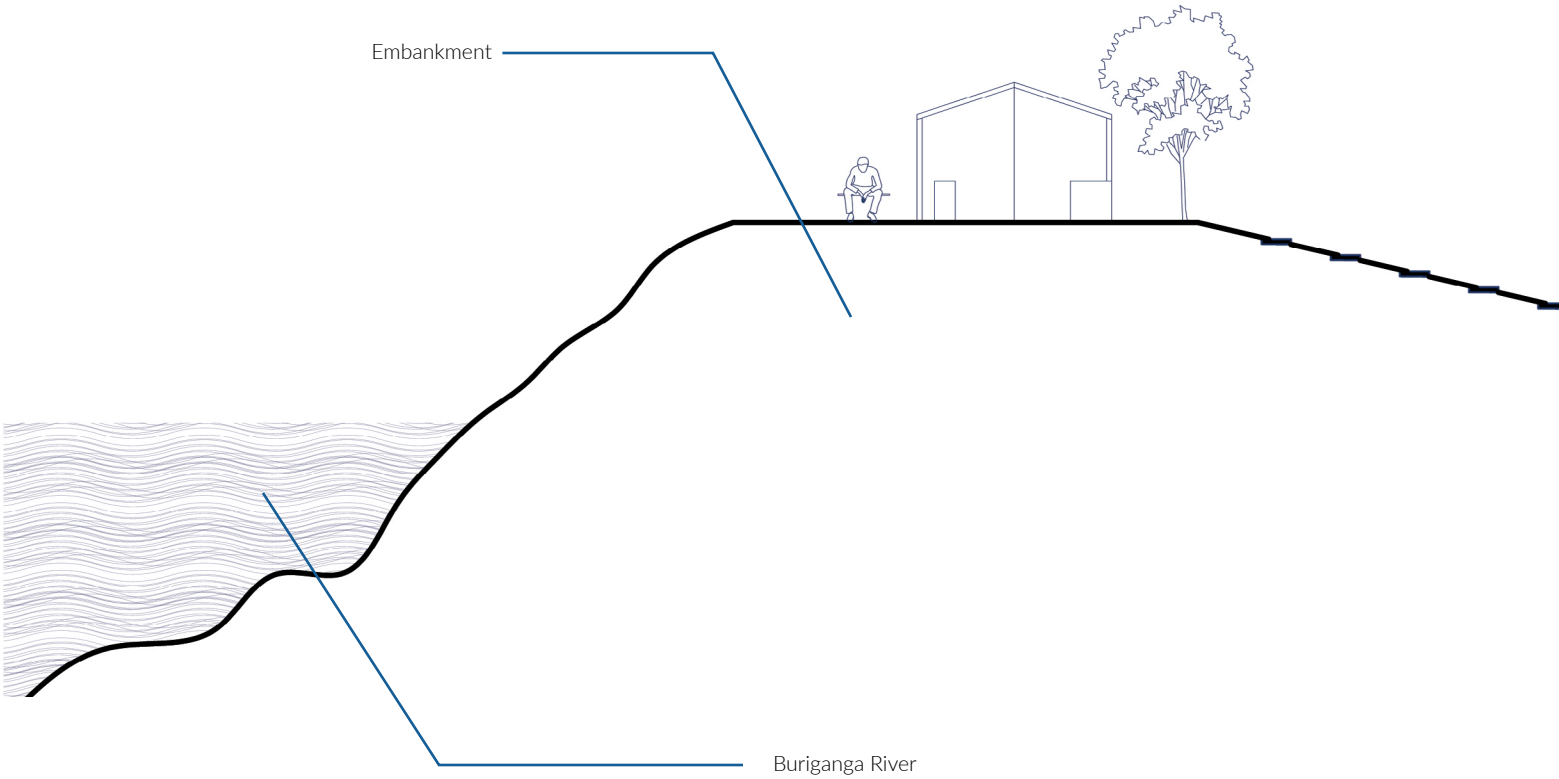


Figure 1.21: Edge condition at the Buriganga River. Section generated from multiple sources. Some genaralizations and deductions were made.

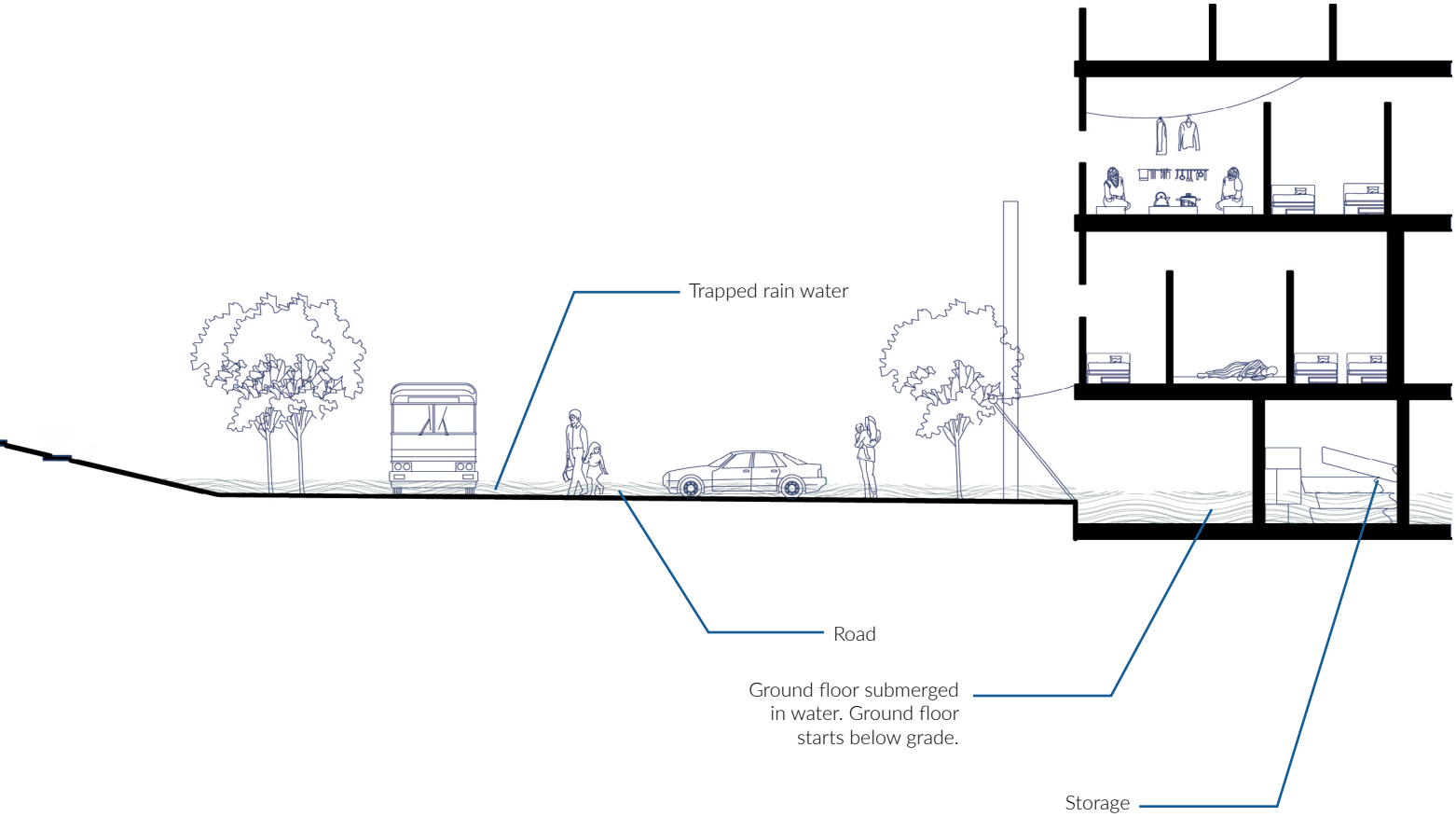

Trapped rain water
Road
Ground floor submerged
in water. Ground floor
starts below grade.
Storage

Figure 1.22: Flood wall constructed along Buriganga river to prevent the city from river flooding.

Figure 1.23: The slope of the embankment along Buriganga river is protected by concrete block.

Figure 1.24: The central spine road running north south in the middle of Dhaka is part of the western embankment.

In the 1970s and early 1980s, Dhaka had fifty canals flowing through the city.[28] Boats could travel freely through the city, but after the construction of the embankments and floodwalls, the city did not leave any opening to allow for the movement of the boats (for example, going from Gabtoli to Narayangonj through the canals or via the Turag River to the Buriganga River was no longer possible). Today, only twenty six of the canals remain, most are struggling due to encroachment, and people are using many canals for garbage disposal. At present, the west side of the city is surrounded by 36 kilometers of embankment and 3.8 kilometers of flood walls, and there are 54 sluice gates, allowing untreated water to reach the river. In terms of stormwater management infrastructure, the city also has 350 kilometers of large-diameter concrete stormwater drains and open canals,[29] 65 kilometers of stormwater drainage, and 3,500 kilometers of feeder drains (open and small-diameter pipes). The main aim of this system is to drain the floodwater from the city into the river.[30]

The responsibility for keeping these canals (as well as box culverts, stormwater drains, and surface drains) clean lies in the hand of Dhaka City Corporation and the Dhaka Water Supply and Sewerage Authority (DWASA), but they are not fulfilling their obligations.[31] One of the biggest problems with water and drainage management in Bangladesh is that the responsibility is divided between multiple government subdivisions. While DWASA is in charge of some of the pumping stations, others are maintained by the Bangladesh Water Development Board (BWDB). Currently only 38% of the city has adequate drainage. DWASA is also responsible for stormwater drainage, but surface water drains are managed by Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC).[32] Figures 1.25 - 1.31 show the key map and the photos of the encroached canals. They have become narrower due to garbage disposal and land grabbing, and the garbage can be seen blocking the sluice gates.

28 Helemul Alam, "Dhaka City Canals in Death Throes," *The Daily Star*, July 21, 2016, https://www.thedailystar.net/city/dhaka-city-canals-death-throes-1257046.

29 World Bank, *Flood Risk Management*.

30 Ibid.

31 Ibid.

32 Ibid.

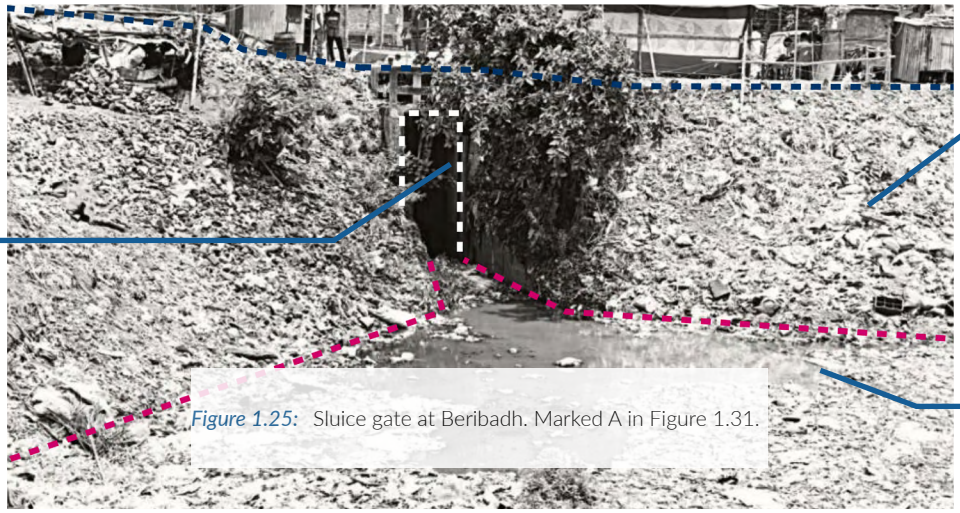


Figure 1.25: Sluice gate at Beribadh. Marked A in Figure 1.31.

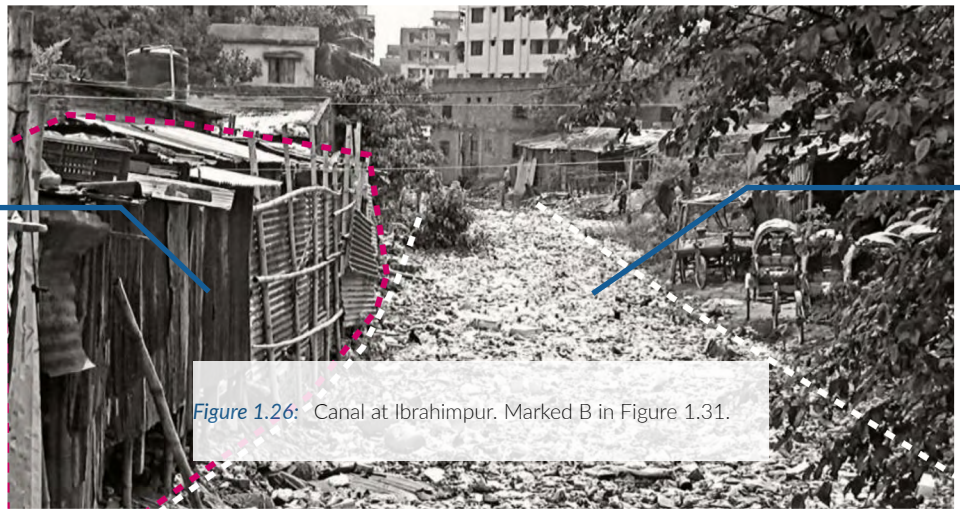


Figure 1.26: Canal at Ibrahimpur. Marked B in Figure 1.31.

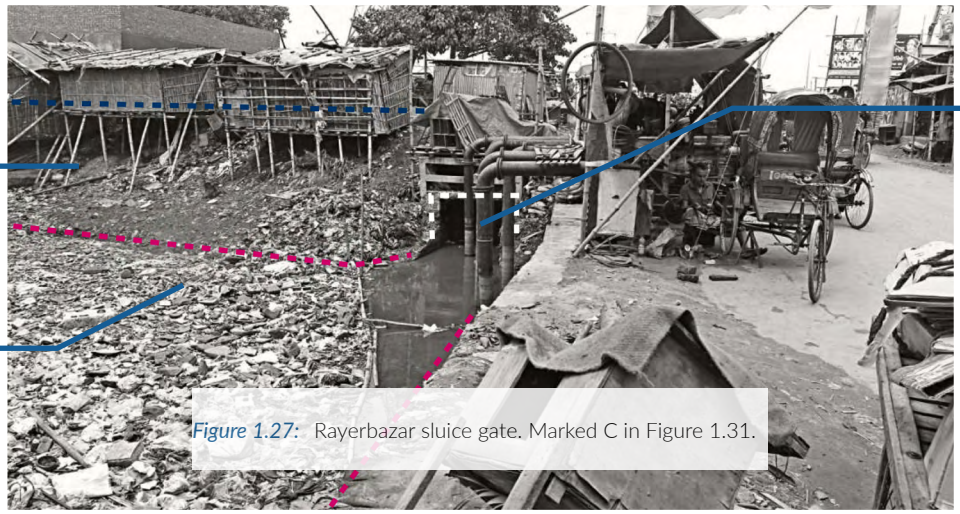


Figure 1.27: Rayerbazar sluice gate. Marked C in Figure 1.31.

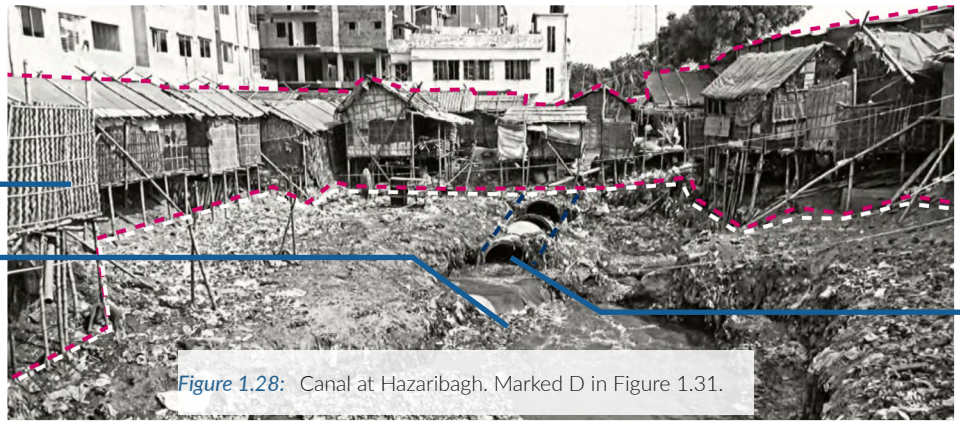


Figure 1.28: Canal at Hazaribagh. Marked D in Figure 1.31.

Figure 1.29: Sluice gate at Hazaribagh. Marked E in Figure 1.31.

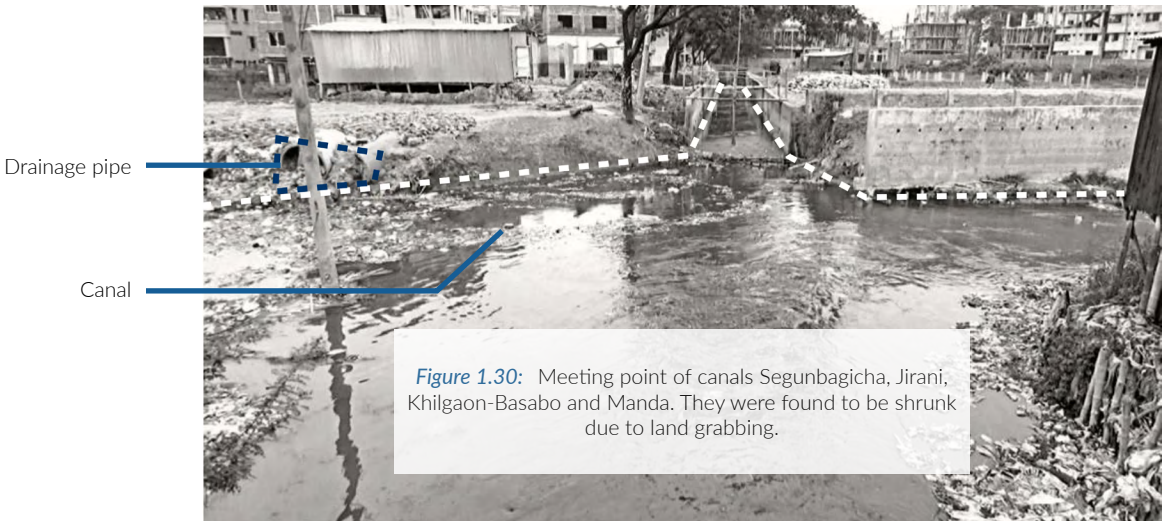


Figure 1.30: Meeting point of canals Segunbagicha, Jirani, Khilgaon-Basabo and Manda. They were found to be shrunk due to land grabbing.

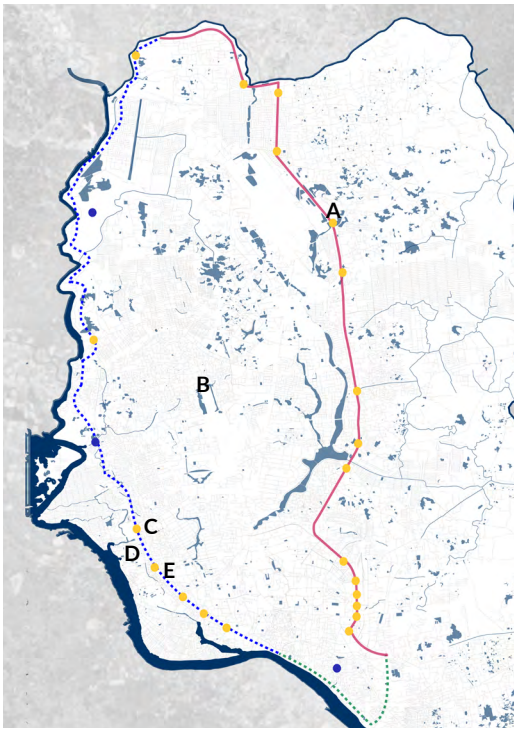


Figure 1.31: Key Map for Figures 1.25 - 1.29. The locations of the photos are identified by the author and is approximate. Location for the canal in Figure 1.30 could not be identified.

2. City

DHAKA

This chapter describes the city of Dhaka – an important step in familiarization with Dhaka before the introduction of my design proposal. The following pages summarize the history, geology, geography and land-use patterns of the city. A comprehensive solution requires deep understanding of all the issues surrounding the problem, and in this part, I bring forward some details on the city.

LOCATION

In the center of Bangladesh, on the north of the river Buriganga is the capital city: Dhaka (Figure 2.1). The center of the city has the highest elevation, with rivers and canals forming the boundaries of the city.[1] These rivers are tributaries of the Brahmaputra river.

Eastern boundary: Balu River and Shitalakhya River.
Northern boundary: Tongi Canal
Western boundary: Turag River and Buriganga River.

Surrounded by rivers and canals on all sides, with rivers and canals flowing through the city and connecting all the waterways to the surrounding rivers, Dhaka used to be called the Venice of the East.[2] When Dhaka was first established, it was a small town by the banks of Buriganga.[3] Dhaka has a humid, subtropical climate, and every year, 2,000 mm of rain falls into the city, 80% of which is during the monsoon season (June to September).[4]

1 Alam, "Dhaka City Canals," 13.

2 Mohammed Islam et al., "Wetlands of Dhaka City: Its Past and Present Scenario," *Journal of Life and Earth Science* 7 (2014): 37, https://doi.org/10.3329/jles.v7i0.20126.

3 Mohammad Hassan and Jane Southworth, "Analyzing Land Cover Change and Urban Growth Trajectories of the Mega-Urban Region of Dhaka Using Remotely Sensed Data and an Ensemble Classifier," *Sustainability* 10, no. 10 (2017): 13.

4 Dewan and Yamaguchi, "Land Use."

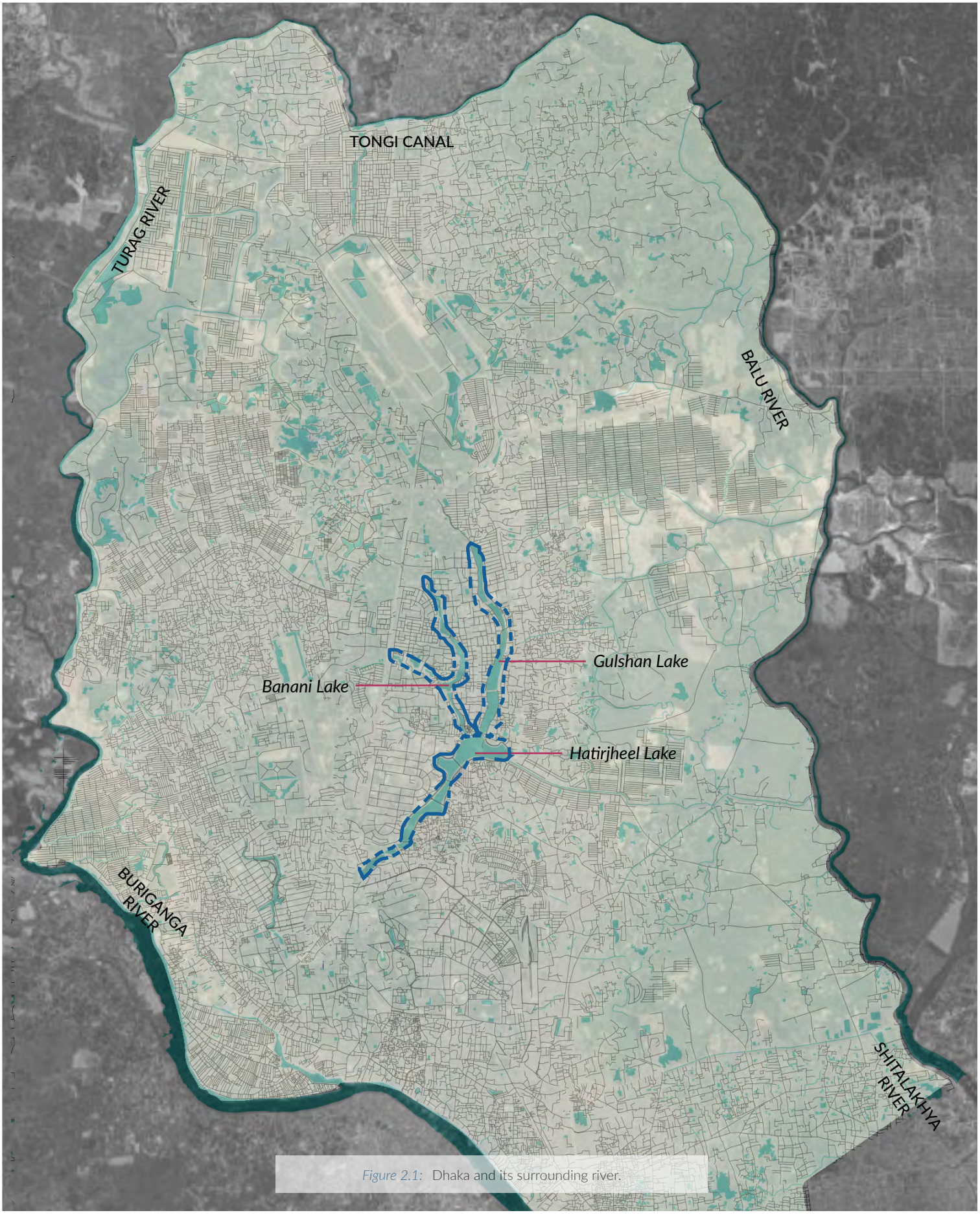


Figure 2.1: Dhaka and its surrounding river.

HISTORY

Dhaka has existed for a very long time. Historians date Dhaka back to 700 AD, when it was ruled by Buddhist kingdoms. Subsequently Hindu rulers took over control of the city. Turks and Pathans ruled Dhaka from 1299 to 1608.[5] In 1610, under the Mughal empire, the governor of Bengal decided to move the capital of East Bengal to Dhaka.[6] The presence of these rulers is still marked by some historical buildings in the old city.

In 1765, the Mughal emperor assigned the right to taxation to the British Army, and the East India Company gained power as the military and commercial ruler of Dhaka.[7] At this time, the growth and flourishing of the city stopped, the citizens began to be taxed heavily, the merchants left, patrons were lost, and the city went into a state of decline. Much beautiful architecture in the city dates back to the period of British rule. In 1947, the East India Company surrendered its power, and it declared India and Pakistan as independent countries. Before partition, present-day India, Pakistan and Bangladesh were one country under the East India Company rule. Extensive migration happened during partition, as the people were forced to relocate to the two countries according to their religion – Muslims were told to go to Pakistan and Hindus were told to go to India. The Bengal region was divided into East Bengal and West Bengal. East Bengal became known as East Pakistan, and it became a part of Pakistan, while West Bengal became a part of India.

East Pakistan was oppressed and overlooked by the government, and finally, after a 9-month war, Bangladesh gained independence on December 16, 1971. Figure 2.2 shows the Timeline of the growth and formation of Dhaka.

5 Hassan and Southworth, "Analyzing Land Cover Change," 3.

6 Prianka Smita, "Render Authenticity: Revisiting Intangible Heritage to Reflect on Historical Structure Network,". *UWSpace* (2015): 29, https://uwspace.uwaterloo.ca/handle/10012/9808

7 Ibid.

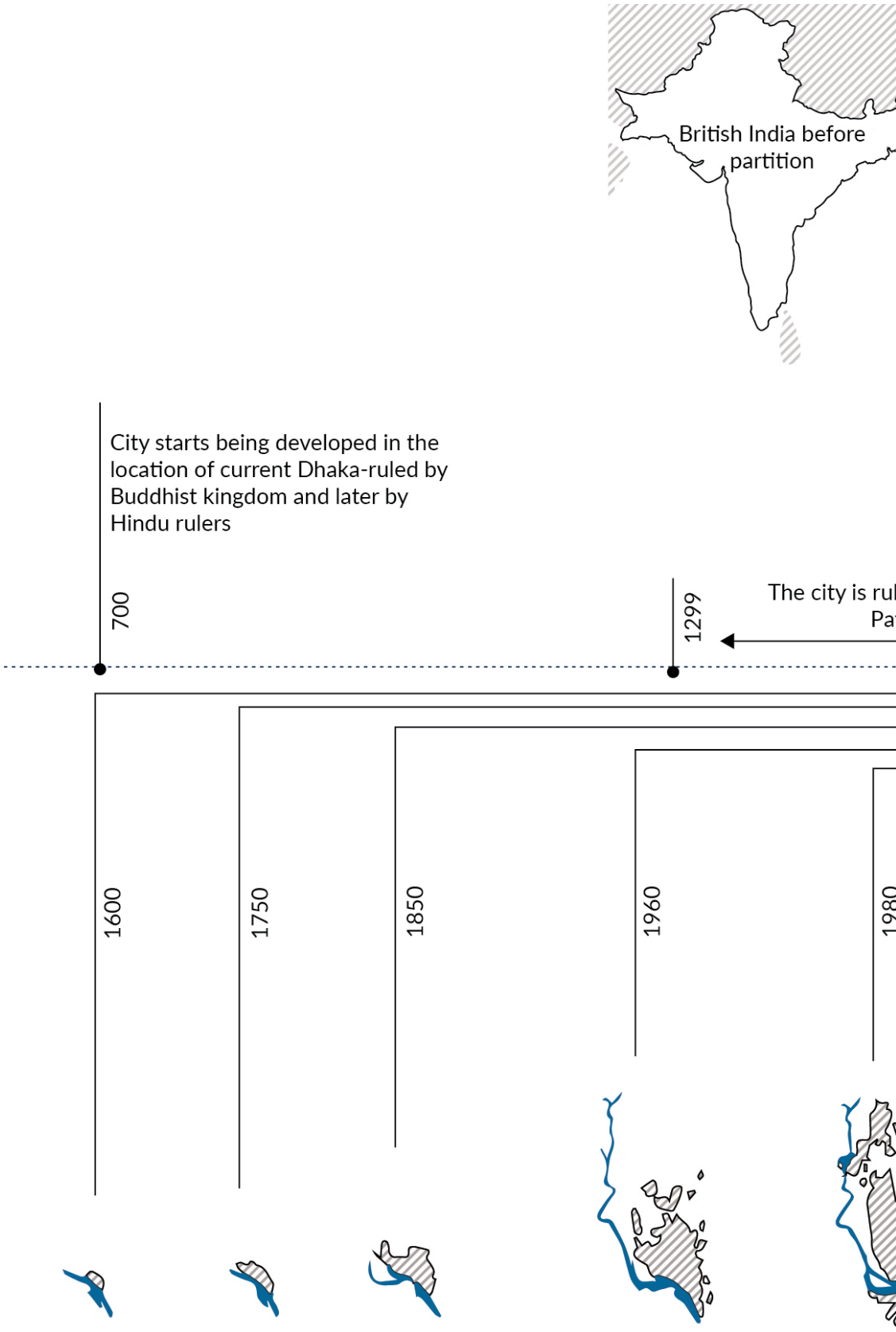
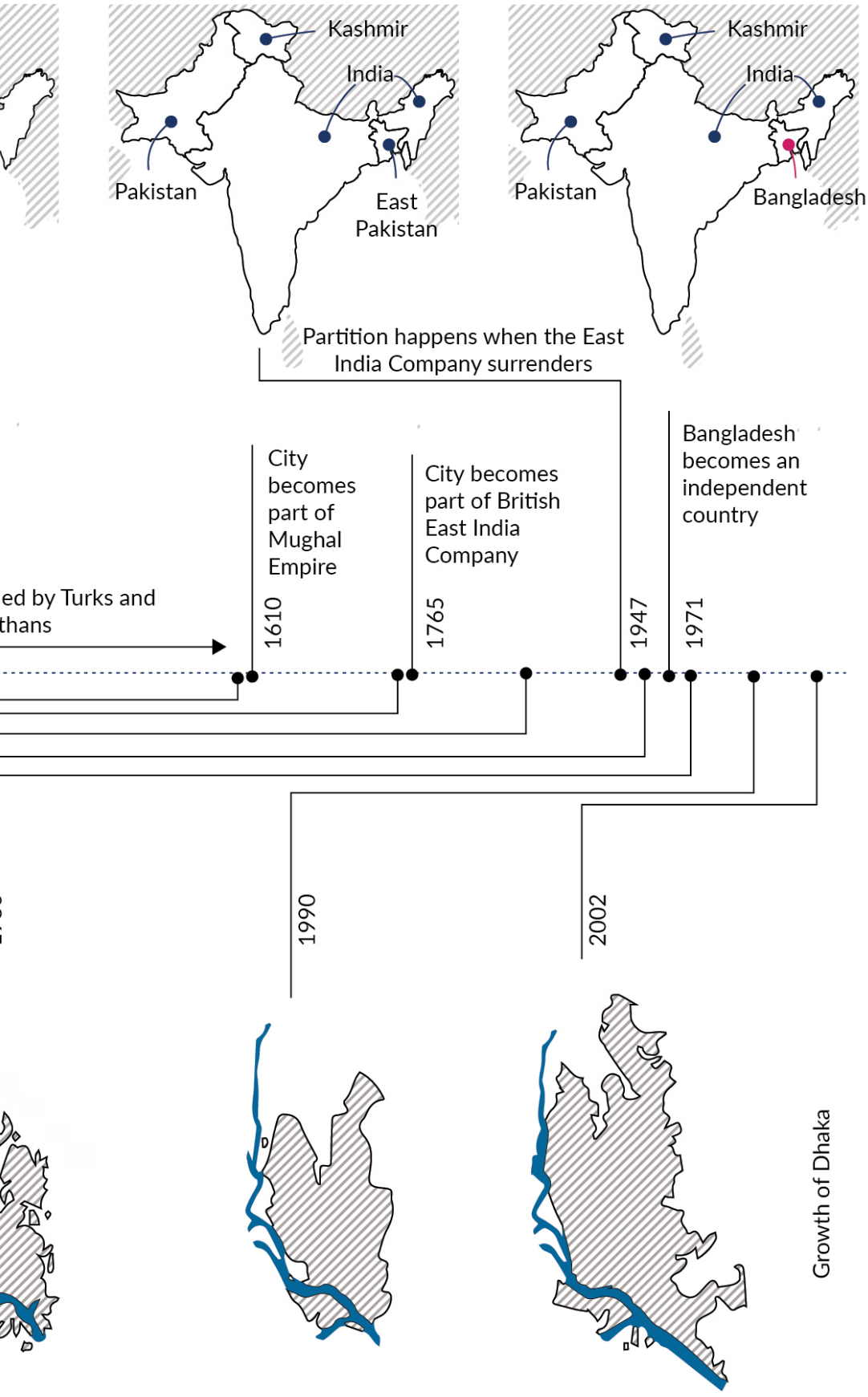


Figure 2.2: Timeline of the growth and formation of Dhaka.


Kashmir
India
Pakistan
East Pakistan
Kashmir
India
Pakistan
Bangladesh
Partition happens when the East India Company surrenders
City becomes part of Mughal Empire
1610
City becomes part of British East India Company
1765
1947
Bangladesh becomes an independent country
1971
ed by Turks and
thans
1990
2002
Growth of Dhaka

> The Kingdom of Bengal, particularly the Eastern part, is naturally the most convenient for trade within itself of any country in the world; for the rivers divide into such a number of branches that the people have the convenience of water carriage to and from any principal place.[8]
>
> - James Rennell

The geomorphological map (Figure 2.3) shows that a natural levee existed by the river. This is where Dhaka started developing.[9] Originally, the low flood plains were not inhabited, but now, all of them are high-use areas, and they are popularly considered as a whole as the old town of Dhaka. Figure 2.4 shows the geomorphology of Bangladesh.

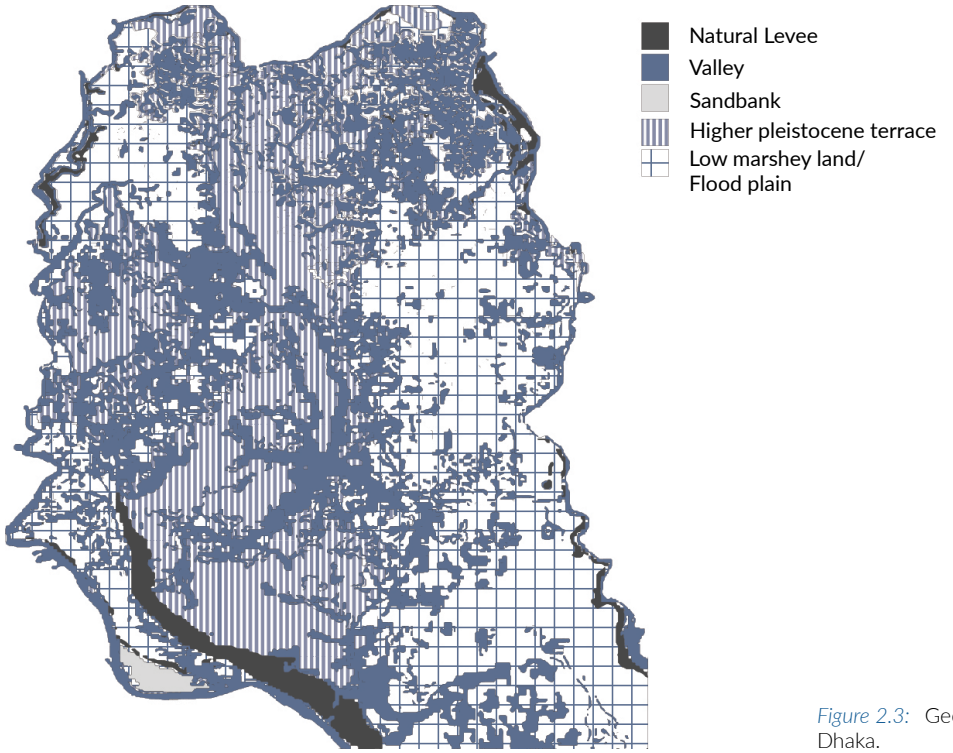


Figure 2.3: Geomorphology of Dhaka.

8 Sharif Uddin Ahmed, *Dhaka : A Study in Urban History and Development*. London Studies on South Asia (London: Riverdale, 1986), 10.

9 Mohammed Rahman et al., "Translating Text into Space for Mapping the Past Territory of a City: A Study on Spatial Development of Dhaka During Mughal Period," *City, Territory and Architecture* 3 (2016): 13, https://doi.org/10.1186/s40410-016-0036-y.

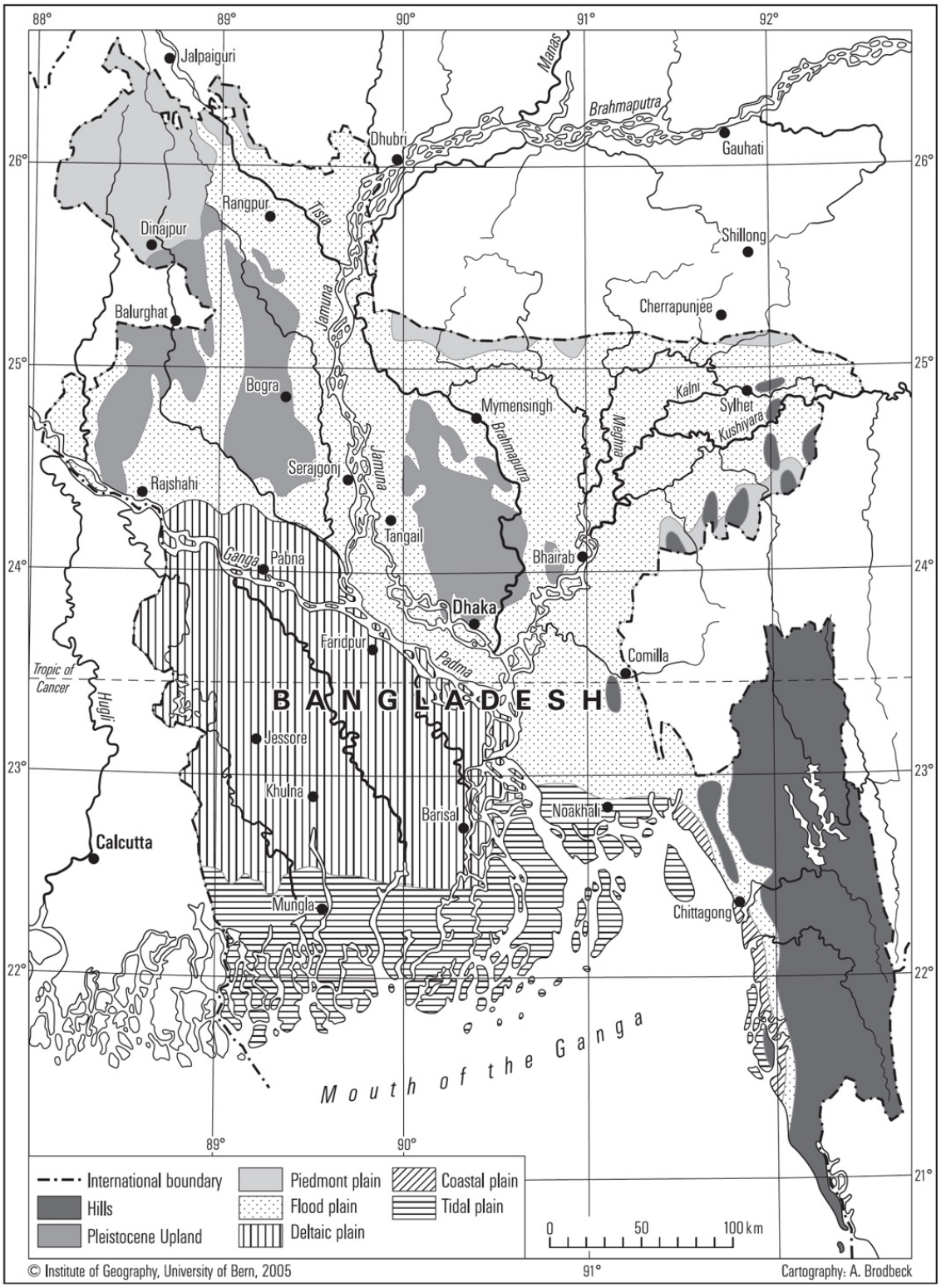


Figure 2.4: Geomorphology of Bangladesh.

PHYSICAL GEOGRAPHY OF BANGLADESH

Due to the lack of adequate access to drawings of and data on Dhaka, physiology of Bangladesh and Dhaka were used in this thesis to understand the landscape of the city, and how it changed over the years. Information on how the city formed was used to understand several aspects of this proposal: how the canals were built and where they existed, rainwater absorption into the ground, groundwater extraction for drinking, soil layers, past flood plains, etc. This part of the thesis discusses the physical geography of Bangladesh and Dhaka.

Bangladesh is situated inside the Bengal basin. To the west is the Precambrian Indian shield, the Shillong shield is on the north, the Indoburman Hill Range surrounds the country on the east side, and the Bay of Bengal is on the south.[10] The Himalayan uplift contributed to the creation of the deltaic landmass and the major river systems that travel through Bengal Basin into the sea (the current Bay of Bengal).[11] The formation of the Bengal Basin was caused by the Indo Australian plate fracturing and sinking below sea level millions of years ago, creating a depression.[12] The depression attracted the rivers to converge on their journeys to the sea, and over time, it filled up with sediments.[13] The geology of Bangladesh is influenced by the delta carrying sediments from the Himalayas to the sea.[14]

The current condition of the Bengal Basin is a result of the weather of the late Pleistocene climatic episode – the North East monsoon – which was prominent 22,000 to 15,000 years ago in the area.[15] The Himalayas at that time were quite high, and they were covered with glaciers. The Bengal basin was an outwash plain. At the time of the glacial maximum (18,000 years ago), the sea level was around 140 meters below the current sea level, causing the rivers connecting the Himalayas to the sea to be narrow and deep. By

10 Hussain Monsur, *Quaternary Geological Mapping of Dhaka, Chittagong and Sylhet Cities* (Dhaka: Comprehensive Disaster Management Programme, 2015), 13.

11 Jahangir Alam and Shamsul Islam, "Geological Aspects of Soil Formation of Bangladesh," Paper presented at the Bangladesh Geotechnical Conference 2009, Dhaka, December 17, 2009.

12 Jakia Akter et al., "Evolution of the Bengal Delta and its Prevailing Processes," *Journal of Coastal Research* 32, no. 5 (Sep 1, 2016), 1213. https://doi.org/10.2112/JCOASTRES-D-14-00232.1.

13 Ibid.

14 Monsur, *Quaternary Geological Mapping*, 13-16.

15 Ibid, 21.

10,000 years ago, the heavy monsoon combined with the meltwater from the Himalayas was causing water to flow over the Bengal plain, contributing to the local pools, depressions, and some north-south islands. When the sea level increased rapidly, erosion stopped, and the rivers started filling up the eroded surfaces with sediments. These complex relations of water and land resulted in the current soil condition of Bangladesh.

In summary, most of Bangladesh has been built by the collision of the Indian and Asian plates, followed by sediments carried by the river system flowing through the region for thousands of years from the Himalayas to the Bay of Bengal.[16]

TOPOGRAPHY AND SOIL CONDITION

Part of Dhaka is on the low-lying flood plains of the Holocene period. Currently, with urban built-up areas, the city is becoming flatter in elevation, destroying the natural flood plains. The height of the city from mean sea level varies between 2 meters and 13 meters, and it consists of three main geomorphic units. The following demonstrates the original elevation of the city:

Central High Area: This unit represents an elevated and north-south elongated table surface above the flood plain level. The elevation is more than 7m from the mean sea level.

Complex of High and Low Areas: This unit consists of narrow strips of benches or foot slopes, rounded to elongated domes of central unit, narrow and shallow erosional gullies and incised valleys or abandoned channels. The elevation of this unit varies from 2m to 5m above mean sea level.

Complex of Low Areas: These areas represent the present flood plain of the rivers Buriganga, Balu and Shitalakhay. These areas annually inundate during the monsoon time. This geomorphic unit is flat and average elevation is 2m

16 Alam and Islam, "Geological Aspects," 1.

above sea level.[17]

Different articles and studies have reported slight variations in this data, but overall, the data remain consistent. For example, another article has reported that Dhaka's elevation ranged from 1 to 14 meters, and that most of the urban areas are located in the 6 to 8 meters of elevation range.[18] Originally when the city was built, the higher ground was covered first. Now, with a rising population and a decrease in land area, the lowlands are rapidly being filled up and sold to individuals, advertised as lucrative, luxurious model towns.

The soil condition of the three units (shown in Figure 2.5) is as follows.

> The Central High Area has hard, reddish-brown clay, silt, and sand.[19] They are from deposits of the earlier river system of the Ganges-Brahmaputra.[20]
>
> The Complex of High and Low Areas has some clays buried under alluvium and fill materials.[21]
>
> The zone that mainly consists of low areas has soft clay silt on the eastern side and silt sand on the western side, forming the flood plain.

Three formations have been found via boreholes in various parts of the city: the Basabo formation from the Holocene age, the Madhpur formation from the Pleistocene age, and the Dupitila formation from the Pliocene age.[22] The four rivers around Dhaka (Buriganga, Shitalakhay, Turag, and Balu) carry suspended sediments like sand, silt, and clay, and they deposit them along the way as active channel deposits. Past active channels such as the Gulshan Lake, Banani Lake, and Dhanmondi Lake had north-south flows, and they used to act as paleochannels, which connected to the Buriganga and

17 Monsur, *Quaternary Geological Mapping*, 25.

18 Dewan and Yamaguchi, "Land Use," 392.

19 Monsur, *Quaternary Geological Mapping*, 25.

20 Zillur Rahman, Sumi Siddiqua, and Maksud Kamal, "Probabilistic Seismic Hazard Analysis for Dhaka City, Bangladesh," Paper presented at GeoOttawa 2017, Ottawa, October 1-4, 2017, 1-2.

21 Monsur, *Quaternary Geological Mapping*, 25.

22 Ibid, 28.

discharged water into it. After the hydrodynamics changed due to the sea level rise, these channels filled up with Holocene sediments – mostly cross-bedded sand and clay. Numerous gullies were formed through present-day Dhaka during the prominent monsoons of the early Holocene period. These areas are predominantly silt and clay with humic matter. Current Dhaka has numerous swamps and marshlands, which are being filled up at high speed. The flood plains around the river at the periphery of the city are annually inundated by floods.[23]

Using the information gathered from these sources and analyzing maps and drawings, sections through Dhaka (Figure 2.5) were created along with soil conditions underneath it (Figure 2.6). To create these sections through Dhaka, GIS data was used. These data are sometimes not able to differentiate between building heights, heights of trees, and other objects on the landscape. However, the number of high-rises in Dhaka is negligible in comparison to numbers in Western countries. Most buildings in Dhaka appear to be up to six stories high. Dhaka is also mostly uniform in terms of building heights, with a few small commercial roads having taller buildings. Thus, even though the section derived may have some noise, it is still useful to see the topography of the city. The height axis has been exaggerated by a factor of twenty to show changes in the topography. Otherwise, at this scale, the city would have appeared completely flat. As can be seen, even with the exaggerated height axis, the city is still mostly flat. This is problematic, because water does not have lower elevations to which it can move.

Figure 2.6 indicates the soil conditions of the different segments of the city, which may be useful to make the ground more permeable to monsoon and flood. Most of the top layers of the city contain clay, which does not absorb water well. This affects the permeability of the soil, and it makes the ground less able to absorb water. Exposing the layers of sand underneath the clay increases the ground's ability to absorb water.

23 Ibid, 40.

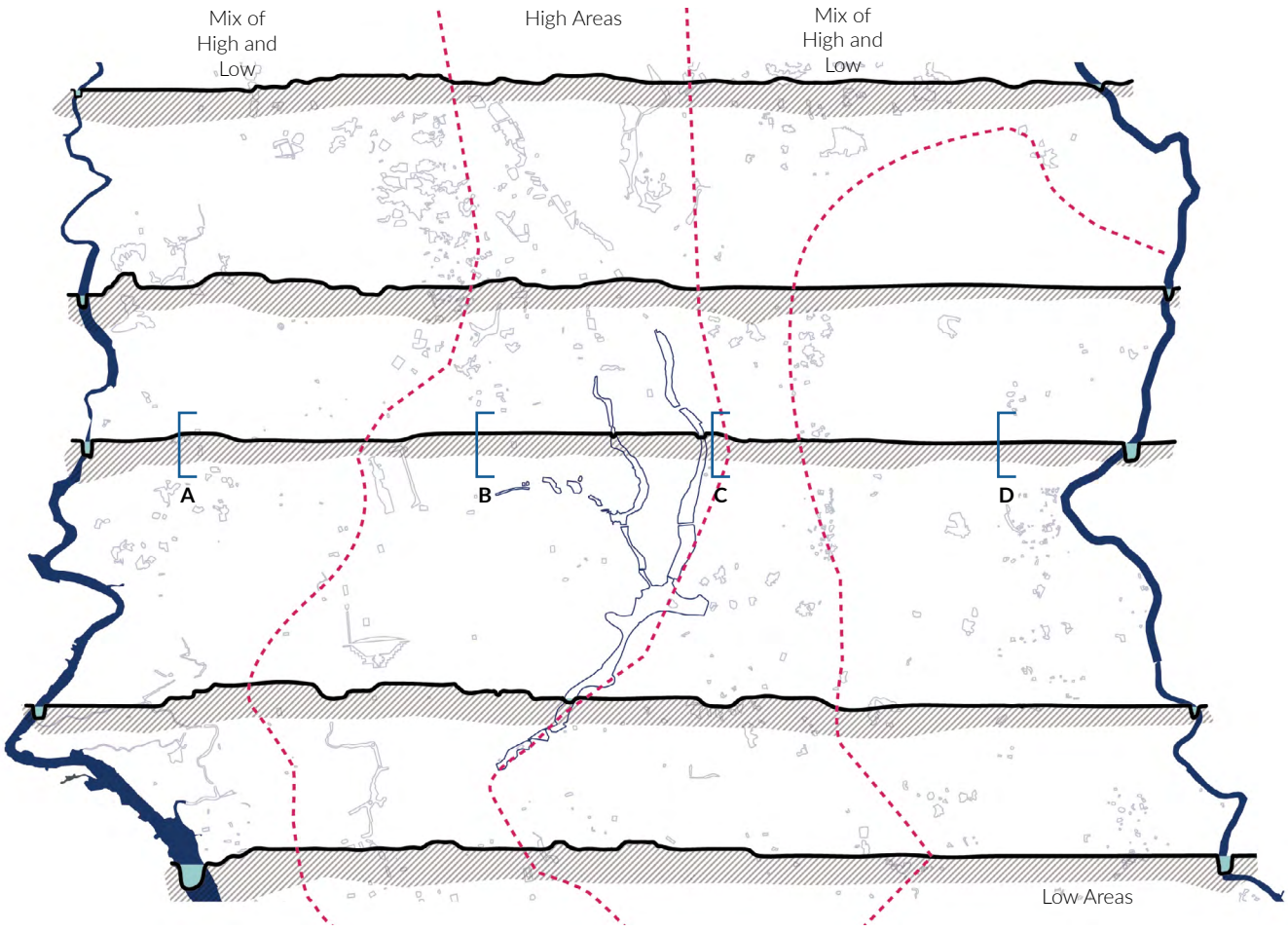


Figure 2.5: Dhaka's Urban Topography. The elevations are exaggarated twenty times. *[discrepancy in numbers - these sections have been created from a base map derived from GIS which had trees and buildings heights. Thus the change in topography is larger than the ones noted in text]*

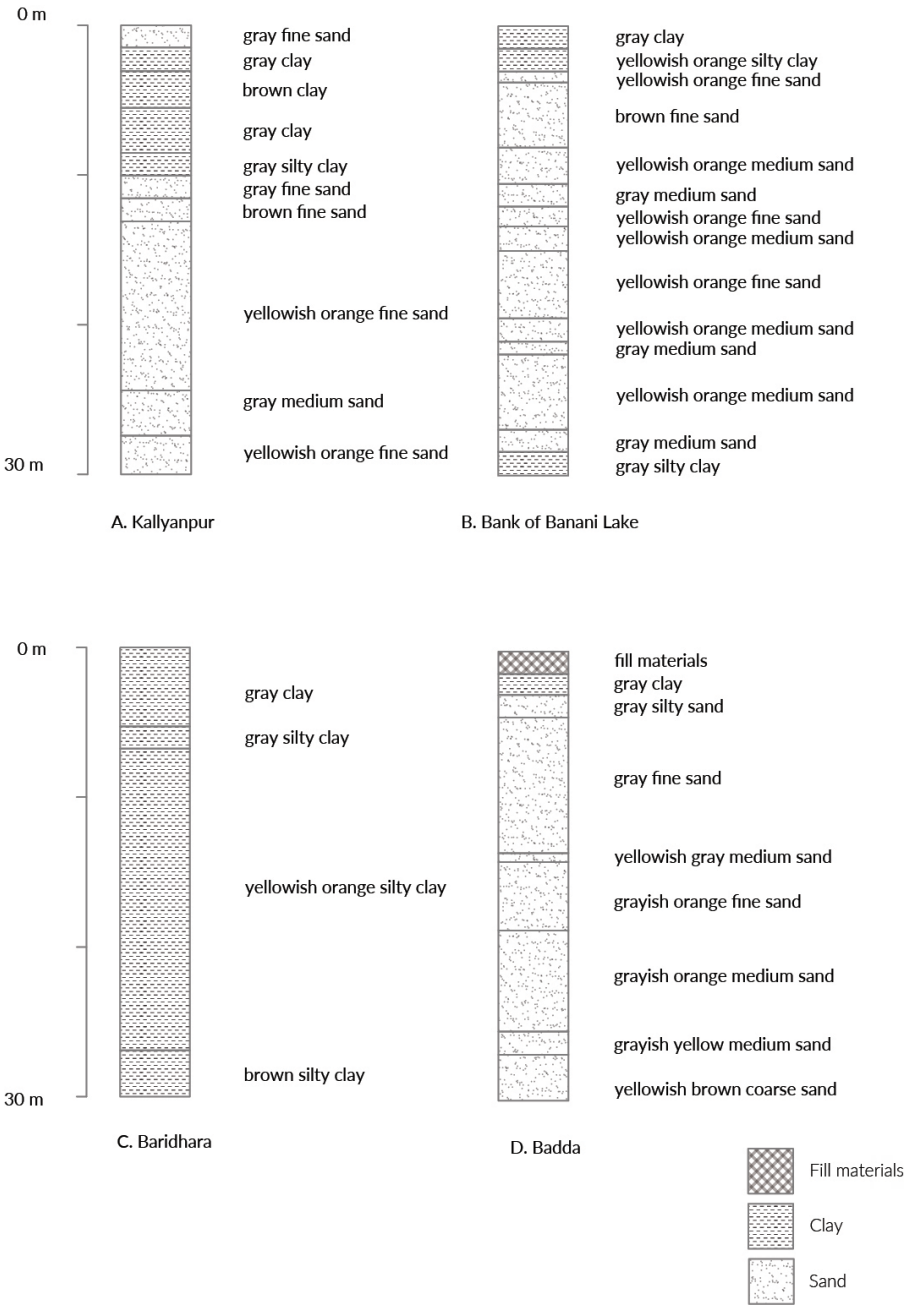


Figure 2.6: Soil sections. Refer to previous figure for section cuts.

GROUNDWATER

The primary source of water in Dhaka is groundwater, found in shallow alluvial aquifers at varying depths in Bangladesh,[24] currently around 60 meters below ground level.[25] In the past, 95% of the water was extracted from the ground for domestic, industrial, and commercial use. Currently, 84% comes from the ground, and 16% comes from surface water.[26] Groundwater extraction began in 1949.[27] In the last few decades, groundwater depth below surface has considerably increased in Dhaka. The water level used to be 11.3 meters in the 1970s, 26.6 meters in 1996, 28.15 meters in 1997, 30.45 meters in 1998, 31.85 meters in 1999, and 34.18 meters in 2000. It was reported at around 60 meters in 2016.[28]

Although Bangladesh faces heavy rain every year, the lack of green spaces and water bodies, impermeable soil layers, and unplanned development everywhere have prevented water from seeping into the ground. While the water table is falling, the need for water is increasing with an increasing population since groundwater is still considered the safest source for consumption. DWASA recently installed sixty-four new deep tube wells in one year to keep up with the city's demands, which resulted in a further drop in the water pressure in the aquifers.[29] In 2016, there were a total of 679 deep tube wells in the city, meeting three-quarters of the daily demand of around 220 million litres for the city.[30]

24 Ratan Majumder et al., "Groundwater Flow System in Bengal Delta, Bangladesh Revealed by Environmental Isotopes." *Environmental Earth Sciences* 64 (2011): 1343.

25 Abhijeet Das, "Dhaka Caving in Alarmingly as Groundwater Level Falls," *Independent*, August 24, 2016, http://www.theindependentbd.com/post/57286.

26 Mohammad Hoque, Mozzammel Hoque, and Kazi Matin Ahmed, "Declining Groundwater Level and Aquifer Dewatering in Dhaka Metropolitan Area, Bangladesh: Causes and Quantification," *Hydrogeology Journal* 15 (2007): 1524.

27 Ibid.

28 Das, "Dhaka Caving in."

29 Ibid.

30 Ibid.

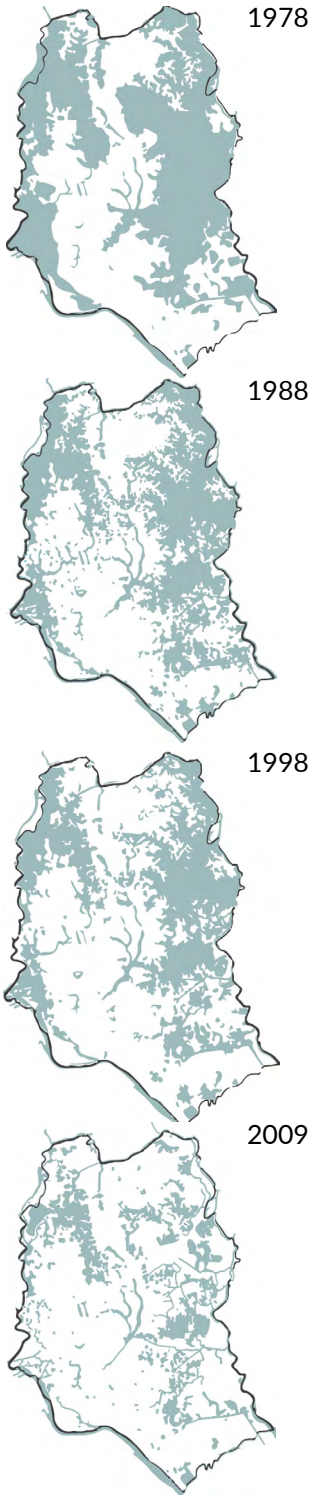


Figure 2.7: Loss of water body in Dhaka. Maps showing water bodies in years 1978, 1988, 1998, 2009.

WETLANDS

The natural landscape of Dhaka consisted of low-lying flood plains, rivers, canals, and lakes, and they made up the natural drainage system of the city.[31] A city that used to be referred to as the Venice of the East now lacks channels that connect the stormwater to the river, resulting in increased problems related to flooding and waterlogging.[32] The factors responsible for this situation are illegal encroachment, unplanned filling of lands, development of buildings and neighbourhoods, lack of system maintenance, disobeying established laws, and insufficient coordination between multiple agencies within the government.[33] A lack of specific plans of the wetlands is another reason why developers can grab these spaces with ease.[34] Catastrophe has increased to the level that during heavy rain, a meter of water inundates the main streets, as there is no space for the water to drain.[35]

Two major ways that the wetlands are being filled up are landfilling and encroachment. Landfilling is when developers fill in the area with earth and other materials, raising the elevation and mostly using the area to implement housing projects by private developers.[36] Encroachment happens in a much more informal way–bamboo and other less stable materials are used by the poor population of Dhaka to build houses along the banks of the wetlands, and eventually, deeper into the wetland themselves.[37] The bamboo is used to create structures on the water, and then substructures with very flimsy materials are built on the bamboo structures.[38] Figure 2.7 shows the drastic change in the water bodies in Dhaka city.

In addition to the wetlands, the lowlands have also been filled in. Between 1960 and 2008, Dhaka lost 32.5% of its water bodies and 51.85% of its lowlands.[39] Currently, efforts are under way to reclaim some of the canals and to reestablish the drainage. The government has taken up a project to reacquire lands and to excavate the current 26 canals under illegal occupation, with the hope that this will solve some of the city's waterlogging problems.[40]

31 Islam et al., "Wetlands of Dhaka City," 37.
32 Ibid.
33 Ibid.
34 Ibid, 38.
35 Ibid, 37.
36 Ibid, 38.
37 Ibid, 39.
38 Ibid.
39 Ibid, 42.
40 Rejaul Byron and Tawfique Ali, "Paying for Our Own Land!" Daily Star, April 4, 2018, https://www.thedailystar.net/frontpage/govt-buying-own-land-1557796.

DHAKA AS DELTA

> We are made of water, we drink water, we wash with water, we purify water, we purify things with water. There is too much water. There is too little water.[41]
> - Kazi Khaleed Ashraf

> Before water is somewhere, it is everywhere.... When water is everywhere, why do we see it somewhere?[42]
> - Anuradha Mathur and Dilip Cunha

The Earth has taken millions of years to reach its present geography. Maps are relatively very recent inventions. Maps draw lines separating water and land.[43] Today, architects look at these maps and design their cities. Today, Dhaka's planners are filling up the water to build more land to build more buildings.

The building on the delta is an ongoing process, as the river travels from the Himalayas to the Bay of Bengal, carrying billions of tons of sediments each year to discharge to the sea.[44] The Ganges and the Brahmaputra start at a 5,000-meter elevation, and they make their way to the Bay of Bengal carrying sediments from a drainage basin of 1.7 million square kilometers.[45] Bangladesh is a mega delta, and it covers most of the present Bengal basin.[46] The Padma (Ganges), the Jamuna (Brahmaputra), and the Meghna are the three main rivers that merge in Bangladesh, contributing to the greater thickness of the fluvio-deltaic sediments in the Bengal basin. The courses of the rivers are controlled by the different geological characteristics of the basin, and they keep changing track, with erosion and deposits.[47] The three rivers combined carry over 2 billion tonnes of sediment per year, and they

41 Kazi Ashraf, "Wet narratives: architecture must recognise that the future is fluid," *The Architectural Review*, May 25, 2017, https://www.architectural-review.com/essays/wet-narratives-architecture-must-recognise-that-the-future-is-fluid/10020074.article

42 Mathur and Cunha, "In the Terrain of Rain."

43 Ibid.

44 Monsur, *Quaternary Geological Mapping*, 13-16.

45 Mead Allison, "Geologic Framework and Environmental Status of the Ganges-Brahmaputra Delta." *Journal of Coastal Research* 14, no. 3 (1998): 827-36. http://www.jstor.org/stable/4298836.

46 Alam and Islam, "Geological Aspects," 1.

47 Akter et al., "Evolution." 1213.

have contributed to the current size of the Bengal Delta. The Bengal Delta has changed over the years, and it will continue to do so. The last biggest change in the Brahmaputra River happened between 1776 and 1830, when the river moved from the east side of the Madhpur Tract to its current location. Some of the reasons for these changes were earthquakes, tributary diversions, and big floods.[48]

The course of the river is naturally changing. Therefore, when we draw lines to separate them on maps, we restrict their natural course and we ignore their ferocity and power. Architecture outlives human beings, and to design in a sustainable and resilient method, we must remember that these boundaries are blurred. We can build an embankment to keep the river away from land, but the course of the river itself will change, and to force a barrier cannot be the only method of water management.

Sand, silt, and mud are carried from the upland mountains by the water, and they are deposited in the flat plains forming *chars* (bengali word representing significant sediment deposits).[49] A *char* is produced by shifting soils and water flows. "Borne out of fluid dynamic (sic), chars pose a conceptual challenge to design imagination. They bear unsettling questions on what is site, what is fixity, and therefore what is architecture ."[50] Dhaka is built on a *char*: it is built on shifting soils and water flows.

Is an embankment the right choice for Dhaka? In a city that is almost flat, with unplanned urbanism and minimal infrastructure to accommodate the growth, the building of the existing embankment has resulted in rainwater becoming captive inside these embankments. Even when the river does not flood, there are floods inside these walls.

Figure 2.8 is an early map of Dhaka as a porous city, and Figure 2.9 is Rennel's map of the Bengal Delta.

> From the heart of the present city, Dhaka and the delta appear as two separate entities, antithetical and strangers to each other. Fed on dry ideas, planners and policy-makers remain befuddled about envisioning or even managing a city in such a toiled terrain; any deliberation begins with an assumption that a water terrain

48 Ibid.
49 Ashraf, "Water as Ground," 91-97.
50 Ibid.

is unreliable for the city and must be thwarted. In the horizon of the contemporary city, the delta does not even appear in the consciousness until a deluge comes, like clockwork, annually and unmistakably. The past tense of Dhaka being a deltaic city marks both a failure to innovate planning positions and [an] exacerbation of the 'natural' opposition between city and landscape.[51]
- Kazi Khaleed Ashraf

Figure 2.10 shows Dhaka's river transportation system in 1975.

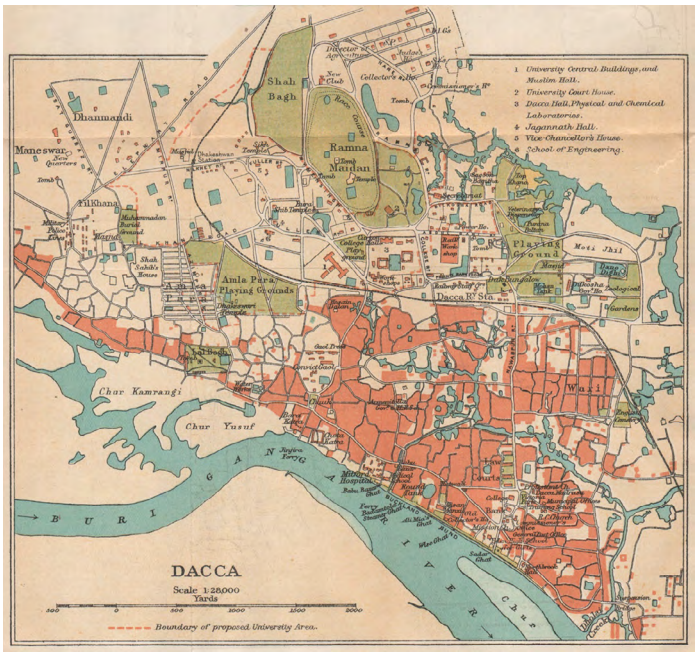


Figure 2.8: Dhaka as a porous city, 1924.

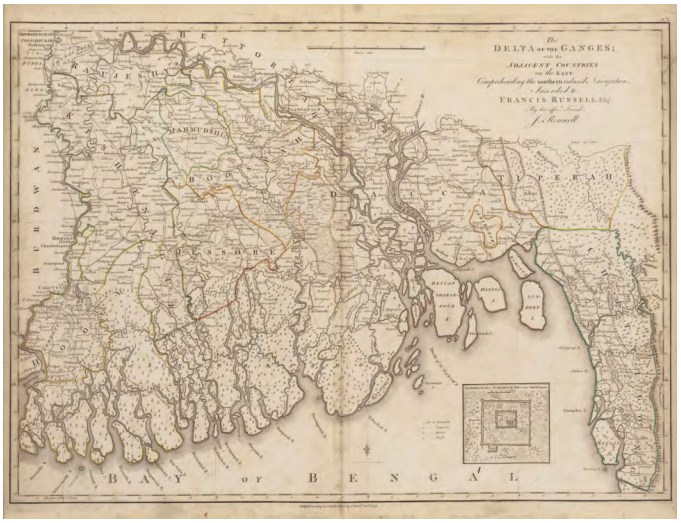


Figure 2.9: James Rennel's early map of the Bengal Delta.

51 Ashraf, "Wet Narratives."

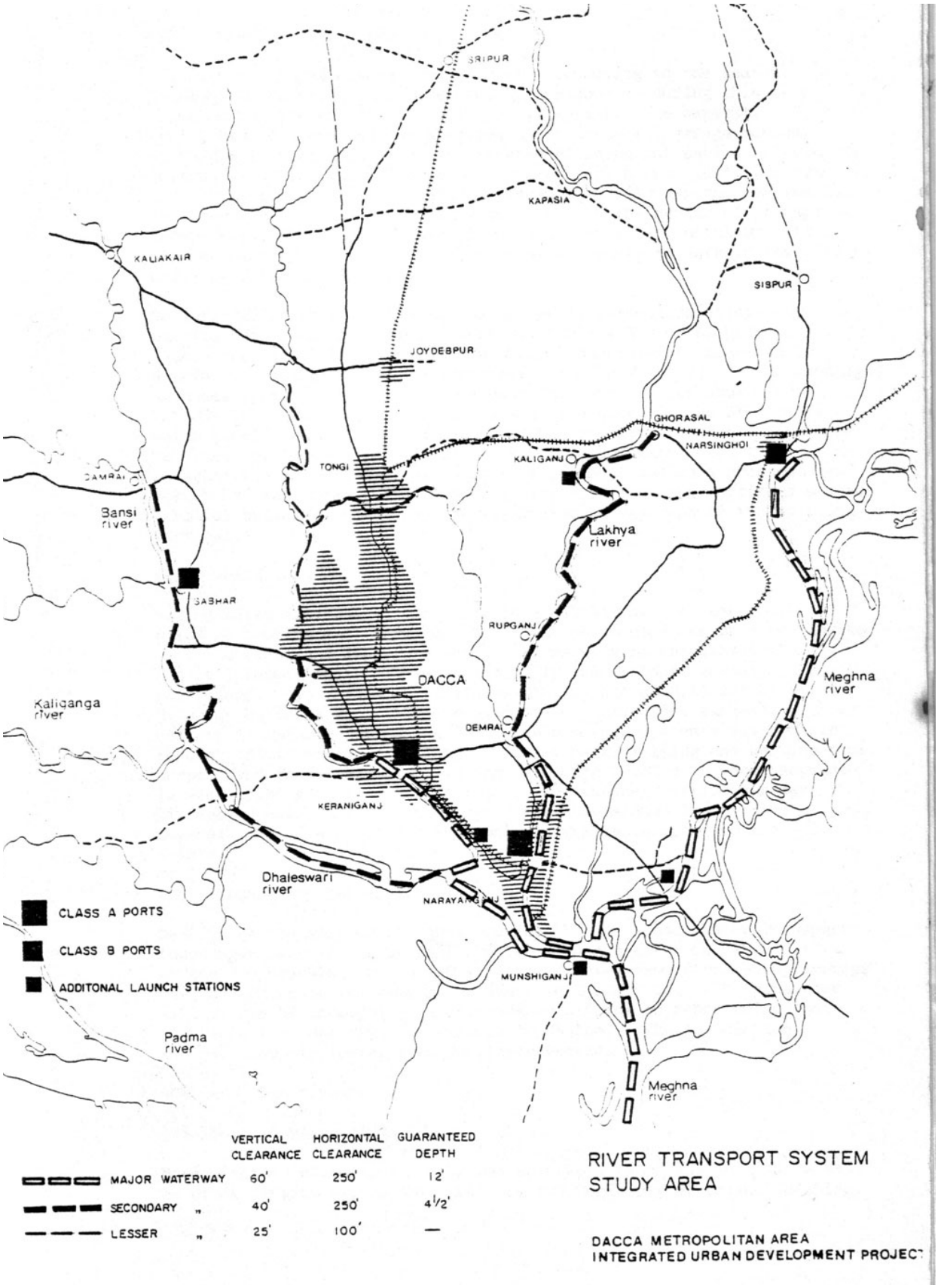


Figure 2.10: Dhaka's river transport system in 1975. At that time, unlike the present, major river transports moved through the city without obstruction.

LAND USE

Looking at the built-up area change of Dhaka city from 1972 to 2015 (Figure 2.11), it is astonishing how quickly the city has grown. In 1972, the main city occupied 35 square kilometers of space; 43 years later, it occupies 378 square kilometers.[52] The city grew to the north. The main reasons were flood-free higher ground, the transportation network, and new factories in the north. The population of the city went from 1 million people in 1972 to 17 million people in 2015. Some of the observations in regard to change in the landscape of Dhaka are as follows:

1972: Lowlands, agriculture lands and water bodies were the dominant landscape of Dhaka.
1995: Residential, commercial, industrial, roads, and mixed urban build-ups replaced many of the lowlands and the water bodies.
2005: Dhaka started growing even more aggressively, taking over most of the remaining lowlands and wetlands. With better road and bridge networks, urban expansion continued to both the south and the north.

Figure 2.12 is a photo of an encroached canal in the city.

52 Hassan and Southworth, "Analyzing Land Cover Change," 1.

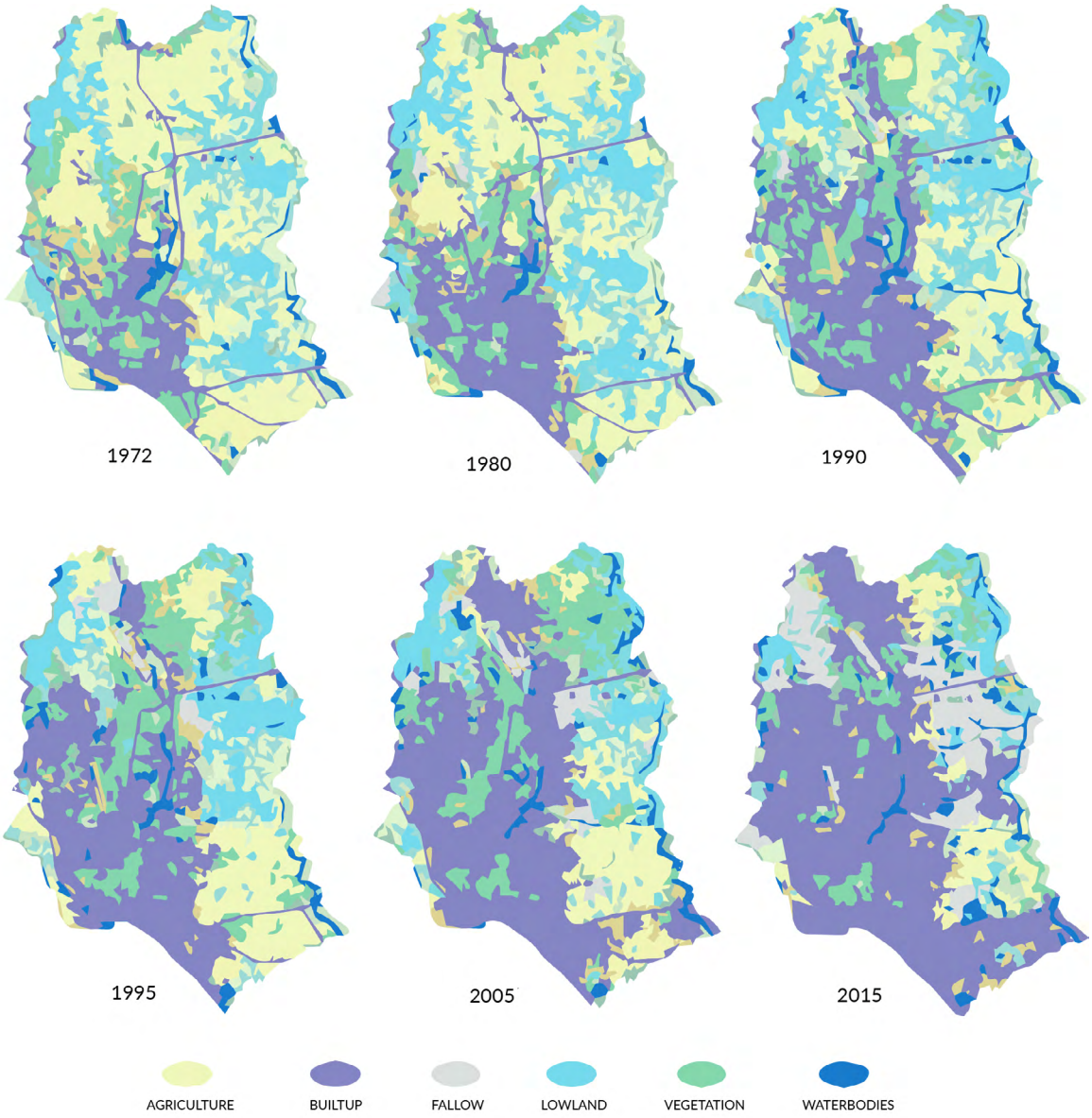


Figure 2.11: "Land cover map of Dhaka City Corporation area (DCC) between 1972 and 2015.

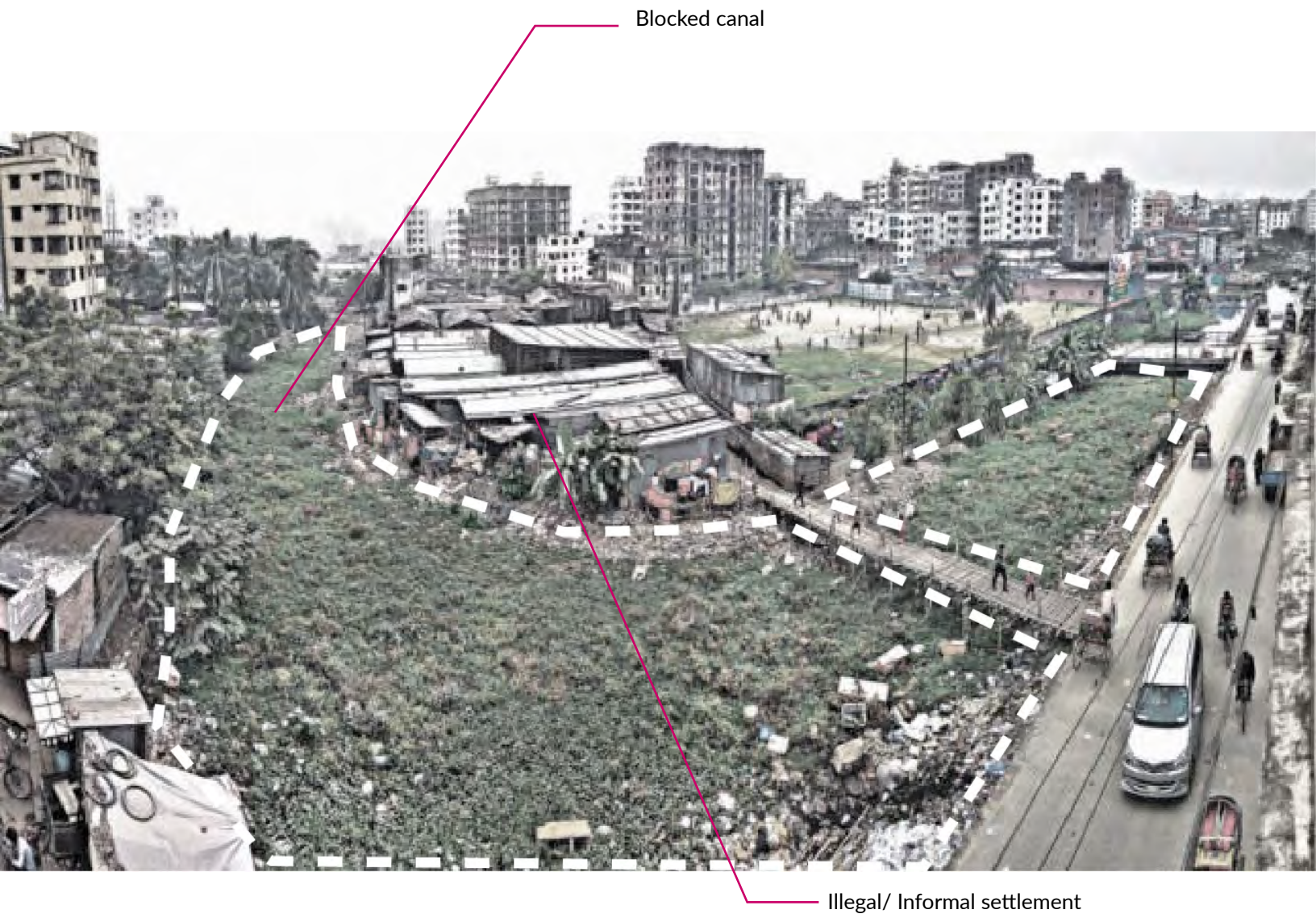


Figure 2.12: Encroachment and dumping of waste into the Ramchandrapur canal in the city causing the canal to be completely blocked.

3. Precedents, Theories, and Strategies

At the beginning of my thesis, my aim was to produce a design solution to flooding in Dhaka that would reduce the difficulty for the people. My design iterations included apartments on pillars, neighborhoods on pillars, concrete pipes repurposed as small dwellings for informal residents, etc. What I soon realized was that the problem is bigger than this thesis, or a group of people, or even a neighborhood. The problem is complex, with many agencies involved and many stakeholders affected. The solution to flooding does not just lie in design. It has a multitude of factors: governance, policies, stakeholders, negotiations, discipline, education, resilience, social equity, justice. In July 2018, I went to the Netherlands for a two-week intensive "Planning and Design with Water" summer program at TU Delft. Eighty students from forty different countries gathered at the Faculty of Built Environment and Architecture to talk and learn about issues surrounding water and land. We were together in a room for eight hours every day, talking, discussing, and learning. Bangladesh came up many times, and I was excited to hear the main organizer call Bangladesh the "Netherlands of the East." At the end of the two weeks, my vision for this thesis was clearer.

I decided to take some of the strategies I had learned at the summer school and to see how they could be placed into Dhaka. Of course, Bangladesh and the Netherlands are very different countries. One is a developed country in Europe, and the other is a developing country in South Asia. I saw the discipline of the people of the Netherlands. They cooperate with each other, and the government puts great emphasis on its citizens and their opinions. The Netherlands is a country that welcomes water and incorporates it in an organic way into its landscape. Everyone works together, and they care for their country. Bangladesh is not there yet. With such a vast proportion of the population going hungry every day, it is not easy to care for others. A large proportion of people in Bangladesh only think about how to feed their families at the end of the day. They lack education, involvement, and housing, and they are denied basic human dignity.

Before I go into details about the strategies I am proposing for Dhaka, I want to acknowledge that Dhaka and its people have shortcomings. People will have to cooperate, work together, learn and teach, and most importantly, follow rules and respect public space for these strategies to work. They can easily throw garbage into the canals, or squat somewhere, park buses in a public park, or fill up wetlands for development. The hope is that the people of Dhaka will continue progressing as they have in the past. They will respect the city and its design, they will respect water and land, and they will fulfill their duties in developing their city and their country. The director of the program said that the Dutch have the money to research and innovate, and they want to share their knowledge with countries less able to do so. I am very thankful to the program for giving me the opportunity to learn from them and to start to think about how Bangladesh can adopt the same practices. As I continued with my research afterwards, I found that researchers and architects in Bangladesh also came up with similar recommendations, which solidified my belief that the strategies I propose are in the right direction.

PRECEDENTS

THE DUTCH DELTA PROGRAMME (THE NETHERLANDS)

Figure 3.1: The Dutch flood of 1953.

The Netherlands decided to approach its water issues in a coordinated manner – instead of waiting for disasters and tackling issues one by one, they formed a common goal and objective to manage water via a National Delta Programme. The Delta Programme is a government-initiated program taking place in collaboration with nonprofit organizations, businesses, residents, and knowledge institutes. The main aim of the program is to ensure that the country is well protected against future floods and extreme weather conditions.[1]

The Delta Programme looks at the whole flood protection system in a comprehensive manner, and it is designed to protect the country from flooding today and in the future, to ensure that a freshwater supply is always available, and to participate in climate-proofing the country. Circumstances and data are constantly changing; therefore, it is essential to update the flood protection plan regularly, something the Delta Programme does annually. With climate change, the summers are getting hotter, posing risks that freshwater may dry up and become unavailable, particularly affecting farmers and industry.[2] The program, therefore, sets out expectations on when and how the government offers help for the awareness and preparedness of the involved sectors. In terms of climate-proofing the Netherlands, the program outlines the country's vulnerabilities to flooding, heat, drought, and other extreme weather conditions, and it is therefore designed to implement adaptability to climate change in all its civil works.

The Dutch Delta Programme is an example of a well-planned organized initiative that involves all stakeholders. It is an excellent model of involvement between government and citizens, and of everyone taking responsibility for their country. Figure 3.1 shows a Dutch town destroyed by the flood of 1953. A storm surge from the North Sea inundated many parts of the Netherlands, and it killed 1,836 people.[3]

1 Ministry of Infrastructure and Water Management, Ministry of Agriculture, Nature, and Food Quality, and Ministry of the Interior and Kingdom Relations, Continuing the Work on the Delta: Adapting the Netherlands to Climate Change in Time (Netherlands: Ministry of Infrastructure and Water Management Ministry of Agriculture, Nature, and Food Quality Ministry of the Interior and Kingdom Relations, 2019).

2 Ibid.

3 Alexander Hall, "The North Sea Flood of 1953." Environment & Society Portal, Arcadia 2013, no. 5. Rachel Carson Center for Environment and Society. https://doi.org/10.5282/rcc/5181.

WATER SQUARE (ROTTERDAM, THE NETHERLANDS)

Water Square Benthemplein (Figures 3.2 and 3.3) is a public space in Rotterdam, the Netherlands, completed in 2013, which turns into water storage during heavy rainfall. It combines the quality of urban public space with necessary water storage.[4] Community involvement with this project was very strong, as in most projects in the Netherlands. At the beginning of the project, through meetings with the local community, the designers drew up ideas about the square. The community and the designers agreed that the square should be a dynamic space with various uses – space for young people to play, as well as green, intimate spaces. They also wanted water to be visible when it acted as water storage.[5]

The water square is designed to hold rainwater during excess rain and until there is enough capacity within the city's infrastructure to drain the water away.[6] The design consists of two shallow basins and one deep basin to collect the water. The three squares together can retain 1,700 m^3 of rainwater.[7] The shallow basins receive water every time it rains, and the deeper basin receives water during heavy rainfall – stainless steel gutters collect rainwater from the surrounding area, and they transport it to the basins. Features include a water wall and a rain well, which also brings water into the square.[8] The two shallow basins allow the water to seep slowly through an underground infiltration device into the ground, and the water from the deep basin flows back into the open water system of the city. During dry weather, the shallow basins are used for roller skating and dancing, and the deeper basin is a sports field fit for soccer, volleyball, and basketball, with steps where audiences can sit and watch.[9]

4 Water Squares. 2019. Retrieved from http://www.urbanisten.nl/wp/?portfolio=waterpleinen

5 Ibid.

6 Ibid.

7 "New Innovative Water Square Combines Leisure and Storm Water Storage in Rotterdam, the Netherlands," 2013, https://www.dutchwatersector.com/news/new-innovative-water-square-combines-leisure-and-storm-water-storage-in-rotterdam-the.

8 Water Squares.

9 Ibid.

Figure 3.2: Water Square Benthemplein - Deep basin.

Figure 3.3: Water Square Benthemplein. All three basins.

RIEHEN NATURAL SWIMMING POOL (SWITZERLAND)

In Riehen, Herzog & de Meuron designed Naturabad Riehen (Figure 3.4 - 3.6), a swimming pool that uses natural filtration methods to clean the water.[10] The design provides chlorine-free water, and it gives the swimming pool a bath-like feeling. The water is filtered by water plants situated on a sloping landscape across the street from the pool, as well as by layers of gravel, sand and soil. The filtration process for the water starts with a strainer, which removes particles, hair, and oil. The regeneration area, where water plants such as water lilies and irises along with aquatic sediments filter the water, absorbing bacteria and other compounds, receives the water next. The water, now clean, is pumped back to the pool.[11]

The pool was modeled after local Badi (traditional wooden pools in the river), and it is situated along the north bank of the River Wiese, which is only separated from the pool by plantings, giving the swimmers a view of the river.[12] The pool can accommodate two thousand bathers each day. Riehen Natural has a recreational swimming area, lap pool, diving area, kids' pool, lounge area covered in grass, and support amenities.

10 Amy Frearson, "Herzog & de Meuron Creates Naturally Filtered Swimming Pool in Switzerland," 2014, https://www.dezeen.com/2014/07/17/naturbad-riehen-natural-swimming-pool-herzog-de-meuron-switzerland/.

11 "New Innovative Water Square."

12 Frearson, "Herzog & de Meuron."

Figure 3.4: View of the pool.

Figure 3.5: Timber amenities building frames the pool.

Figure 3.6: Lap pool is part of the swimming pool complex.

BORDEN PARK NATURAL SWIMMING POOL (EDMONTON, CANADA)

This is a natural pool in Canada, the first of its kind in the country, which uses a natural, chemical-free system Figure 3.7 - 3.8) to clean the water used in the pool.[13] A sandy beach, a concrete pool perimeter, and decking made of wood flow into each other and up to vertical surfaces made of steel and concrete. The water is cleaned using plants, microorganisms, sand, and gravel at the north end of the pool. Filtration occurs through constructed wetland, gravel filters, and zooplankton, and by means of biological and mechanical systems.[14]

13 GH3, "Borden Park Natural Swimming Pool," Accessed May 2019, https://www.gh3.ca/work/natural-swimming-pool-02.

14 Ibid.

Figure 3.7: A panoramic photo showing the hydrobotanic pond where the filtration processes takes place.

Figure 3.8: Part of the purification process is filtration through crushed granite as shown.

GOWANUS CANAL, BROOKLYN (NEW YORK, UNITED STATES)

The Gowanaus Canal in Brooklyn, New York has a masterplan that envisions a series of interconnected parks and public spaces around the Gowanus Canal, with connections to the watershed surrounding it (Figure 3.9). The goal of the project is to ensure that the canal stays available to the people around it with clean waterway and community activities. The edge of the canal will have varieties of landscape treatments with different topographies – sloping banks, raised lookout points, and forest-like seating areas. The network of streets and canals will have spaces for different activities: performance space, picnic areas, cafes, and playgrounds. The key green strategies proposed for adaptation are stormwater management streets, restoration of salt marshes, water storage and filtration gardens at the ends of streets, green roofs, and the regeneration of urban forest.[15]

15 Gowanus Canal Conservancy , "Bioswales in New York Cit." Accessed September 2018, https://gowanuscanalconservancy.org/wp-content/uploads/2018/02/Bioswales-in-NYC_extra-small.pdf.

Figure 3.9: Rendering of a portion of the Gowanus Canal masterplan.

SYDNEY PARK WATER REUSE PROJECT (AUSTRALIA)

The Sydney Park water reuse project (Figure 3.10) was completed in 2015. It captures, purifies, and reuses stormwater to irrigate the park, which occupies 44 hectares, and to supply water to the neighboring council depot.[16] The project is expected to capture and clean 850 million liters of stormwater. The stormwater is collected near the park, and it is sent through underground pipes to be filtered by a pollutant trap and bio-retention beds. The pollutant trap uses a physical screen to remove litter, coarse sediments, and organic matter, the bio-retention system uses plant roots and soil in shallow depressions to collect and filter water, and finally an ultraviolet cleansing process purifies the water further before reuse. The park has four wetland areas contributing to the ecology and flood mitigation, cleaning stormwater, and managing stormwater runoff and urban wildlife habitat.[17]

16 City of Sidney, **"Sydney Park Wetlands," Accessed July 2018, https://www.cityofsydney.nsw.gov.au/vision/better-infrastructure/parks-and-playgrounds/completed-projects/sydney-park-wetlands**.

17 **Ibid.**

Figure 3.10: Sydney Park water reuse project.

THEORIES
RIGHT TO THE CITY

> Now we have a literature on global warming and a general sense of an environmental crisis that is no doubt mediated by the inequalities of capitalist development, but it is a crisis that faces humanity as a whole. In all these moves, we are left with three images of the human: the universal-Enlightenment view of the human as potentially the same everywhere, the subject with the capacity to bear and exercise rights; the postcolonial-postmodern view of the human as the same but endowed everywhere with what some scholars call "anthropological difference"–differences of class, sexuality, gender, history, and so on. The second view is what the literature on globalization underlines. And then comes the figure of the human in the age of Anthropocene, the era when humans act as a geological force on the planet, changing its climate for the millennia to come.[18]
> - Dipesh Chakrabarty

> The right to the city is far more than the individual liberty to access urban resources: it is a right to change ourselves by changing the city. It is, moreover, a common rather than an individual right since this transformation inevitably depends upon the exercise of a collective power to reshape the processes of urbanization.[19]
> - David Harvey

Henri Lefebvre first conceptualized the idea of the right to the city in his book *Le Droit a la Ville* in 1968. Lefebvre's aim was to open up a society beyond capitalism, state, and consumer society.[20] For Lefebvre, the right to the city involved appropriation and de-alienation of urban spaces – the inhabitants of the city taking the space from the government because rightfully, the space belonged to them, and appropriating it to their own use.[21] In that sense, the informal settlements rightfully belong to the residents. However, the view of the right to the city has evolved, and Lefebvre's view has met its share of criticism.

18 Chakrabarty, "Postcolonial Studies."

19 David **Harvey, "The Right to the City," New Left Review 53 (2008): 23.**

20 Mark Purcell, "Possible Worlds: Henri Lefebvre and the Right to the City," Journal of Urban Affairs 36, no. 1 (2014): 144. http://faculty.washington.edu/mpurcell/jua_rtc.pdf.

21 Ibid, 149.

In recent years, the term has regained traction, and in this thesis, it is a term worth remembering when talking about migration and illegal occupation. Looking at Dhaka today, the entire city is being taken over by developments. These developments are being sold at hefty prices to the wealthy. Squatters constantly fear eviction. The affluent of the city do not think the poor have the right simply to squat anywhere. While planned development of a city is necessary, the poor cannot just be banished. They also have the right to the city, as everyone has the right to urbanization. On the flip side of the argument is Haussmann's Paris, where many communities faced eviction and demolition for the betterment of the city. I believe Dhaka needs to be designed keeping both these theories in mind.

David Harvey argues that cities from inception were a result of surplus product, and the decision on how to control the surplus products was taken by the few people in power.[22] Therefore, he argues that urbanization has been a "class phenomenon," [23] which already existed under capitalism, but in this case, it also required the mobilization of the surplus product.

Haussmann was given the responsibility of changing Paris in 1853, and he realized that urbanization was the solution to the use of surplus capital and unemployment.[24] His design was radical, and it involved complete changes of neighborhoods, demolition of houses, and creating the grand boulevards that made Paris what it is today. This proposition was very expensive, and it involved the relocation of a vast number of people and the creation of new infrastructure. Paris had Haussmann; New York had Robert Moses. After World War 2, Moses changed the way infrastructure worked in New York. He solved the problem of capital surplus absorption, and he re-imagined the entire metropolitan area through highways and new infrastructures.[25]

Dhaka is an overcrowded city. Every day, people from the villages get onto the roofs of trains and buses and come to Dhaka in search of work. It is their right to come. Everyone has the right to a better life, and if they think that coming to the city will give them the opportunity to make something of themselves, the people who have already made it do not have the right to

22 Harvey, "Right to the City," 24.
23 Ibid.
24 Ibid, 26.
25 Ibid, 27.

say otherwise. The solution is not to send the overcrowded population back to their villages so that development stops. Nor is it to stop development because the vulnerable population living in informal settlements would be displaced. However, as architects and planners, it is important to keep in mind the necessity to offer alternate solutions to the displaced population.

SUSTAINABILITY AND RESILIENCE

Sustainability, resilience, and adaptability have become keywords in architecture and design. With climate change and more frequent and intense natural events, it is very important that any design that we create is sustainable and resilient.

One of the most popular definitions of sustainability comes from the Brundtland Commission, which states that "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[26] Sustainability takes into account environmental factors, social factors, and economic factors, and it aims to improve the current conditions and the future of these factors.[27]

Traditionally, resilience was known as the ability of a system (such as the environment) to bounce back after being exposed to extreme conditions.[28] However, in recent studies, it has been defined as not just the immediate response to a disaster, but also the ability to adapt to challenges and the ability to change in new situations. Historically, response to flood has been one dimensional – building walls to keep water out, building structures on stilts, and rebuilding after everything is wiped out by a flood.[29] Resilient design looks beyond a single response and individual projects. During and after flooding, resilient design looks at the whole system. Examples of resilient design include better ecosystems able to act as natural buffers, parks that

26 Herbert Dreiseitl et al., Making Cities Liveable (Copenhagen: Ramboll Foundation, 2016).

27 Dayton Marchese et al., "Resilience and Sustainability: Similarities and Differences in Environmental Management Applications," Science of the Total Environment 613-614 (2017): 1275. https://dx.doi.org/10.1016/j.scitotenv.2017.09.086

28 Ibid.

29 "Professional Practice." Resilient Design: Flooding. Accessed September 1, 2018. https://www.asla.org/flooding.aspx.

store flood water temporarily, and infrastructures that also participate in absorbing and purifying floodwater[30].

One of the biggest drawbacks of the unplanned development of the city is its inability to plan for resilience. People are individually selling their plots to developers, and developers are designing to maximize their sales. The strategies I suggest later in this chapter deal with making Dhaka a more resilient and sustainable city.

BLUE AND GREEN INFRASTRUCTURE

Cities are becoming increasingly gray. Buildings and roads, asphalt and concrete are replacing the greenery and the water bodies of nature. Our porous ground is becoming increasingly impermeable. We are building on the ground and blocking our relation to it. The gray infrastructure we have built has become harmful to our climate and the natural water cycle. The solution to this problem is turning the gray into green and blue.

Green infrastructure is defined as "a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits."[31] Typically, gray stormwater infrastructure employs the use of pipes and water treatment systems to move stormwater away from the cities. Green infrastructure does not aim to move water away; the system treats water in the urban environment where it originates.[32] It also replicates the natural water cycle[33] by using vegetation, plants, and greenery.

Examples of green infrastructures are rain gardens, planter boxes, bioswales, permeable pavements, green streets, green roofs, and urban tree canopy.[34]

Rain gardens: Rain gardens are shallow landscapes with vegetation that can be installed in any natural grounds. They enhance infiltration, evaporation, and transpiration of rainwater that collects in them from rooftops, sidewalks, and street runoff.[35]

30 "Resilient Design: Flooding,"

31 United States Environmental Protection Agency. "What is Green Infrastructure?", Accessed May 3, 2019, https://www.epa.gov/green-infrastructure/what-green-infrastructure.

32 Ibid.

33 Ibid.

34 Ibid.

35 Ibid.

Planter boxes: These are conceptually similar to rain gardens, and they are small areas in a defined, boxed area installed in urban environments. They can be found on sidewalks and parking lots, where they collect stormwater runoff from the street and surrounding areas.[36]

Bioswales: These are also similar to rain gardens, and they are installed beside streetscapes and parking lots. They are less defined than planter gardens, and they act as long, narrow vegetated channels that move stormwater.[37]

Permeable pavements: Permeable pavements can be made of pervious concrete, porous asphalt, or permeable interlocking blocks.[38] They can form streets, sidewalks, and a permeable floor for the city. They catch rainwater when it falls, and they allow rain to seep into the ground.

Green streets: Green streets take the above concepts and create streets with the capacity to manage stormwater better. Doing so reduces stormwater runoff, and it integrates green infrastructures into everyday streets.

Green roofs: Green roofs are particularly important in dense urban areas. They employ the use of vegetation and growing media on the roofs of buildings. This sytem helps manage stormwater, enables infiltration of rainfall and facilitates evapotranspiration of stored water.[39]

Urban tree canopy: Trees reduce stormwater runoffs by soaking up the water for their own use. Tree canopies also provide cooling shade.[40]

Blue infrastructure is closely related to green infrastructure. While green infrastructure refers to the employment of plants and vegetation in building our cities, blue infrastructure refers to the water bodies to be incorporated in our cities. Usually the two systems work together as a comprehensive system by incorporating natural processes into the urban environment, and they assist in managing stormwater and supplying sustainable water while keeping up with the demands of the cities.[41]

36 Ibid.
37 Ibid.
38 Ibid.
39 Ibid.
40 Ibid.
41 Dreiseitl et al., Making Cities Liveable, 3.

BENEFITS OF BLUE AND GREEN INFRASTRUCTURE

The quality of water improves with the implementation of blue and green infrastructure (BGI). As water moves through the soil layers, through sediments, plant roots, and filtering particles, it is purified. The "natural unsealed surface" also allows water to seep deep into the ground to the aquifers and to recharge them.[42]

The quantity of water is managed in a useful way when BGI takes in the water. Some of the water evaporates, and some is transported to retention areas and stored for future use. Retention areas also act as buffers until the water can be released into the environment. This reduces stormwater runoff discharge into the water transport channels.[43]

Climate change adaptation is a benefit of BGI. Benefits include restoration of diurnal temperature variation, natural air ventilation and the reduction of the heat island effect. BGI improves stormwater management, biodiversity, aquatic ecosystems, and landscape connectivity. All of these are related to each other, and BGI offers a holistic improvement of the environment and climate.[44]

Finally, with good design, BGI can improve public spaces and provide spaces for social activities, human connectivity to each other, and human connections to the environment.

Many of the BGI concepts overlap with the concepts of a sponge city. The intention behind the design elements of a sponge city is to absorb as much extra water into the city as possible. Sponge city approaches the design related to stormwater management in a holistic fashion. The design elements include storage tunnels, green rooftops, permeable pavements, rain gardens, wetlands, and constructed ponds. The intention is to store as much extra water as possible. Some cities in China have started to adopt this concept.[45]

42 Ibid, 6.

43 Ibid, 6.

44 Ibid, 7.

45 Suzie Housley, "Three Ways to Think Like a Sponge City:: StormSensor: Creating Smart Urban Watersheds.," Accessed April 22, 2020, https://www.stormsensor.io/three-ways-to-think-like-a-sponge-city/

STRATEGIES

The current system of floodproofing the city is failing, as mentioned in previous chapters. The western embankment is a non-porous wall, which does not take the difference in levels of water on the two sides into account. As a result, even when the river is not full, monsoon rain gets boxed inside the embankment. Poor upkeep and the general ignorance and irresponsibility of citizens has resulted in the sluices and drainage systems being blocked and unable to let the water out.

The goal of the following four strategies is to incorporate elements into urban Dhaka that will be able to deal with flooding in a sustainable and resilient fashion. The goal is also to create visible designs that may educate Dhaka's people on the role of these implementations. Most importantly, the goal is to create designs not to keep water away, but to welcome water back into our cities, into our ground, and into our lives. I am proposing the following four strategies to reduce the flooding in the city and to increase public spaces and connections:

1. Water-retention sunken plazas.
2. Blue and green features.
3. Reconnecting canals for stormwater management.
4. Connecting the city via walkways.

Figures 3.11 and 3.12 are author's renderings created in response to the desire to break down barriers between the city and water.

Figure 3.11: Imaginative rendering of a rainy day in Dhaka City.

Figure 3.12: Imaginative rendering of an inundated city.

1. WATER-RETENTION SUNKEN PLAZAS

Much like the Water Square in Rotterdam, these sunken plazas would act as water reservoirs during heavy monsoon rain. In a dense city like Dhaka, the possibility of having large-scale sunken plazas and water reservoirs is limited, but with cooperation between landowners and government, creating a few large water-retention basins, plazas, and reservoirs, along with smaller reservoirs in larger quantities would be possible. Public parks and empty government lands have the potential to adopt the sunken plaza strategy – the space would still be useful – but in terms of heavy rainfall, the spaces would hold the extra water and then slowly release it into the canals using pumps.

One way the space for these plazas can be squeezed out is by sharing the margins of lots for new buildings upon which building is not permitted and combining those spaces between adjacent plots to create smaller plazas. Another method would be government acquisition. Plots are constantly being bought and sold, and the government could decide to buy land systematically when it is being sold to use it to build smaller public sunken plazas. Government acquisition is not new in the city and happens for various city projects. Figures 3.13 - 3.14 are theoretical examples of government acquiring lands in built-up neighborhoods and Figures 3.15 - 3.17 show examples of micro sunken plazas. They can act as fields for use by the neighborhood in dry weather, and as water-retention spaces during heavy rainfall. This strategy would require cooperation between citizens and governments, and, most importantly, everyone working towards a common goal for their country.

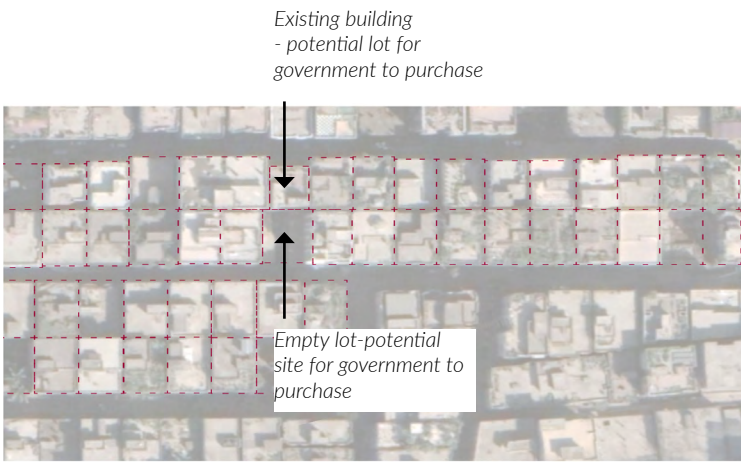


Figure 3.13: Dhaka Block's existing condition.

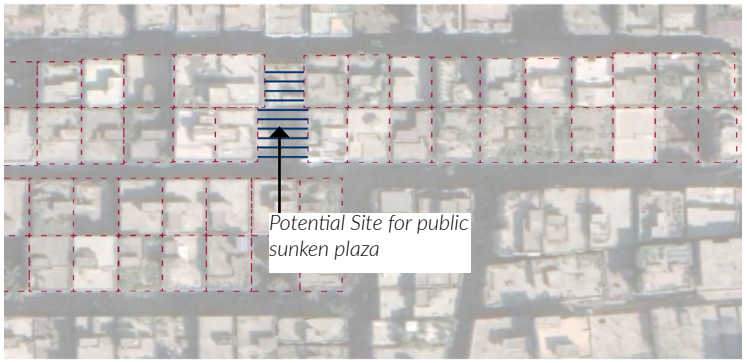


Figure 3.14: A potential site for intervention.

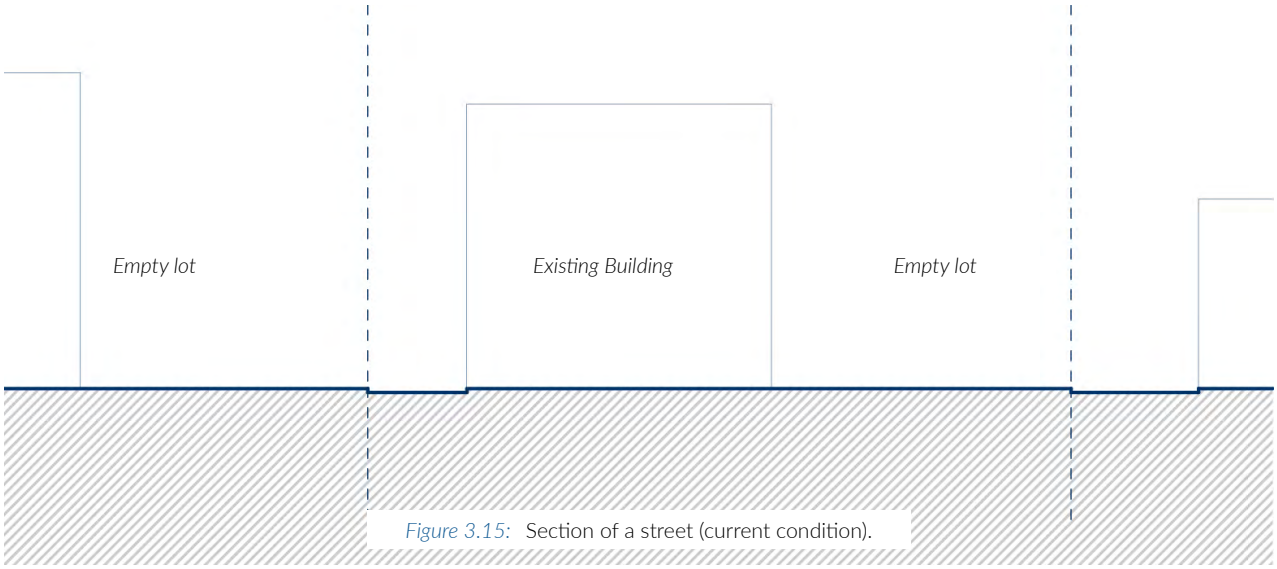


Figure 3.15: Section of a street (current condition).

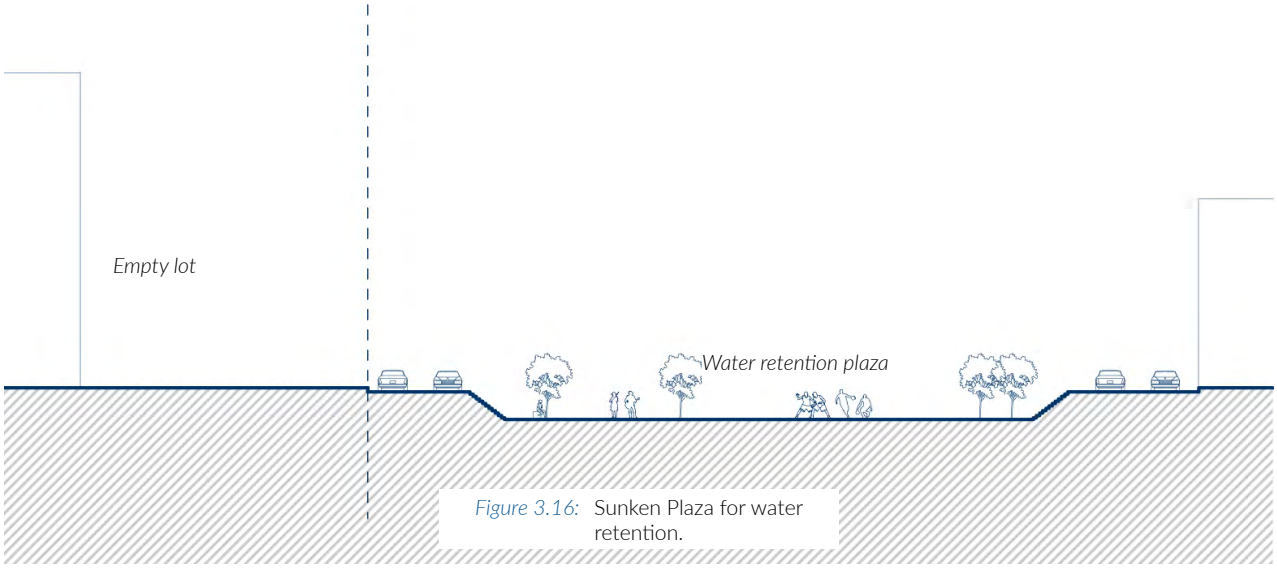


Figure 3.16: Sunken Plaza for water retention.

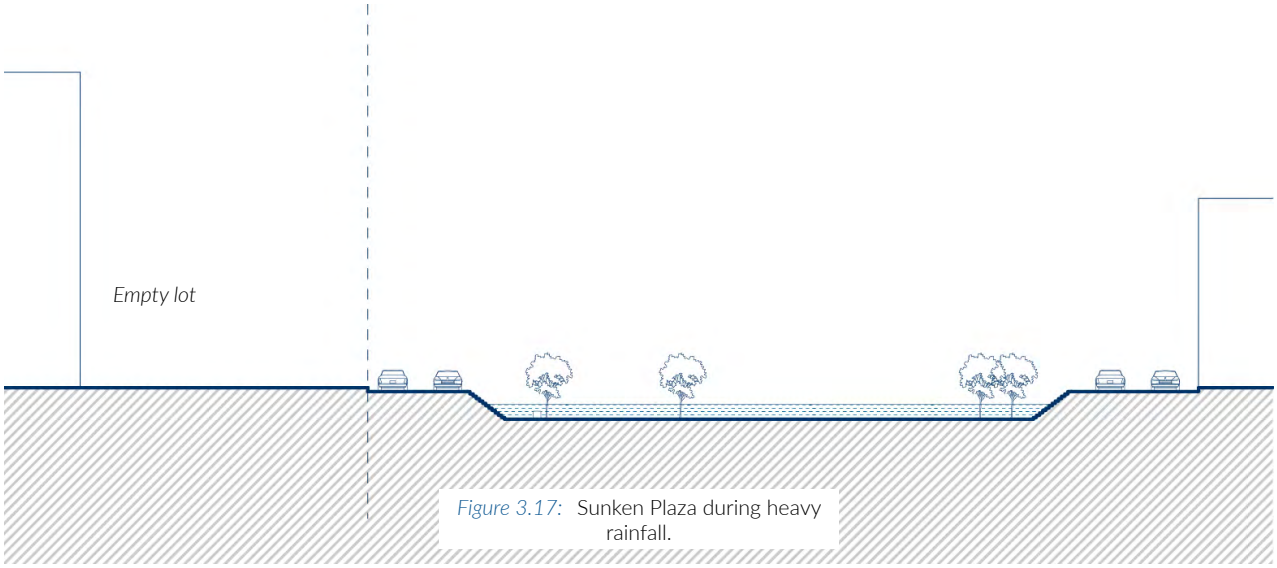


Figure 3.17: Sunken Plaza during heavy rainfall.

2. BLUE AND GREEN FEATURES

These four features are directed towards creating permeability and greeneries in the ground. Dhaka's impervious surface retains a significant portion of the water, and it prevents the water from penetrating the layers of non-porous ground and reaching the aquifers. The following features would incorporate more blue features into Dhaka.

The sandy soil in the ground is covered by clay in the city because of human intervention during the growth of the city. These sub strategies also remove the clay layers thus exposing the sand and allowing for better absorption of water into the ground. Some of the stormwater management proposals would need to be incorporated into Dhaka's ground. Raingardens, rainwater cisterns, bioswales, and permeable pavers are effective strategies in stormwater management.[46] These strategies will reduce the strain on Dhaka's rainwater management.

1. Raingardens (Figure 3.18) collect rainwater. Some of it is absorbed into the ground and some is absorbed by plants. In a dense city like Dhaka, space is limited, but it is still possible to incorporate raingardens into lawns, backyards, and parks throughout the city. Public complexes such as Dhaka University are perfect places for raingardens. Overflow from the rain slowly seeps through mulch and gravel. Excess water is eventually carried away by the perforated pipes when the city's water drainage system clears up.

2. Rainwater cisterns (Figure 3.19) are an easy way to increase the stormwater storage capacity of the city. They are large underground tanks that hold rainwater when necessary and eventually perforated pipes inside the cistern drain out the water into the city's water drainage system.

3. Bioswales (Figure 3.20) can be incorporated into streets, and they do not take up too much space. They can soak up rain and runoff from the streets. The water is then absorbed by the trees or absorbed into groundwater. The main arteries of the cities already have greenery, and it can be modified to increase rainwater absorption into the ground. Smaller streets can also have smaller strips of bioswales.

4. Repaving residential streets (Figure 3.21) with permeable pavers would recreate the natural hydrological cycle and allow water to seep into the ground. Permeable pavements such as interlocking concrete pavers have narrow gaps between them through which runoff water would seep through, pass through aggregates and reach the soil.

46 Gowanus Canal Conservancy, "Bioswales in New York City." Accessed April 7, 2019, https://gowanuscanalconservancy.org/wp-content/uploads/2018/02/Bioswales-in-NYC_extra-small.pdf.

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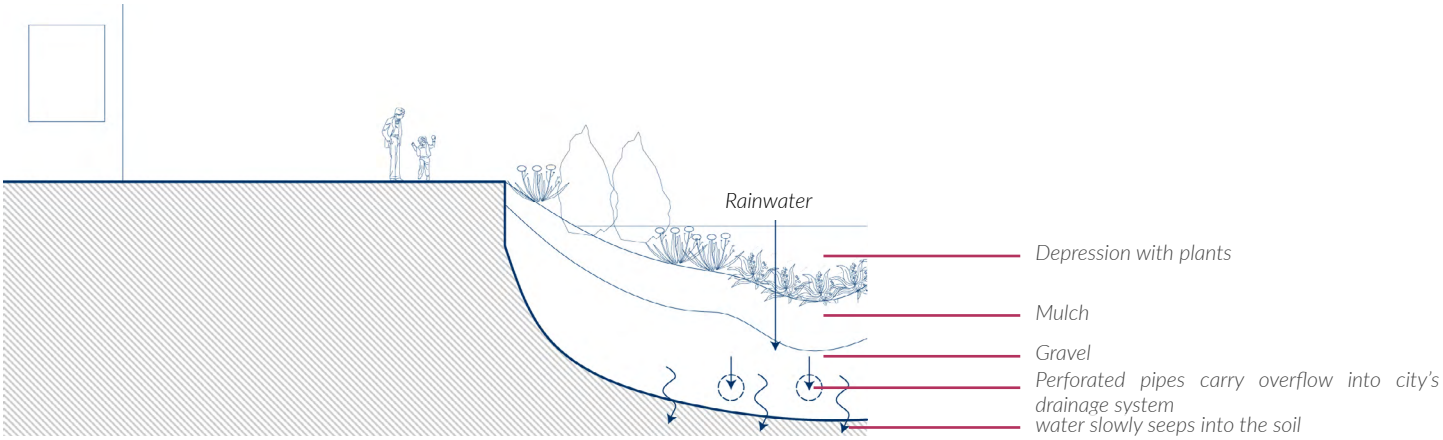


Figure 3.18: Raingarden.

2

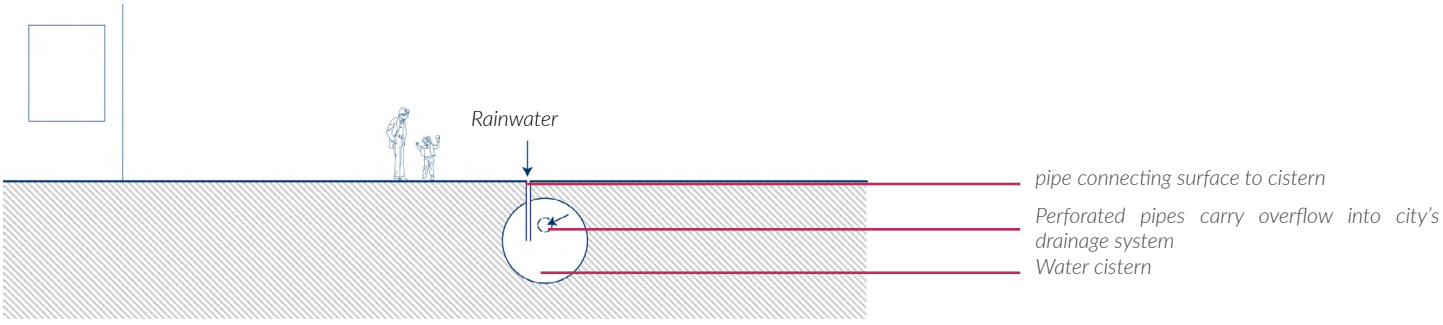


Figure 3.19: Rainwater cistern.

3

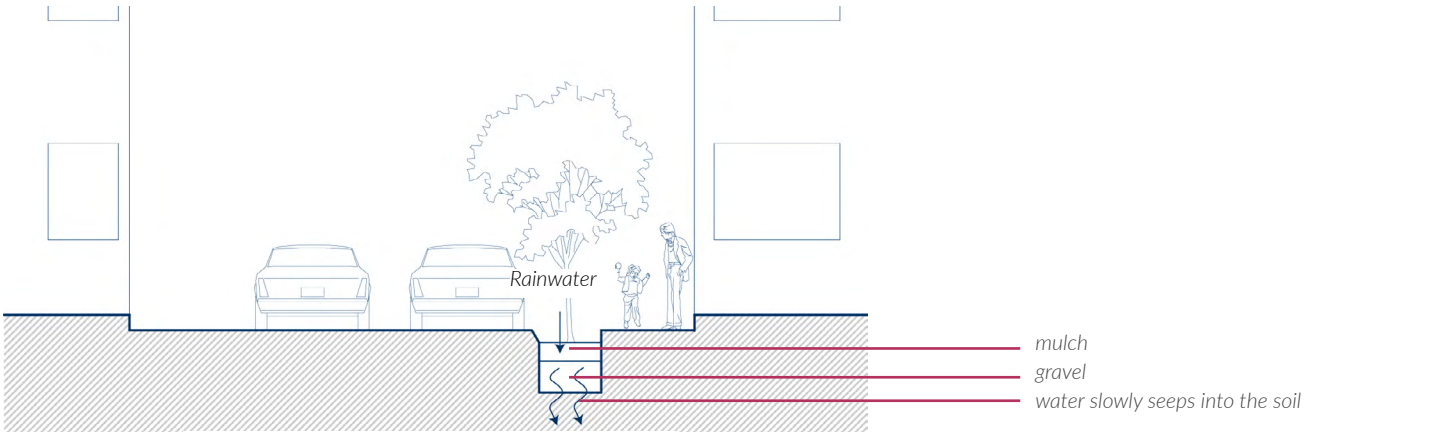


Figure 3.20: Bioswales introduced on street sides.

4

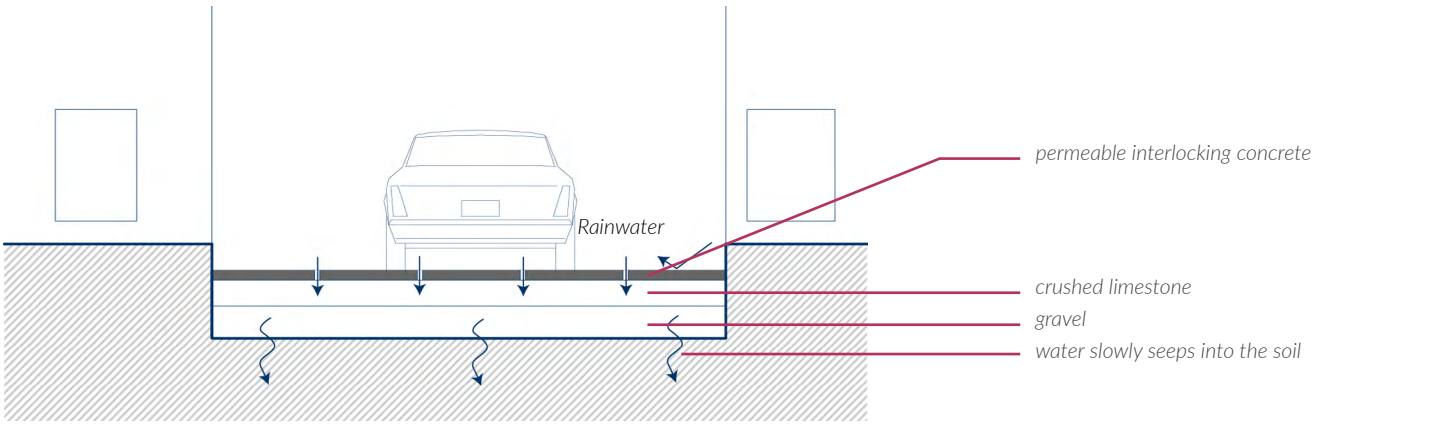


Figure 3.21: Streets repaved with permeable concrete.

3. RECONNECTING CANALS FOR STORMWATER MANAGEMENT

As mentioned previously, the main drainage of Dhaka is via the canal running through the center of the city. Due to encroachment, unplanned developments and improper use of the canal, the canal is currently segmented and inefficient at its job. Reconnecting the fragmented canals with each other and properly to the rivers around Dhaka would allow the water to flow through the city into the rivers, relieving some of the waterlogging.

A geomorphological map shows the past canal system of the city (Figure 3.22). The map shows the depression where the original canal used to exist (the light blue segments on Map 2 and 3 in Figure 3.22 are the original depressions). Map 1 shows the current plan of the city with the water bodies, rivers, and canals filled in blue. Map 2 is the plan of the city overlaid on top of the geomorphological map of the city. Map 3 uses the depressions in Map 2 to trace out the presumed original canals in the city. Map 4 is the proposed connected drainage system for the city. The fragmented canals would be reconnected to the rivers surrounding the city. Figures 3.23 - 3.25 show the current edge condition between the city and the canal at Banani Lake marked A in Figure 3.22 Map 4.

Figure 3.22: Tracing the canals using the geology of the city to connect the water system.

Figure 3.23: Edge condition between the canal and the city.

Figure 3.24: Edge condition between the canal and the city.

Figure 3.25: Edge condition between the canal and the city.

4. CONNECTING THE CITY VIA WALKWAYS CONSTRUCTED ALONG THE RIVER

Finally, embankments along the canal would increase the volume of water the canal can hold. Instead of creating walls, the proposal is to create embankments with gradual slopes and greenery. The embankment would incorporate walkways, public sitting areas, art exhibition areas, and other amenities (Figure 3.26). Figure 3.27 is a map of Dhaka showing the proposed strategy. The commercial districts of the city are close to each other, and yet, because of heavy traffic and lack of proper pedestrian walkways, movement is not easy. Creation of a pedestrian-friendly walkway on top of the embankment serves two purposes. First, it prevents the embankment to act as a wall, which would alienate the city from the water. Instead, the embankment is gradual, and it allows views and public spaces along the canal. The second purpose is to guarantee that vehicles cannot take over the pedestrian spaces. This concept is elaborated more in chapter 5 along with drawings.

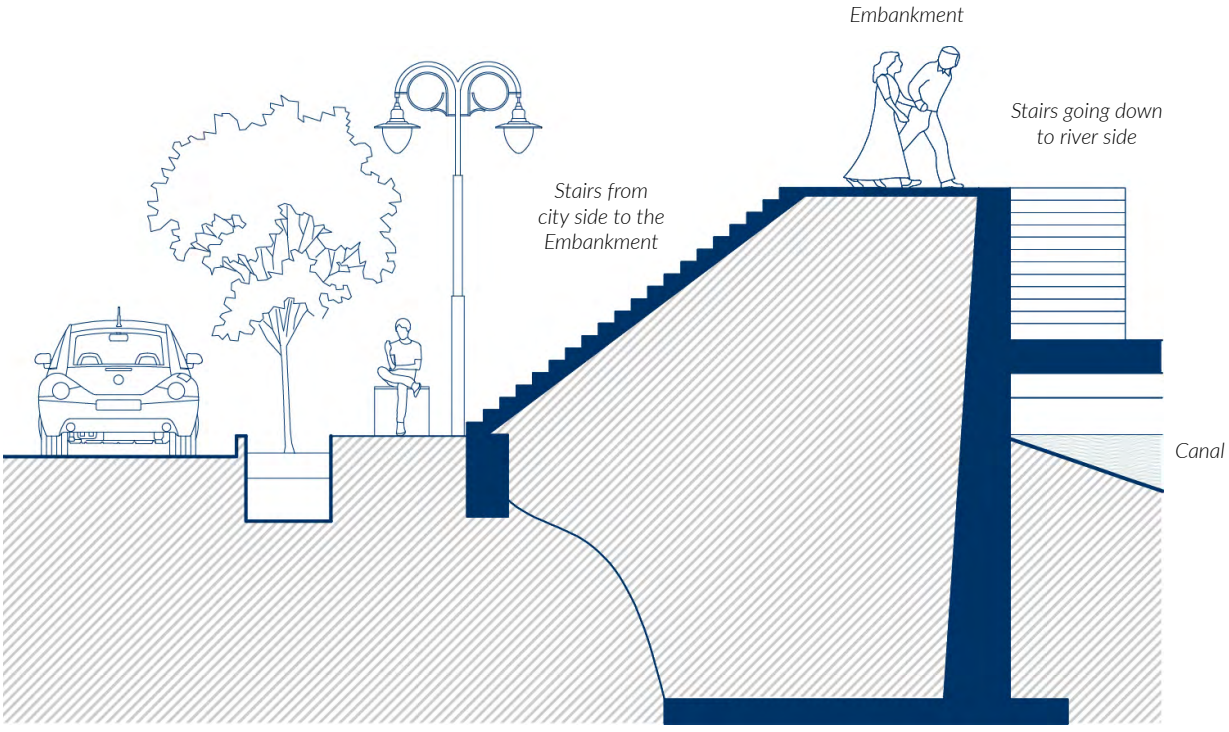


Figure 3.26: Section through proposed embankment. More details in Chapter 5 Figure 5.35.

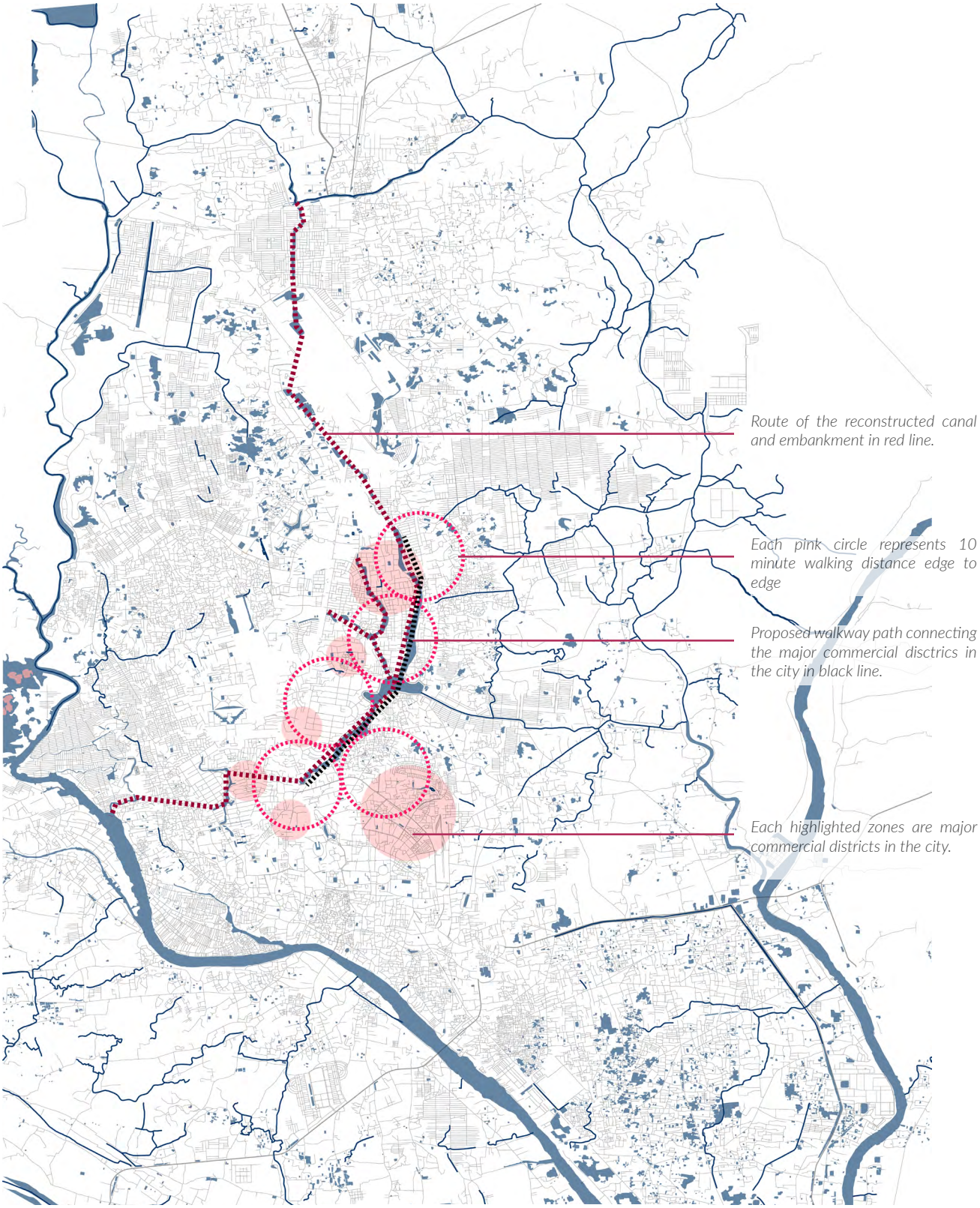


Figure 3.27: Diagram showing the pathway for reconnected canal and walkway.

4. Context and Site

I spent the first 18 years of my life in Dhaka. In the dense and congested streets of Dhaka, I would spend at least 2-3 hours every day stuck in traffic. Whenever the car stopped, street beggars would knock on the windows and little children would try to clean random cars' windshields with dirty rags. Magazine sellers, towel sellers, fruit sellers, tea sellers – any kind of commodities that were cheap and that could be easily carried would pop up near the windows of cars, sides of rickshaws, openings in baby taxis. Sometimes little children no more than 6 or 7 years of age would beg for money while their mothers would wait on the streets. Sometimes mothers would beg for money with infants in their lap – the infants would be borrowed by the beggars to get people's empathy. There was no end to the people showing up, no end to the sea of people jumping into the street at every traffic light and every stopped vehicle. That is what I grew up seeing. Hundreds of human beings walking on the streets, sleeping on the sidewalk, and collecting garbage are all part of the architecture of the city, part of my memory of Dhaka.

-Author's Entry
March 2018

This thesis does not deal with the housing crisis or attempt to design social housing. This thesis is about water and its presence and absence in the city. The vulnerable community of Dhaka is the people described above – those living in the streets and slums of Dhaka. My design proposal asks for some relocation of these vulnerable people. Thus, I think this thesis will be incomplete without some exploration of the practices, policies, and crisis regarding the issues of housing, informal settlements, and relocation policies of the city. The housing crisis (more specifically the affordable housing crisis) is connected to the site I eventually chose for my design proposition. In this chapter, following some general exploration of the issues, I zoom into the site I chose for the design proposal, and I discuss the nature, shortcomings, threats, and opportunities of the site.

THE CONSTITUTION OF BANGLADESH

The constitution of Bangladesh was written soon after the Liberation War. Bangladesh became an independent country in December 1971. The constitution dates back to November 1972.[1] The following are excerpts from the constitution that mention design, housing, and relocation.

ARTICLE 11
DEMOCRACY AND HUMAN RIGHTS

The Republic shall be a democracy in which fundamental human rights and freedoms and respect for the dignity and worth of the human person shall be guaranteed, and in which effective participation by the people through their elected representatives in administration at all levels shall be ensured.[2]

ARTICLE 15
PROVISION OF BASIC NECESSITIES

It shall be a fundamental responsibility of the State to attain, through planned economic growth, a constant increase of productive forces and a steady improvement in the material and cultural standard of living of the people, with a view to securing to its citizens –

(a) the provision of the basic necessities of life, including food, clothing, shelter, education and medical care;
(b) the right to work, that is the right to guaranteed employment at a reasonable wage having regard to the quantity and quality of work;
(c) the right to reasonable rest, recreation and leisure; and
(d) the right to social security, that is to say, to public assistance in cases of undeserved want arising from unemployment, illness or disablement, or suffered by widows or orphans or in old age, or in other such cases.[3]

1 Bangladesh Const. § 2, cl. 11, http://bdlaws.minlaw.gov.bd/act-367/section-24559.html
2 Ibid.
3 Bangladesh Const. § 2, cl. 15, http://bdlaws.minlaw.gov.bd/act-367/section-24563.html

Forty-six years after the constitution was written, the government has yet to succeed in fulfilling its citizen's rights. Article 11 says that dignity and worth of human beings shall be guaranteed. Article 15 says that government shall aim to secure food and shelter for all the citizens. When the government failed to provide food and shelter for all the citizens, dignity and worth ceased to be important for the hungry and the homeless. Their only goal became survival, and they did whatever was necessary to do to survive.

On the other hand, the elite, the privileged, and the influential members of the society have been benefiting from the actions of the government.[4] Public housing exists in the city, but it was developed for government employees.[5] Some 5.4 million people in the six major cities in Bangladesh live in slums.[6] From an economic point of view, housing is not seen as a major driver of economic growth in Bangladesh, but in reality, proper housing contributes to better health and wellbeing among the people, thus resulting in higher productivity and higher growth for the country.[7] Proper housing allows citizens to contribute to the development of the country.

Soon, we will see that the site for this thesis is a slum in the middle of Dhaka. As such, I think it is important that we look at slums in-depth to understand their life, their demographics, and their lifestyle. By studying and understanding the population for which we are designing, I hope to come up with an inclusive and thoughtful proposal. There are lots of numbers in the next few pages, but they are important in painting a clearer picture for those who have never visited these slums.

Today, the word slum comes with political and social connotation and is sometimes used in a derogatory manner. However, in Bangladesh, the word slum is still widely used by academics to describe certain kinds of informal settlements in the city. Since the sources for this thesis have used the word slum to describe these settlements, in this thesis I continue to refer to the informal settlements as slums.

4 Kazi Ashraf et al., "The Future of Housing in Bangladesh," Daily Star, February 19, 2019, https://www.thedailystar.net/supplements/28th-anniversary-supplements/avoiding-urban-nightmare-time-get-planning-right/news/the-future-housing-bangladesh-1704259.

5 Ibid.

6 Nazrul Islam et al., Slums of Urban Bangladesh: Mapping and Census, 2005 (Dhaka: Centre for Urban Studies, National Institute of Population Research and Training and MEASURE Evaluation, 2006), 14.

7 Ashraf et al., "Future of Housing."

WHAT IS A SLUM

The Center for Urban Studies (CUS) in Dhaka looked at various studies and their earlier works to come up with a definition of slum that works in the context of Bangladesh. It maintained that slum and squatter settlements are the same thing.[8] It defined slums as "settlements with a minimum of 10 households or a mess unit with a minimum of 25 members and: predominantly very poor housing; very high population density and room crowding; very poor environmental services, especially water and sanitation; very low socio-economic status; and lack of security of tenure."[9] The CUS noted that any settlements meeting any four of the five criteria were considered slums. They went on to define their terms further.

Poor Housing: Communities that consisted of more than 50% of housing made of non-permanent structures such as inexpensive woods, bamboo, corrugated iron sheet roofs on brick walls, or fragile old buildings were defined as very poor housing.[10]

High Population: A high population settlement is one with over 751 people per hectare.[11] In terms of room crowding, it is when there are three or more mixed-sex adults in one room, four square meters of floor space per person and mostly one family living in a single room. Again, if the cluster had more than 50% of homes comprising three or more people sharing a room, that was considered room crowding.

Poor Environmental Service: The factors considered were water source, sanitation, and electricity.[12] When there was no water connection at home and water had to be collected from more than 50 meters away, that was considered poor service. For poor sanitary conditions the criterion was whether the dwellings lacked latrines in their homes or lacked access to proper latrines (if more than 50% of households had poor sanitary conditions, the community was considered to have poor environmental service).[13] Poor drainage was also part of the investigation, since poor drainage causes waterlogging and the spread of diseases. The last environmental factor considered was provision of electricity, gas, and garbage clearance.

Low economic status: Low economic status was defined by low income with more than 50% of households making less that 5000 Taka ($60 USD) per

8 Islam et al., Slums of Urban Bangladesh, 14.
9 Ibid.
10 Ibid.
11 Ibid.
12 Ibid.
13 Ibid.

month. Majority of the people in this group worked in informal sectors such as domestic workers, rickshaw pullers, etc. Other factors considered were low rent and whether socially the settlement was seen as a slum.[14]

Lack of security of tenure: This was determined by high vulnurability of the households to eviction.[15]

2005 CENSUS

2005 was the last year the Center for Urban Studies conducted an in-depth census of the slums of Bangladesh. In the 14 years since the last census, some numbers may well have changed, but a lot has remained the same. Due to the lack of a more recent thorough study, the data collected in 2005 is referred to here. The criteria mentioned in the previous section were used to identify slums through extensive fieldwork following mapping using satellite image, and the investigation took place in six major cities in Bangladesh: Dhaka, Chittagong, Khulna, Rajshahi, Sylhet, and Barisal.[16] Some 35% of the combined population of these cities were slum dwellers. A total of 5.4 million people lived in slums in these cities. The biggest populations of slum inhabitants were in Dhaka and Chittagong: Dhaka had 3.4 million people living in slums, and Chittagong had 1.5 million people living in slums. The total area covered by all the slums in the country was 26.5 square kilometers.

Some 9,048 slum clusters were found in the six cities combined.[17] Dhaka alone had 4,966 slums, making up 54.9% of the total number. Most of the slum communities were small in size, and 33% of slums had fewer than twenty households. The room size on average was 10 square meters, and in Dhaka, the room sizes were smaller than average.

Many slums were located in flood-prone locations such as marshes, sewage canals, railway tracts, riversides, low topography areas, and alongside dikes.[18] These locations do not have adequate drainage, and they are frequently waterlogged during floods. Figures 4.1 - 4.6 are images of slums in different parts of Bangladesh.

14 Ibid.
15 Ibid.
16 Ibid.
17 Ibid, 35.
18 Ibid, 43.

Figure 4.1: Slum in Khulna.

Figure 4.2: Slum in Khulna.

Figure 4.3: Slum in Sylhet.

Figure 4.4: Slum in Sylhet.

Figure 4.5: Slum in Rajshahi.

Figure 4.6: Slum in Barisal.

SLUMS IN DHAKA

Figure 4.7 shows the slum distribution in Dhaka in 2005. In the city, 38.5% of slums were fully flooded, 22.4% of slums were partially flooded, and 39.1% of the slums were flood free during the monsoon that year.[19] In Dhaka, 92.3% of slum dwellers received drinking water from municipal taps, 6.5% had water drawn up from tube wells, and 1.2% received water from other sources such as ponds and lakes. Some 45% of the households in Dhaka shared water sources with 6-10 other households, and 6.8% had to share water with over 30 other households, while only 1.4% of households had their own source. While the number shows that most people had access to tap water, the locations were not necessarily ideal or close to the clusters. Out of all the environmental conditions, the worst factor seemed to be access to proper toilets. The census established that latrines that were linked to sewers and septic tanks, as well as latrines that were water sealed, were safe. In Dhaka, 35.6% of households had access to safe latrines, while 46.3% of households used pit latrines, 13.9% used hanging latrines, and 3.2% had no access to toilets. Some 48.6% of households shared their toilet with 2-5 other families, and 38.8% shared with 6-10 other families. Finally, 1.9% of households shared their toilet with more than 30 other families.[20]

The people living in the slums had mostly migrated from the villages, and they were/are vital to the economy of the city. They contribute to the economy of the city and the day-to-day lives of the people through extremely cheap labor.[21]

In terms of the location of slum establishments, there were a large number of slums on the eastern side of the city, along the western embankment, Badda had its fair share, and one of the biggest slums is near old Dhaka in an area called Kamrangir Char:[22] this was a new land that had emerged from under the river due to silt deposition. The largest slum by far was the Karail slum in Mohakhali–a central location in Dhaka.[23] After investigating several areas that had the potential for design intervention, I chose Karail for the design intervention.

19 Ibid.

20 Ibid.

21 Sayeda Alam and Mihoto Matsuyuki, "Applicability of Land Sharing Scheme to Korail Slum, Dhaka, Bangladesh," Urban and Regional Planning Review 4 (2017): 151. https://doi.org/10.14398/urpr.4.151.

22 Islam et al., Slums of Urban Bangladesh, 21.

23 Ibid.

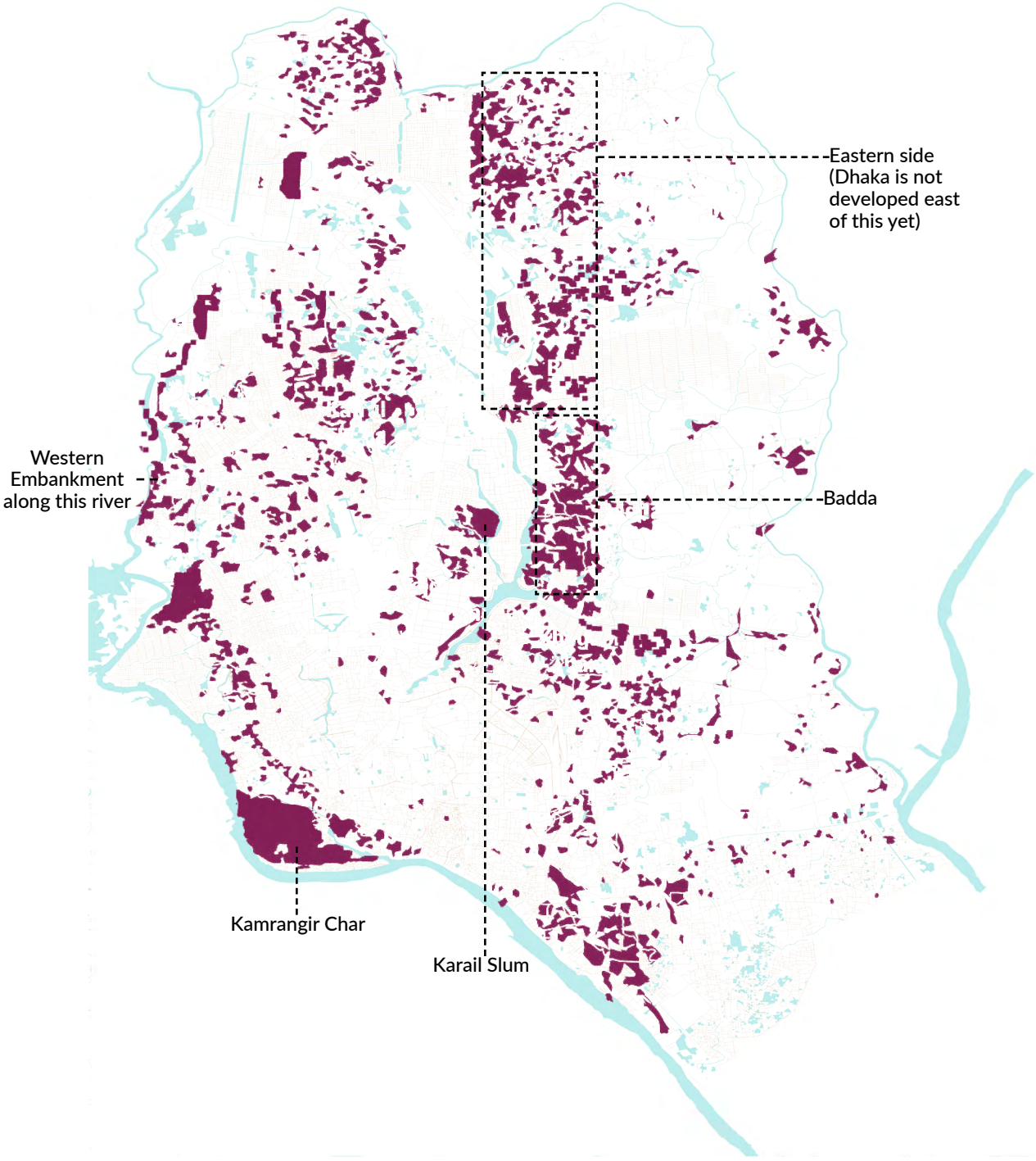


Figure 4.7: Slum Distribution in Dhaka

SITE

After going through potential sites, I chose the site – the T&T playground and its adjacent spaces. The reasons for choosing this site are its edge conditions.

Edge condition 1: The site of the design (Figures 4.8 - 4.10) is at the intersection of the poorest and the richest – Karail, the biggest slum in Dhaka, and Banani/Gulshan, the most expensive neighborhood in the country. The slum is located on a 100-acre government plot, and it has a population of 50,000 people. Essentially an informal settlement neighborhood, the temporary houses are owned (by force) by the more affluent (hoodlums with political backing) within that slum. The rest of the residents pay their landlords for a room in the slum. Very often, one room is shared by five members of the family.

Edge condition 2: The site is also at the intersection of water and ground. Part of the site is the T&T playground, owned by the Bangladesh government, and just on the north and east of the playground is the Banani Lake, a canal originally flowing through the city for drainage but currently encroached upon by the informal settlements.

Edge condition 3: The third edge condition for the site is its public location within a residential neighborhood. It is surrounded by residences, and it is the public meeting place for residents. The site used to accommodate prayers during Eid, a cattle market before Eid, and different fairs throughout the year. Very recently the entrances to the site have been closed with only small gaps in the walls remaining for entrance. Now it is primarily used as a playground and sports field.

The reason I chose this site for intervention was these three edge conditions. The design aims to implement the strategies mentioned earlier on the micro-scale in a small site in the city.

Figure 4.8: Karail slum seen from the other side of Banani Lake.

Figure 4.9: View of Karail slum with Dhaka's buildings visible in the back.

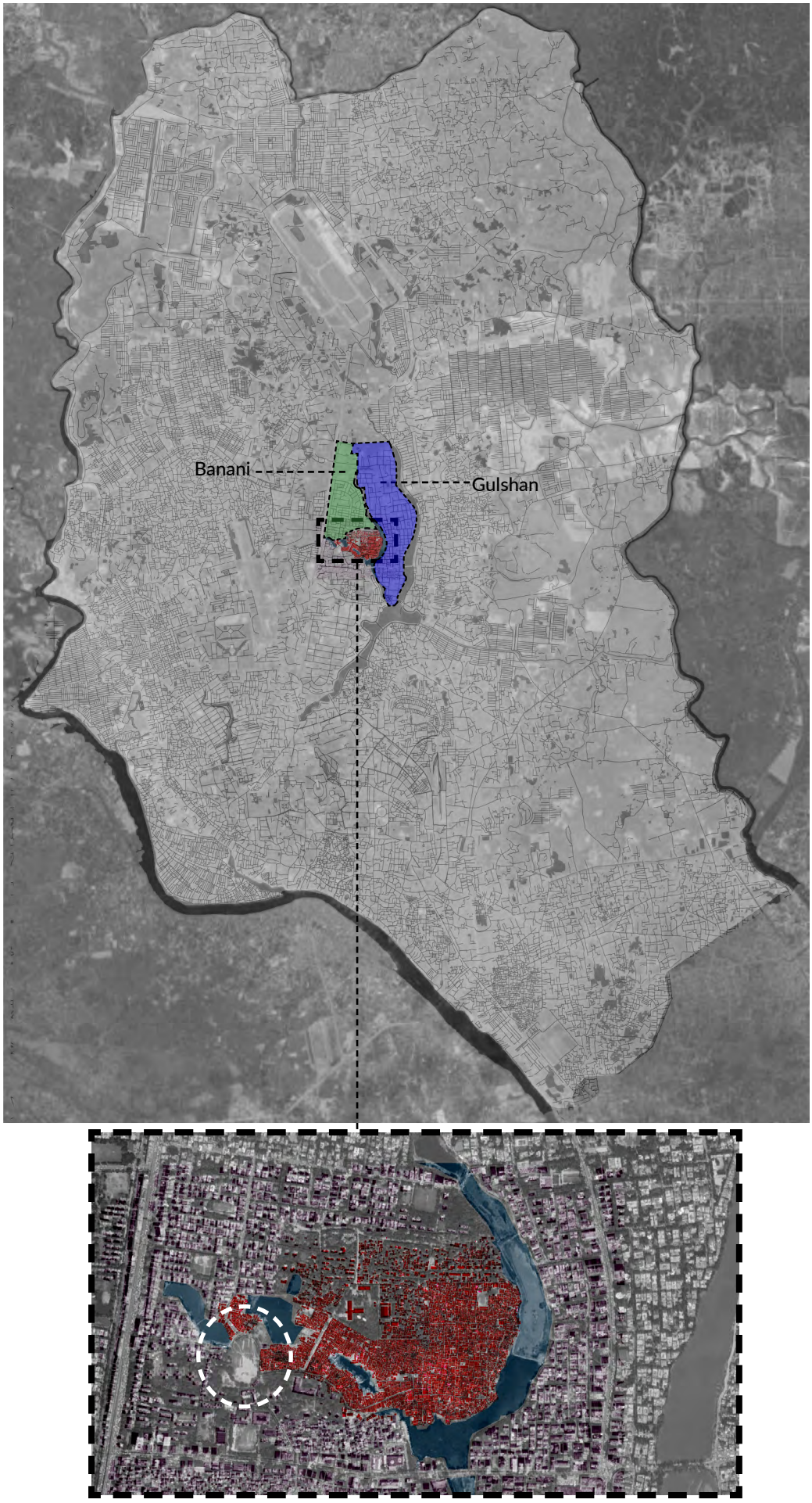


Figure 4.10: Map of Karail Slum. The slum is highlighted red. White circle shows the site for intervention.

KARAIL–LOCATION AND OWNERSHIP

Karail is at an intersection of river and land, of the poor and the rich. It is at the center of Dhaka, and it is the largest slum in the city, both in terms of space and occupancy. It is adjacent to the Gulshan Banani Lake.[24] Access to the slum is via several roads and by water.

In 1961,[25] the land now occupied by the slum was originally given to the Bangladesh Telecommunication Company Limited (BTCL, also known as T&T in the past) by the government of Bangladesh to allocate land and housing to BTCL's staff[26] and for use for BTCL's infrastructure.[27] With progress in technology, the land was not necessary for BTCL anymore, and 90 acres of the land were handed over to Public Works Department (PWD) in the 1990s. However, this handover was in violation of the agreement with the previous landowners, and the land was reclaimed by BTCL. Three stakeholders – private landowners, BTCL, and PWD – went into dispute, and amidst these disputes, local mastaans (bengali word for hooligans) and influential upper-class people with political connections started taking over unoccupied parts of this land in the 1990s. The urban poor started renting from these illegal landowners, and with the limited availability of empty land and the demand for low-cost housing, Karail turned into what it is today. Eventually, many bought parts of the land from the already illegal owners.[28]

Because of the slum's proximity to an affluent neighborhood, it is a highly sought-after area. The urban poor want to live in Karail because of its location–many are able to walk to work, and there are plenty of informal jobs available in the area–maids, drivers, cooks, etc.

A survey by BRAC in 2014 reported that the population of Karail was 54,590 in 16,900 households, occupying an area of 100 acres.[29] Karail has Banani Model Town on one side and Gulshan Model Town on the other side–the two most expensive neighborhoods in the country.[30] It is on the edge of Gulshan Banani Lake,[31] and it has encroached on a fair part of the lake,

24 Alam and Matsuyuki, "Applicability of Land Sharing Scheme," 153.

25 Moving Backwards: Korail Slum Eviction (Dhaka: Shiree-DSK, 2012), 7.

26 Alam and Matsuyuki, "Applicability of Land Sharing Scheme," 154.

27 Moving Backwards, 7.

28 Ahmed Sinthia, "Sustainable Urban Development of Slum Prone Area of Dhaka City." International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering 7, no. 3 (2013): 702.

29 Korail. 2014. http://www.brac.net/sites/default/files/factsheet/new/Korail.pdf.

30 Alam and Matsuyuki, "Applicability of Land Sharing Scheme," 151.

31 Ibid.

breaking the drainage route. With the lake right beside the slum and the canals encroached, the slum suffers from serious waterlogging during heavy rain. Dhaka also went through a major eviction drive in many parts of the city in 2007 and 2008, and many of the slum dwellers relocated to the already established Karail slum at that time.[32] Figures 4.11 - 4.16 shows the development of Karail slum over the years. In 2001, the canal is shown to be connected and free of informal settlements. Over the years with the growth of the slum, the canals have also been taken over. Many times, these canals are filled up by politically powerful local people who would build the slum structures and rent them out to the urban poor population.

32 *Korail.*

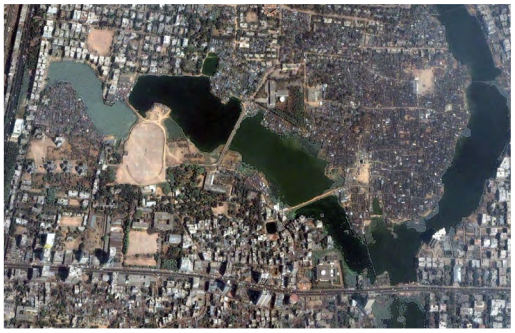


Figure 4.11: Satellite image of Karail slum, 2001

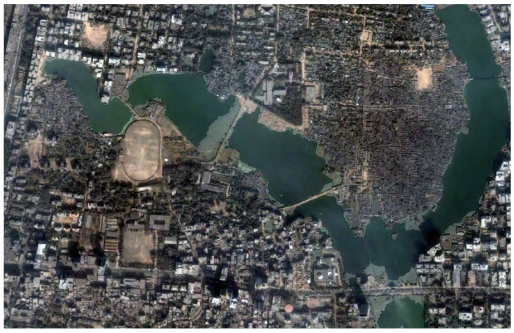


Figure 4.12: Satellite image of Karail slum, 2003

Figure 4.13: Satellite image of Karail slum, 2006

Figure 4.14: Satellite image of Karail slum, 2011

Figure 4.15: Satellite image of Karail slum, 2015

Figure 4.16: Satellite image of Karail slum, 2018

OVERVIEW

In 2015, the Human Development Research Centre carried out a study of Mirpur and Karail for the United Nations Children Fund (UNICEF) as a report on the conditions in the slum. The main purpose of the study was to collect information regarding the quality of life, health, nutrition, water, sanitation, and hygiene in these slums, but it also collected other data on the side. Since the design part of this thesis used Karail as the site, some context for Karail slum is established here, and the results of the report concentrating on Karail are summarized.[33] (Figures 4.17 - 4.20 show conditions inside Karail slum).

The residents of Karail (and other slums) are employed in a range of jobs, most of which are informal jobs working as maids, drivers, rickshaw pullers, and day laborers.[34] A huge number of females work in the garment and manufacturing industries, and some slum residents are also employed in lower grade government and non-governmental positions.

Some 91% of households in Karail had a male as the head of household. 52% of the household heads had no education. The gender ratio was almost equal, both male and female were economically active. 72.4% of the population between the ages of 15 and 64. Some 70.8% of the households in Karail were paying rent for their accommodation, 20.9% "owned" their house, and 8.3% occupied someone else's housing without paying any rent to anyone.[35]

In terms of housing, most of the slum dwellers had finished floors, but they had basic, temporary materials for walls and roofs (mostly corrugated tin[36]), and each room had an average of 3.6 people living in it.[37] Some 87.3% of the dwellers also had no lands or properties.

In terms of education, 84.5% of children in the secondary school age group went to school.[38] For those who did not attend school, the reasons were that

33 Abul Barkat et al., Report on Survey for Project Areas in Urban Slums of Mirpur and Korail, Dhaka (Dhaka: Human Development Research Centre, 2015), 3.

34 Alam and Matsuyuki, "Applicability of Land Sharing Scheme," 151.

35 Barkat et al., Report on Survey, 3.

36 Afroza Ahmed et al. "Should Architects Work for Mastaans for House Reconstruction Activities?" (Seoul World Architects Congress, 2017).

37 Barkat et al., Report on Survey, 4.

38 Ibid, 5.

Figure 4.17: Latrine for communal use in Karail Slum.

Figure 4.18: Garbage filled site beside housing in Karail slum.

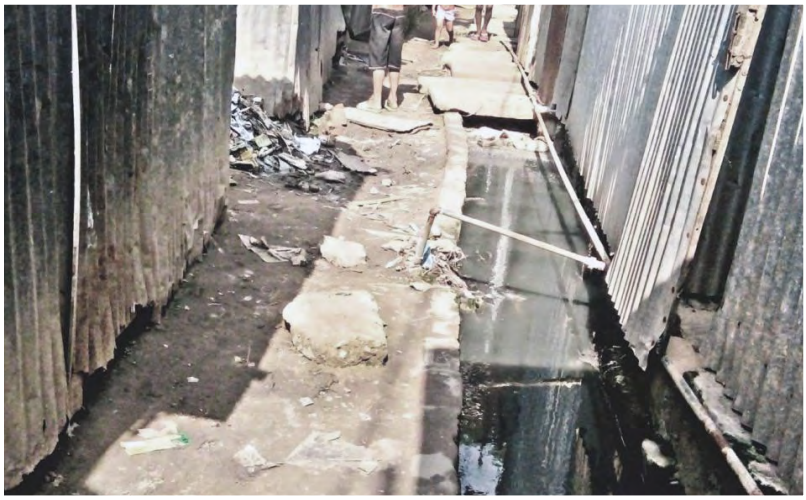


Figure 4.19: Unsanitary open drainage in the alleyways of the slum.

Figure 4.20: Alleyway stores inside the Karail slum.

the children were responsible for working and bringing in money, the family's inability to pay for education, and to help with household work.

The demographics for women in Karail were as follows: 67% of women were under 30, 94% of women in Karail were married, and 50.1% of women had no education at all.[39] Preschool facilities existed in the slum, and they were mostly provided by NGOs, with some government services for preschoolers attached to primary schools.[40] Islamic education through mosques also existed, and it was attended by 32% of the children.

WATER

Some 98.5% of the population of Karail had access to proper water through piped water connections to their household (67.7%), tube wells (17.1%) and public taps (8.5%).[41] Some 76.6% of slum residents also reported that they had access to enough water (more than 20 liters) for drinking and household chores. Some 94% of people had access to water within 50 meters of their household, but the water supply was not continuous, and on average it stayed operational for between 4.7 hours and 5.2 hours a day during the dry and wet seasons, respectively. More than half the people reported that they did not have enough water.

Tests were carried out on stored water and source water, and no cases of arsenic levels above the limits set by Bangladesh and WHO were found.[42] However, 93.4% of stored water and 82.6% of source water were contaminated with fecal coliforms. Only 23% of the residents further treated their water (such as boiling to kill pathogens and/or straining the water using cloths). The canal is right beside (and often under) the slum, and half the residents dispose of their liquid waste into the canal.[43]

39 Ibid, 4.
40 Ibid.
41 Ibid, 6.
42 Ibid, 6.
43 Ibid, 8.

SANITATION

Only 41.8% of the residents of Karail used proper sanitation, and almost 70% of the population did not dispose of their garbage properly, just dumping it in ditches or in open space.[44]

EVICTION AND RELOCATION

In Karail, the tenants have very few rights, and they often risk evictions. In 1999, Ain o Salish Kendra and the Bangladesh Legal Aid and Services Trust, which are legal aid agencies, petitioned to the high court on behalf of the Karail slum dwellers.[45] As a result, the high court issued an order stating that although it was legal to evict the slum residents due to its illegal nature of occupation, eviction would directly conflict with Article 15 of the country's constitution, and thus eviction must be followed by rehabilitation.

This gave the slum dwellers a level of security, but it did not protect them completely. A portion of the slum residents were evicted in 2012 when an injunction was issued by the high court ordering that the Banani Lake be protected from slum developments. Finally, 2,000 houses around the lake were removed.[46]

44 Ibid.
45 Moving Backwards, 7.
46 Ibid, 8.

ROADS AND ACCESS

Figure 4.21 shows the main roads and connections around the site. Figures 4.22 - 4.27 are street views captured in the locations marked in Figure 4.28. The T&T playground is separated from the streets by a concrete and metal wall with its entrance near Location 3, pointed in Figure 4.21. The roads are two-lane and narrow (like most lanes in Dhaka). Karail, on the other side of the street, is also blocked off by walls.

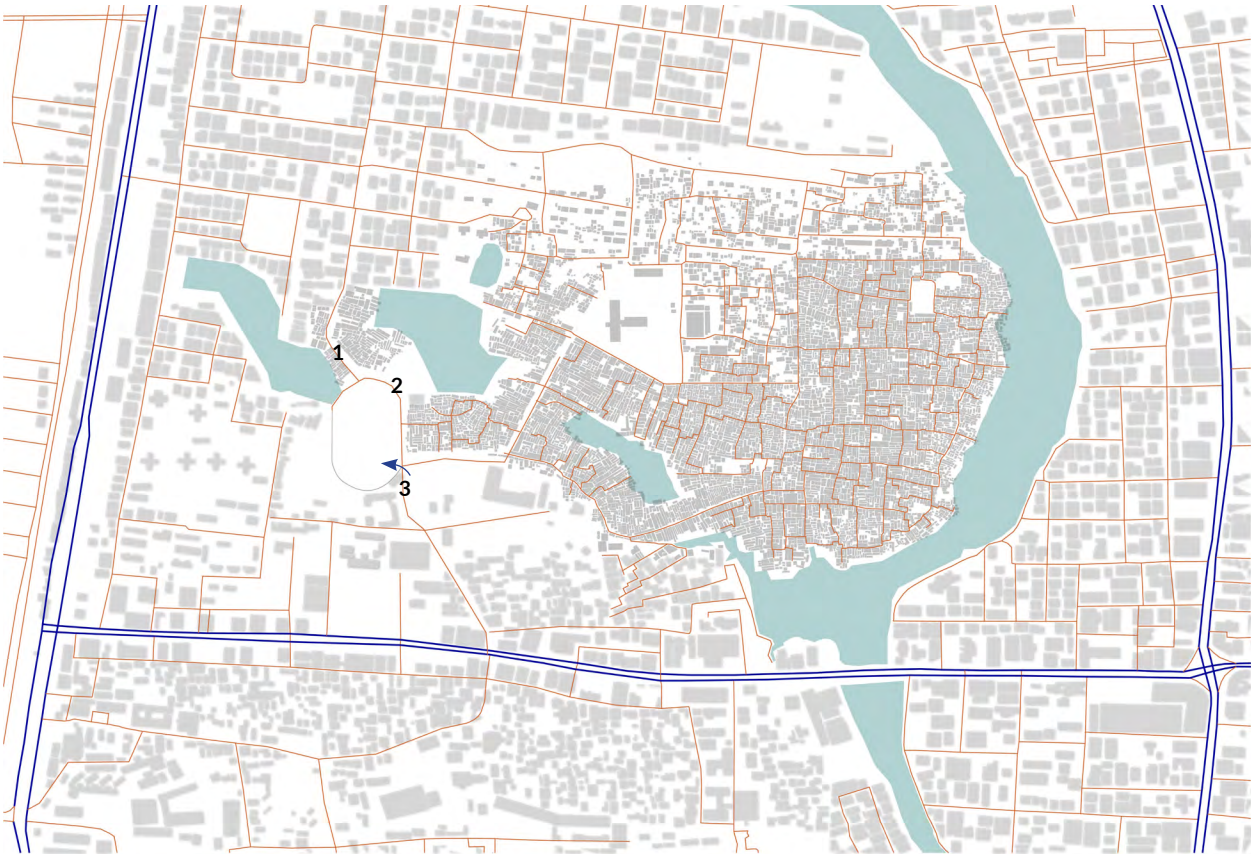


Figure 4.21: Road Network around the site.

Main Streets

Smaller Roads

Arrow shows entrance to T&T Playground

Figure 4.22: Edge condition between canal and land. Location of image shown in Figure 4.28.

Figure 4.23: The T&T playground and the Karail slum are separated by walls. Location of image shown in Figure 4.28.

Figure 4.24: A wall separates the T&T playground from the street. Location of image shown in Figure 4.28.

Figure 4.25: A wall separates the T&T playground from the street. Location of image shown in Figure 4.28.

Figure 4.26: A co-op market is situated at the edge of the playground. Location of image shown in Figure 4.28.

Figure 4.27: A co-op market is situated at the edge of the playground. Location of image shown in Figure 4.28.

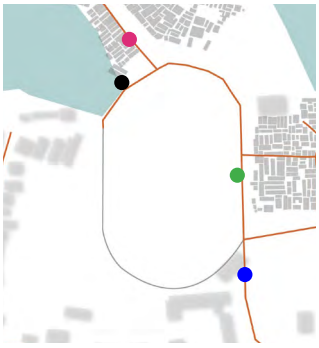


Figure 4.28: Key map showing the location where the photos Figures 4.22 - 4.27 were taken around the T&T playground.

MOSQUES

Bangladesh has a Muslim majority population, and mosques are essential social and religious places of congregation and prayer in the country. Mosques are within walking distance, and the azan (call for prayer) echoes through the city five times a day. Figure 4.29 shows the locations of mosques around the site. Figures 4.30 - 4.35 show the mosques numbered 1, 2 and 3 in Figure 4.28. The photos show that these mosques have humble and modest interiors and provide spaces for congregation and prayers. These are the mosques around the site. They are not lavishly ornamented mosques. Each blue dot in Figure 4.29 represents a mosque in the vicinity of Karail. These are not the only mosques in the area; there are other mosques that are not in the diagram due to lack of data.

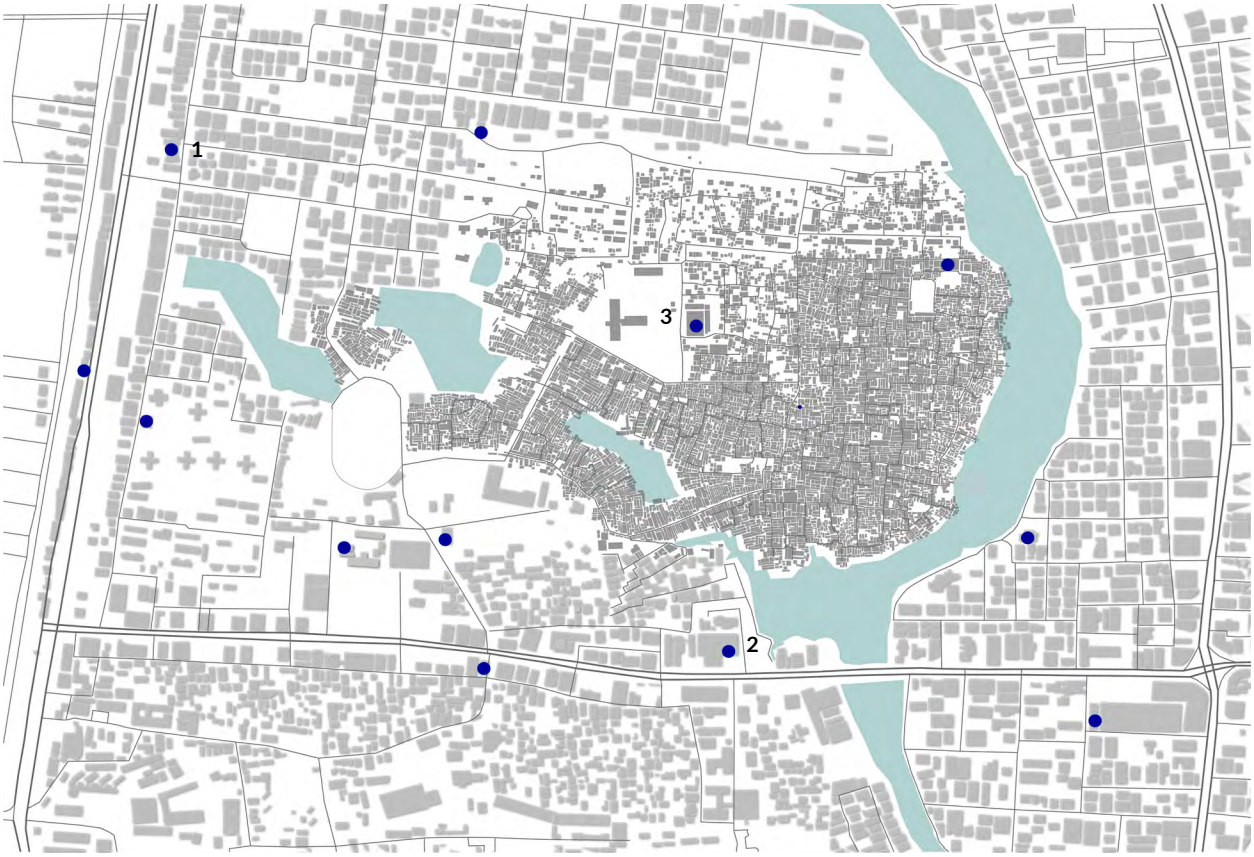


Figure 4.29: Location of mosques around the site.

1. Banani Chairmanbari Masjid
2. Gausul Azam Jame Masjid
3.. T&T Colony Jame Masjid

1

Figure 4.30: Outside of Banani Chairman Masjid.

Figure 4.31: Inside of Banani Chairman Masjid.

2

Figure 4.32: Exterior of Gausal Azam Jame Masjid.

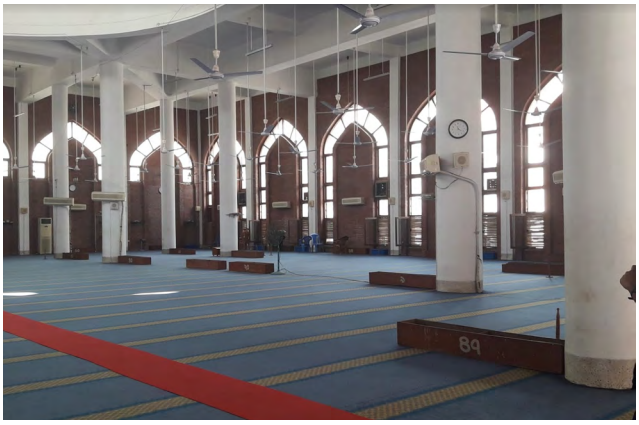


Figure 4.33: Interior of Gausal Azam Jame Masjid.

3

Figure 4.34: Exterior of T&T Colony Jame Masjid.

Figure 4.35: Interior of T&T Colony Jame Masjid.

OPEN SPACE

In a city as dense as Dhaka, open spaces are minimal. The T&T playground is one of the bigger fields available, and it is used for different activities. Figure 4.36 shows some of the spaces in the city that are currently unoccupied, but any open space has the potential to become encroached upon or taken over by developers to build residential/commercial complexes. In some cases, the open spaces are simply individually owned land that has not been built up yet. The green spaces marked in Figure 4.36 were identified via satellite images.

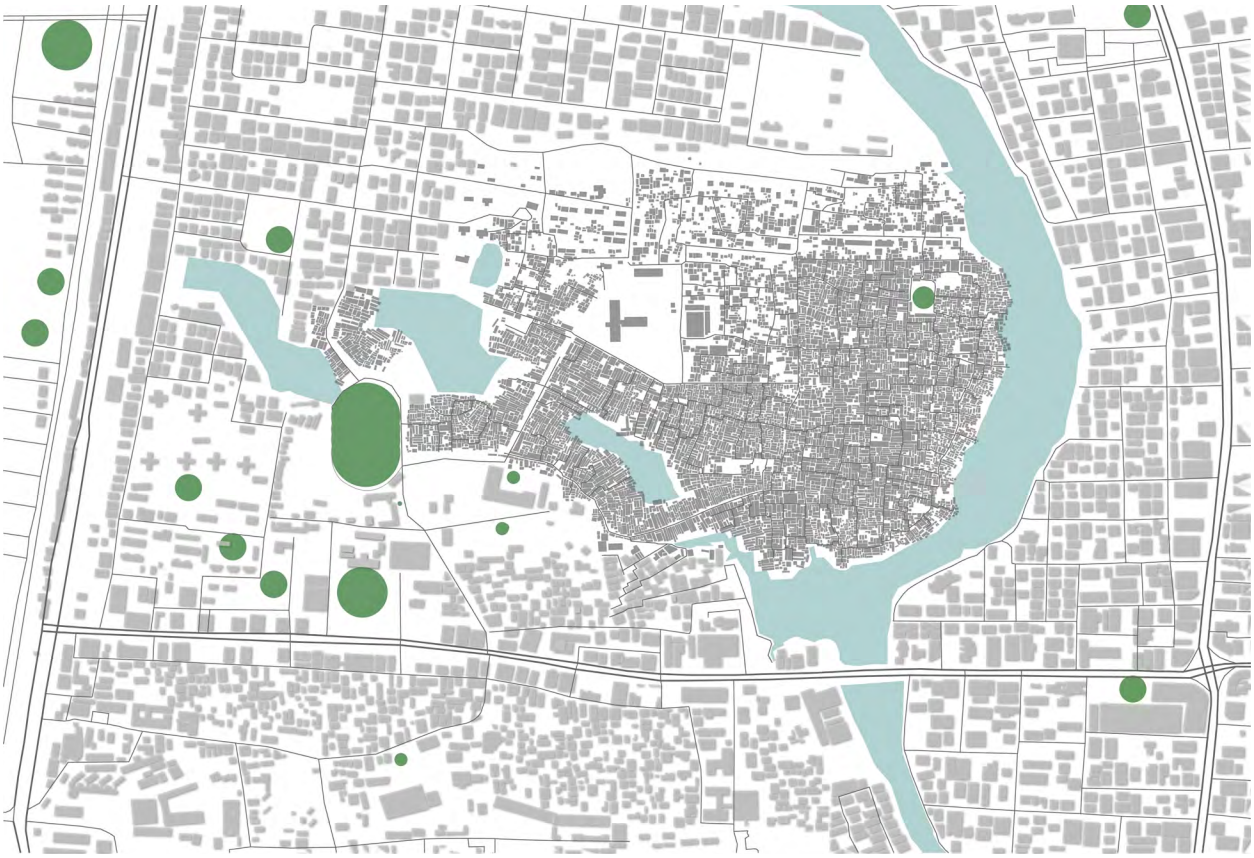


Figure 4.36: Parks and green space around the site as determined from satellite view.

SITE CONTEXT

Figures 4.37 and 4.38 show the T&T playground in relation to Karail and its surrounding context. Karail (marked 1 in Figure 4.37) is to the east of the T&T playground (marked 2 in Figure 4.37). Figure 4.38 zooms into the site more. The arrow marked 3 in Figure 4.37 shows the entrance to the playground, 1 used to be a co-op market, but is now an empty building (Figure 4.26), and 2 is the T&T government high school. The high school has its own field, and the T&T playground does not belong to the high school. South and west of the T&T playground are residential buildings. Until very recently, the playground was used for different purposes (Figures 4.39 - 4.44): a cow market before Eid ul Adha, Eid prayers during Eid ul Fitr and Eid ul Adha, public fairs, general use, and sports. Figures 4.45 - 4.48 are images of the playground taken in the late afternoon. Recently the entrance to the playground have been closed down (small gaps in the wall remains now to act as entrance) perhaps to stop the illegal occupation of the park by hoodlums, buses and trucks. Figures 4.49 - 4.52 are images of the peripheri of the T&T playground. The field used to be able to accomodate many functions during the dry season (Figures 4.53 - 4.57), but during the wet season, it is flooded and not usable (Figures 4.58 - 4.59). The design proposal in the next chapter suggests ways to make the playground usable in all seasons by incorporating the strategies mentioned in Chapter 3. The proposal introduces design elements that would preserve the current uses of the playground including Eid prayers, fairs, cow market, and playing field while also creating different levels of topography to accommodate stormwater when necessary.

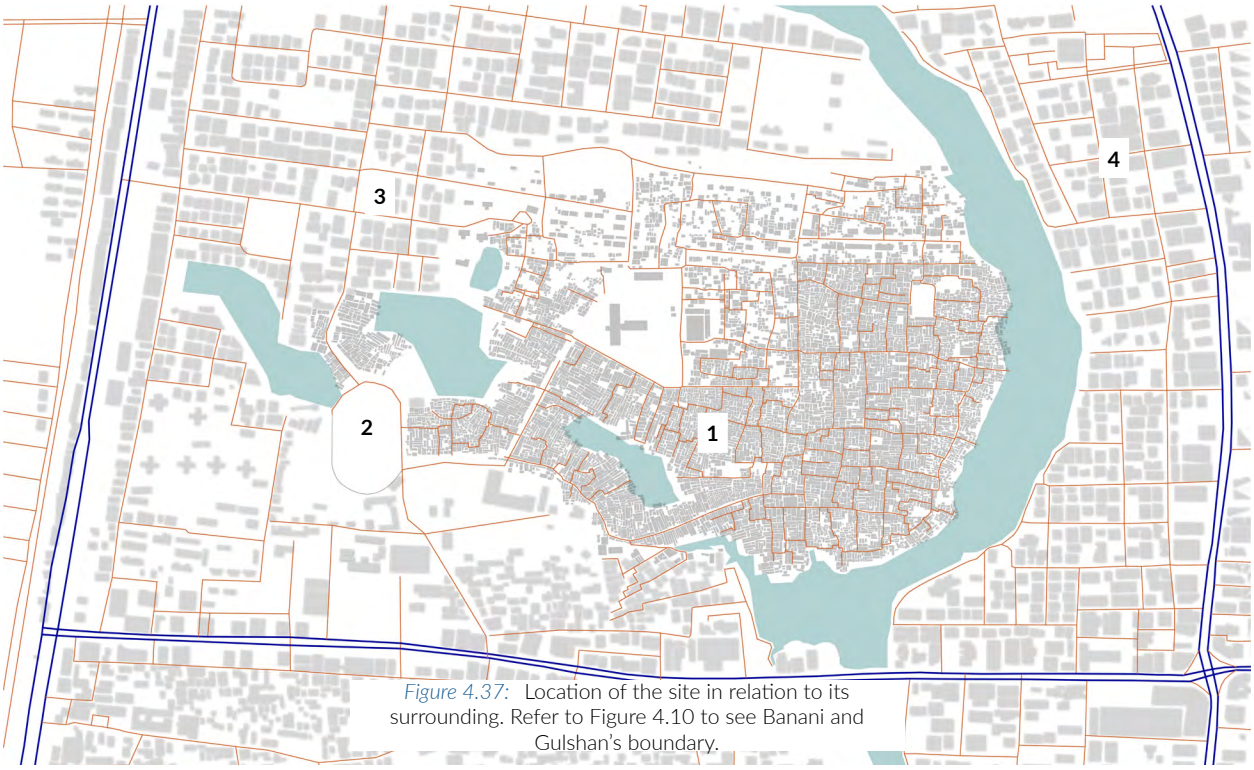


Figure 4.37: Location of the site in relation to its surrounding. Refer to Figure 4.10 to see Banani and Gulshan's boundary.

1. Karail Slum 2. T&T Playground 3. Banani 4. Gulshan

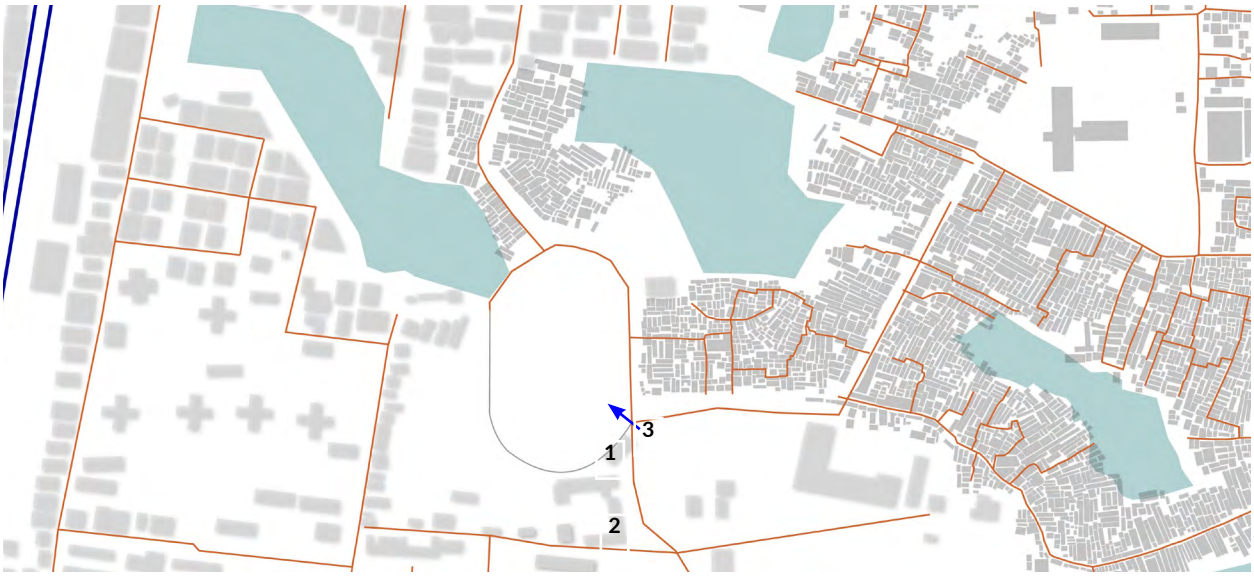


Figure 4.38: Location of site in relation to its surrounding.

1. Coop Market 2. T&T Public School 3. Entrance to the Playground

Figure 4.39: Cow market before Eid.

Figure 4.40: Community Fair.

Figure 4.41: Playground for cricket.

Figure 4.42: Friendly cricket match.

Figure 4.43: Co-op market at the edge of the playground.

Figure 4.44: Pickup soccer. Source:

Figure 4.45: Inside the T&T Playground.

Figure 4.46: Inside the T&T Playground.

Figure 4.47: Inside the T&T Playground.

Figure 4.48: Inside the T&T Playground.

Figure 4.49: The wall around the T&T playground. Small gap remains for entrance.

Figure 4.50: The wall around the T&T playground.

Figure 4.51: The wall around the T&T playground. Small gap remains for entrance.

Figure 4.52: The wall around the T&T playground.

CURRENT USE OF T&T PLAYGROUND

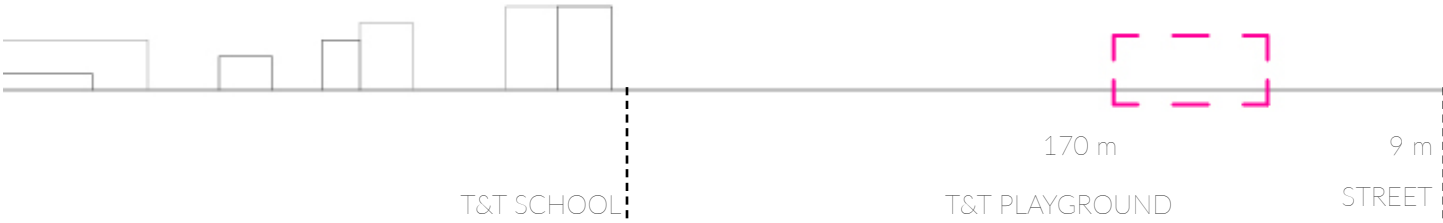


Figure 4.53: Site Section. See Figure 4.60 for section cut marker.

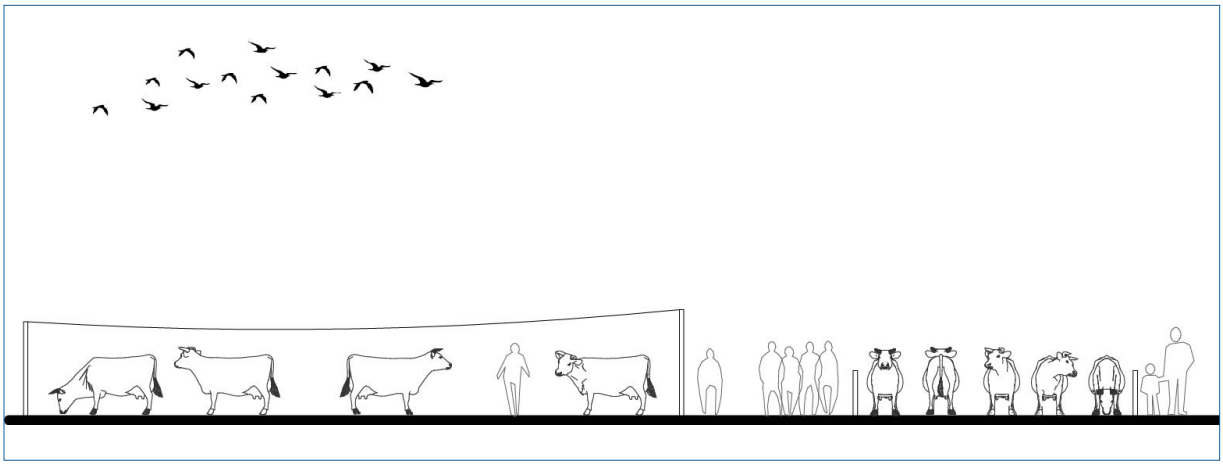


Figure 4.54: Cow market before Eid

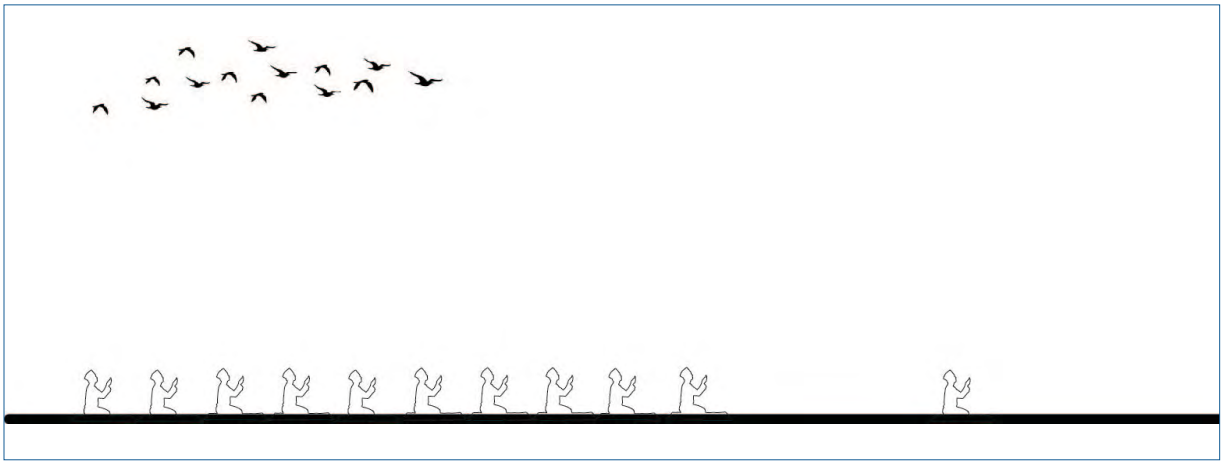
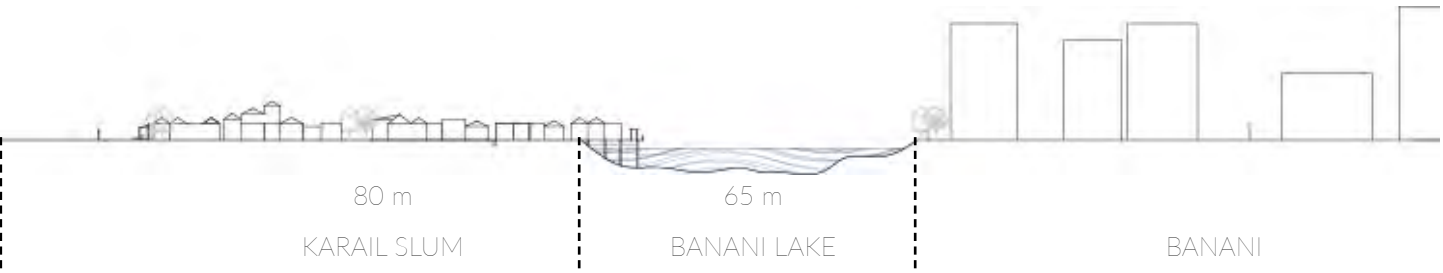


Figure 4.55: Eid prayer



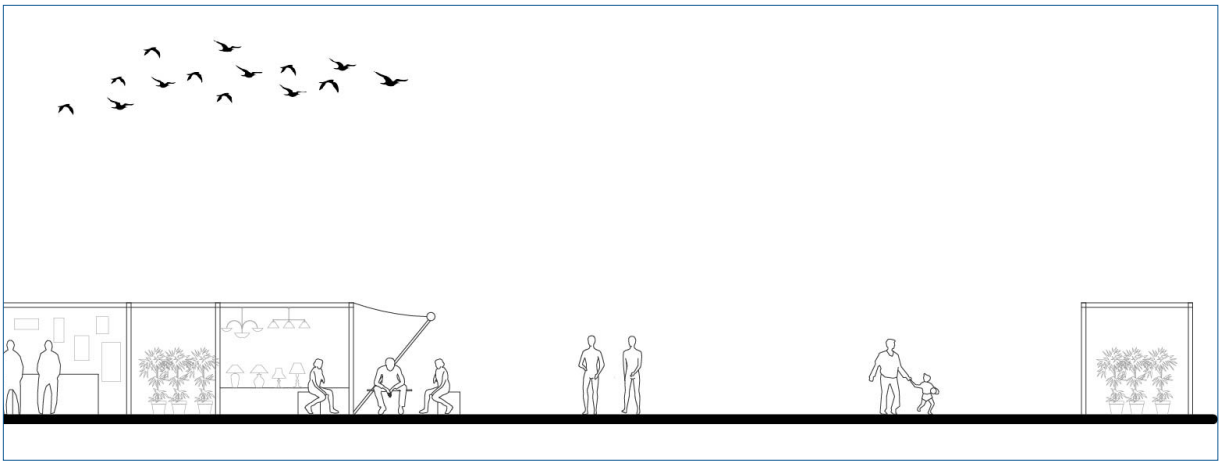


Figure 4.56: Public Fair

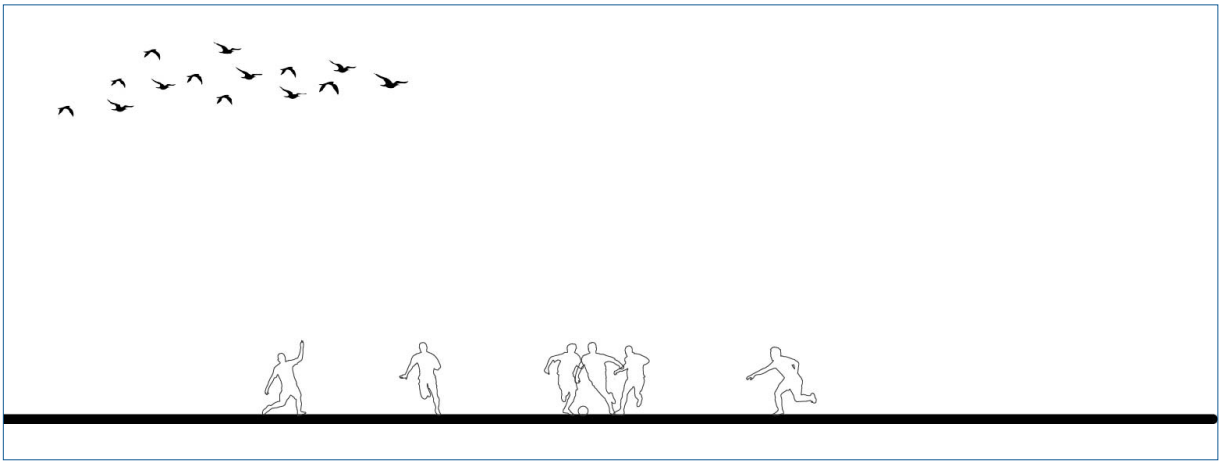


Figure 4.57: Sports field

CURRENT USE OF T&T PLAYGROUND (AFTER WATERLOGGING)

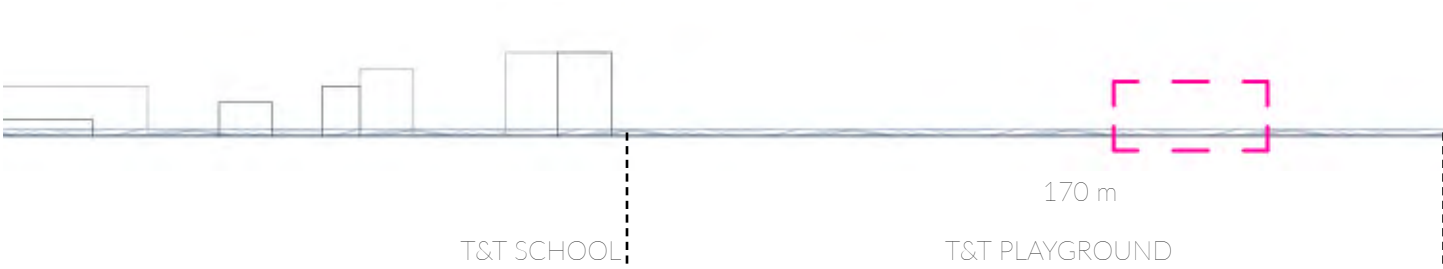


Figure 4.58: Site section - waterlogged. See Figure 4.60 for section cut marker.

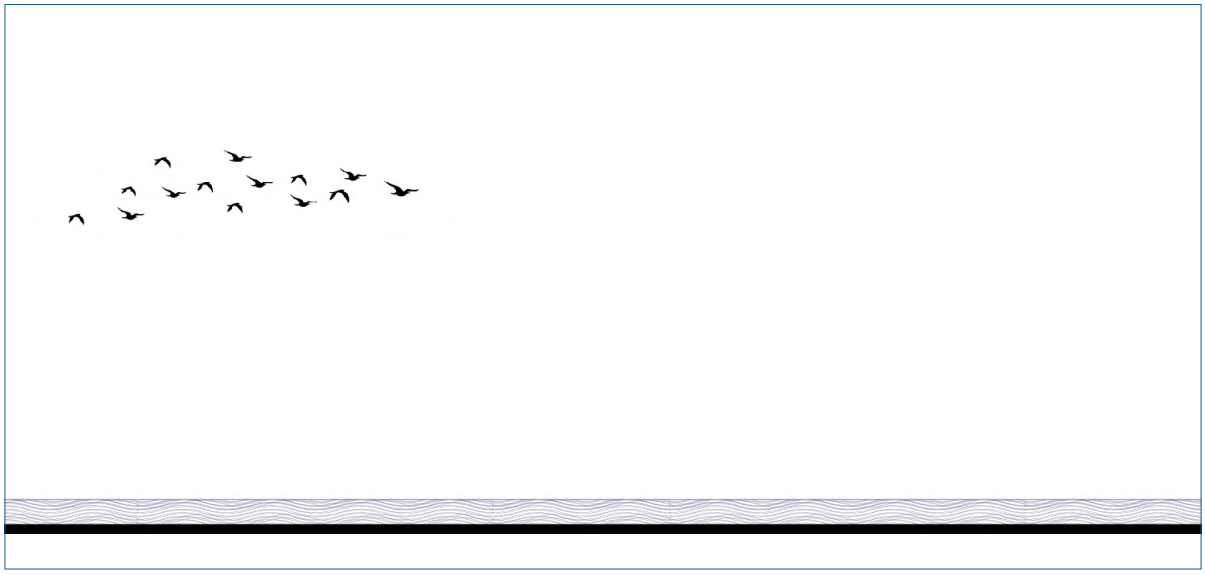
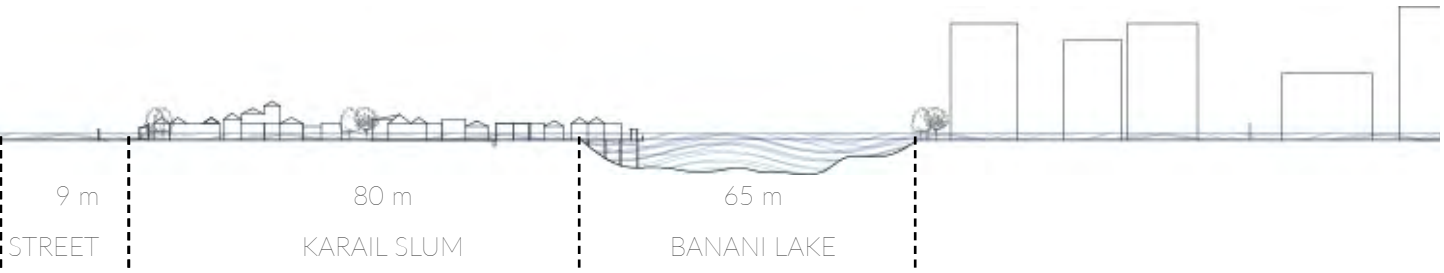


Figure 4.59: No activities



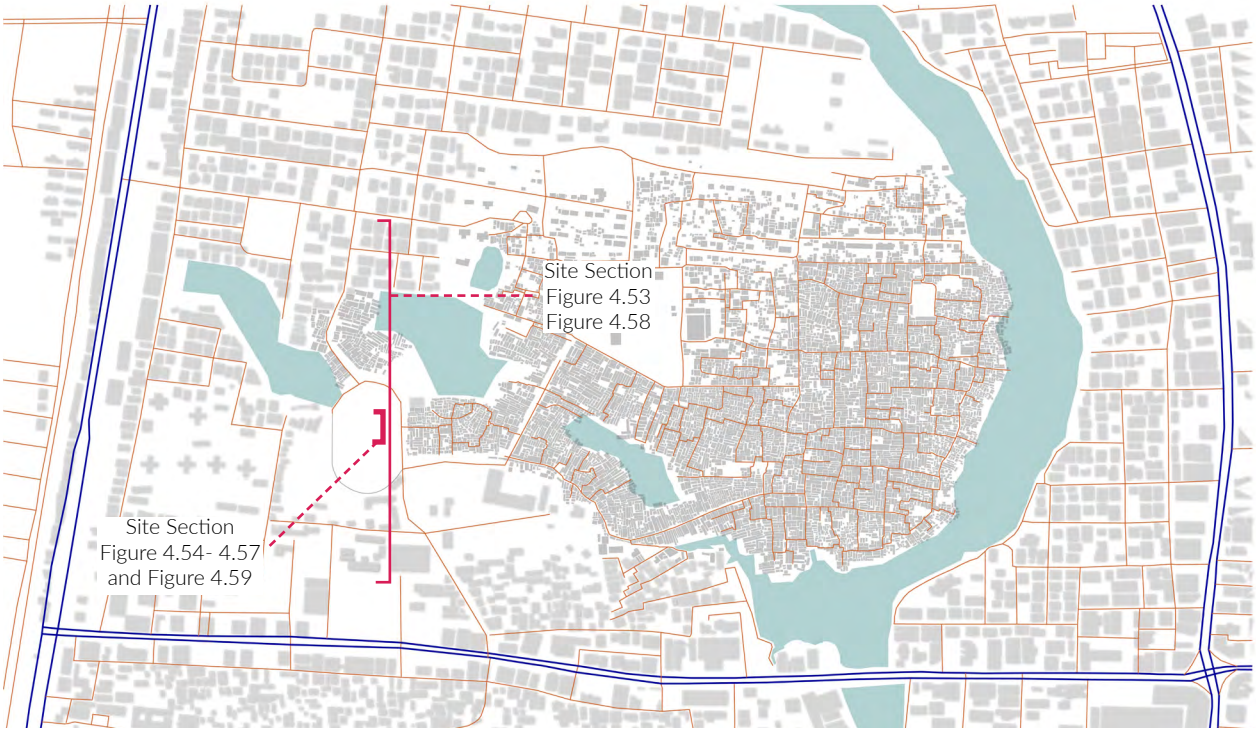


Figure 4.60: Key plan showing section cut for Figures 4.53 - 4.59.

5. Design Proposal

The first four chapters of this thesis have explored the city of Dhaka and its relation to nature, water, and the ground. This is the final chapter of the thesis. This design proposal aims to connect the city and water pragmatically and poetically. The design elements are developed based on a few assumptions made from observing the current human behavior of the city. The most significant assumption is that the user of the space will treat the design and its purpose with respect.

Looking back at the situation of Dhaka, it may be difficult to believe that this space will be kept clean and free of garbage and encroachment. Still, in recent times, Bangladeshis have kept many new public areas in the city clean and enjoyable. With awareness and progression, Bangladeshis are changing and building a better city and country. When the user of the space is given a clean environment, knowledge, and a little bit of help (monitoring and using hired cleaners), the proposed area will be able to maintain its purpose. In recent years, Dhaka city has built a few prominent public spaces, and they have all been maintained and enjoyed by the residents. I believe this proposed open space will also be well kept and enjoyed by the people of the city. More on this will be elaborated in the conclusion.

The poetics of the design lie in welcoming water for ritualistic use through various architectural elements. The pragmatism lies in the technicality of not allowing the water to be destructive by establishing embankments and retention spaces. The hope is that the design will invite users to experience water in a clean and pure state and that it will create cooperation, awareness, and consciousness in the people, reminding them about the responsibility they bear in protecting their city.

Some strategies were discussed in Chapter 3. Those strategies are applied in this proposal on a cohesive but microscopic scale. Flooding is a complex problem, and a small amount of land and a few strategies will not solve the issue. This proposal will not solve the problem of flooding, but it will create a public space, create awareness, and act as an example of what can be done to increase the city's resiliency.

After surveying the available empty spaces in Dhaka, the T&T playground and its adjacent areas were chosen as the site for the design (Figure 5.1). This site was chosen because of its three edge conditions and the proposal works on these edge conditions:

1. The site is at the intersection of the poor and the wealthy.
2. The site is at the intersection of land and water.
3. The site is a public location in a residential neighborhood.

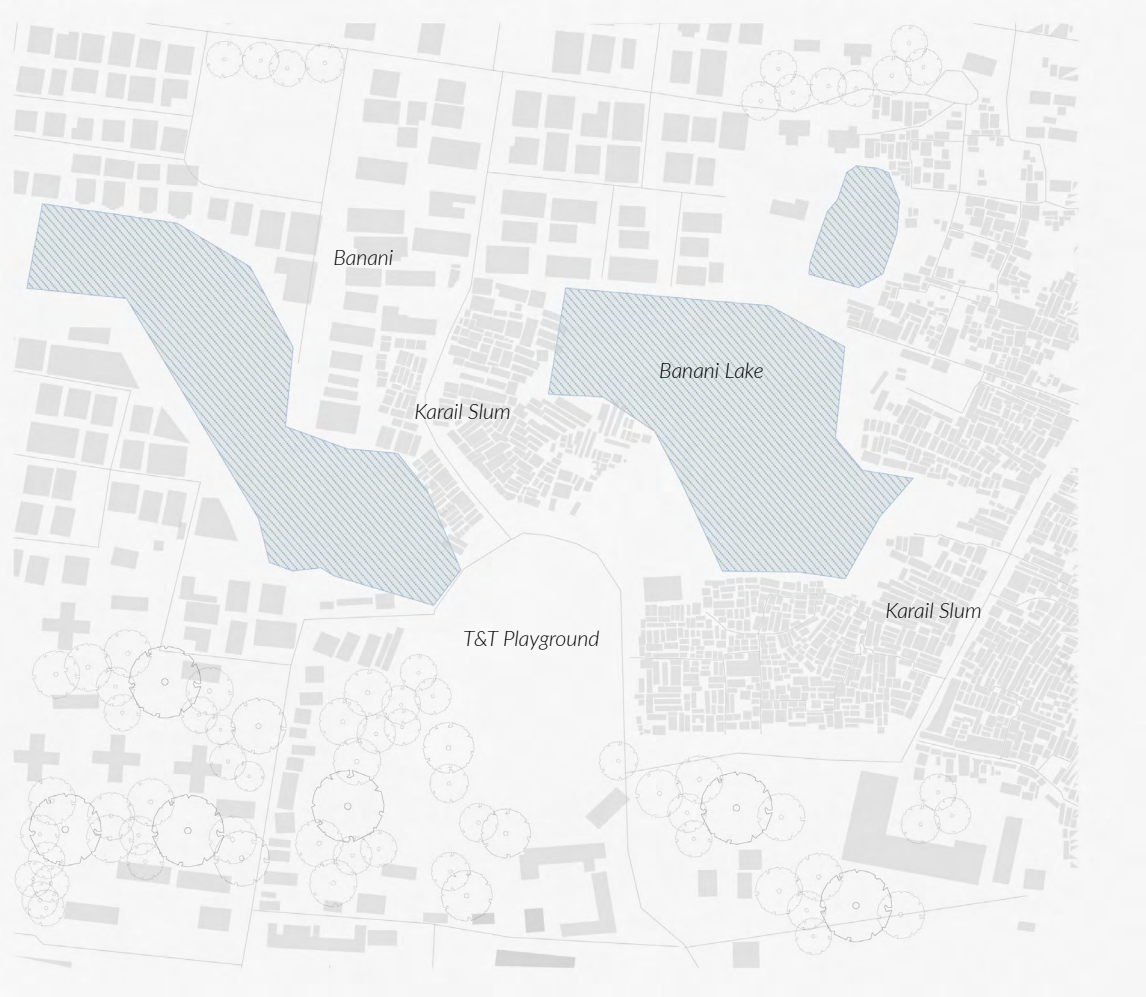


Figure 5.1: Site Plan 1:4000

INTERSECTION

The site of the design is at the intersection of the poorest and the richest (Figure 5.2): Karail Slum, the biggest slum in Dhaka and Banani/Gulshan, the most expensive neighborhood in the country. The slum is on a 100-acre plot of government land, and it has a population of 50,000. Essentially an informal settlement, the temporary houses are owned (by force) by the more affluent (hoodlums with political backing) within that slum. The rest of the residents pay their landlords for a room in the slum. Very often, one room is shared by five members of the same family.

The site is also at the intersection of water and land (Figure 5.3). Part of the site is the T&T playground, owned by the government, and just to the north and east of the playground is the Banani Lake (a canal originally flowing through the city, but currently encroached upon by informal settlements).

The site is a public location within a residential neighborhood (Figure 5.4). It is surrounded by residences and it is the public meeting place for the residents. Currently, the site accommodates prayers during Eid, the cattle market before Eid, and different fairs throughout the year. It also acts as a playground and a sports field.

Figure 5.5 shows the proposed site plan.

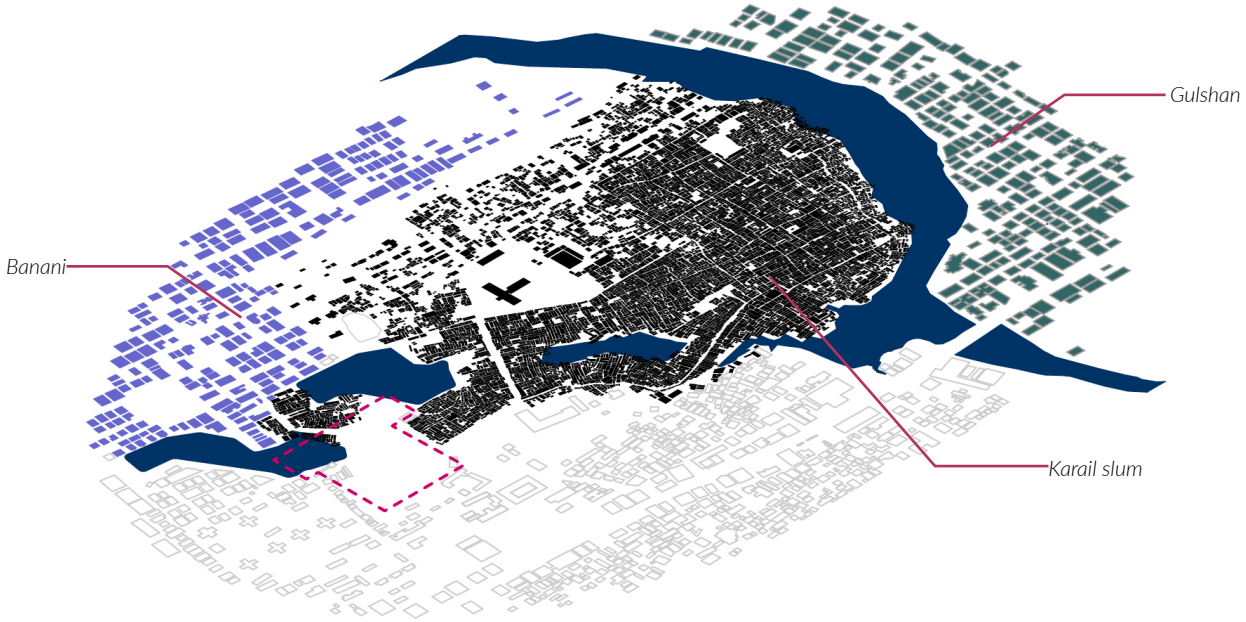


Figure 5.2: In between the poor and the wealthy.

Figure 5.3: In between land and water.

Figure 5.4: In between public and private.

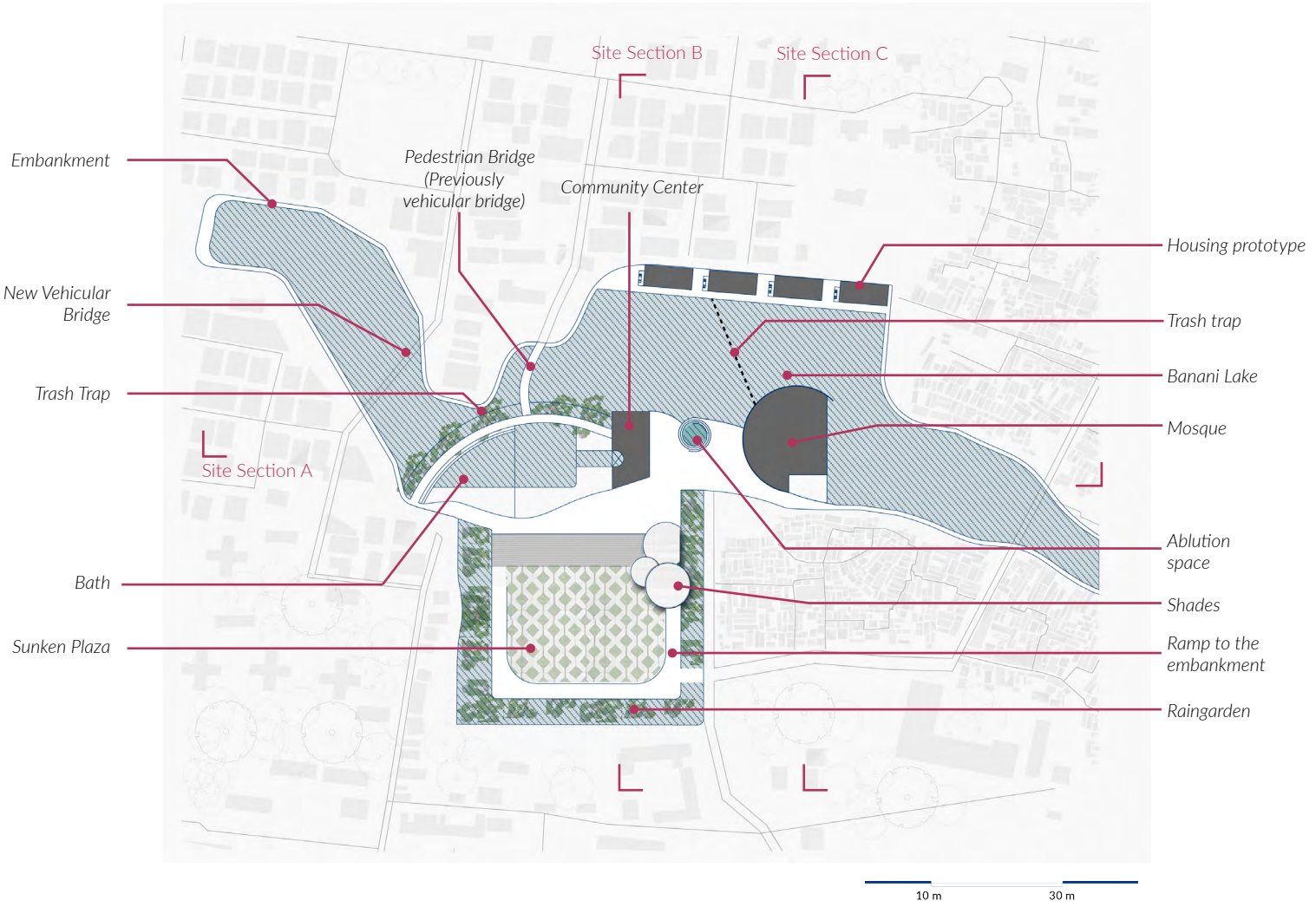


Figure 5.5: Design proposal - Site Plan 1:4000

Please see Figures 5.19 - 5.24 on Pages 150 - 153 for sections A,B and C

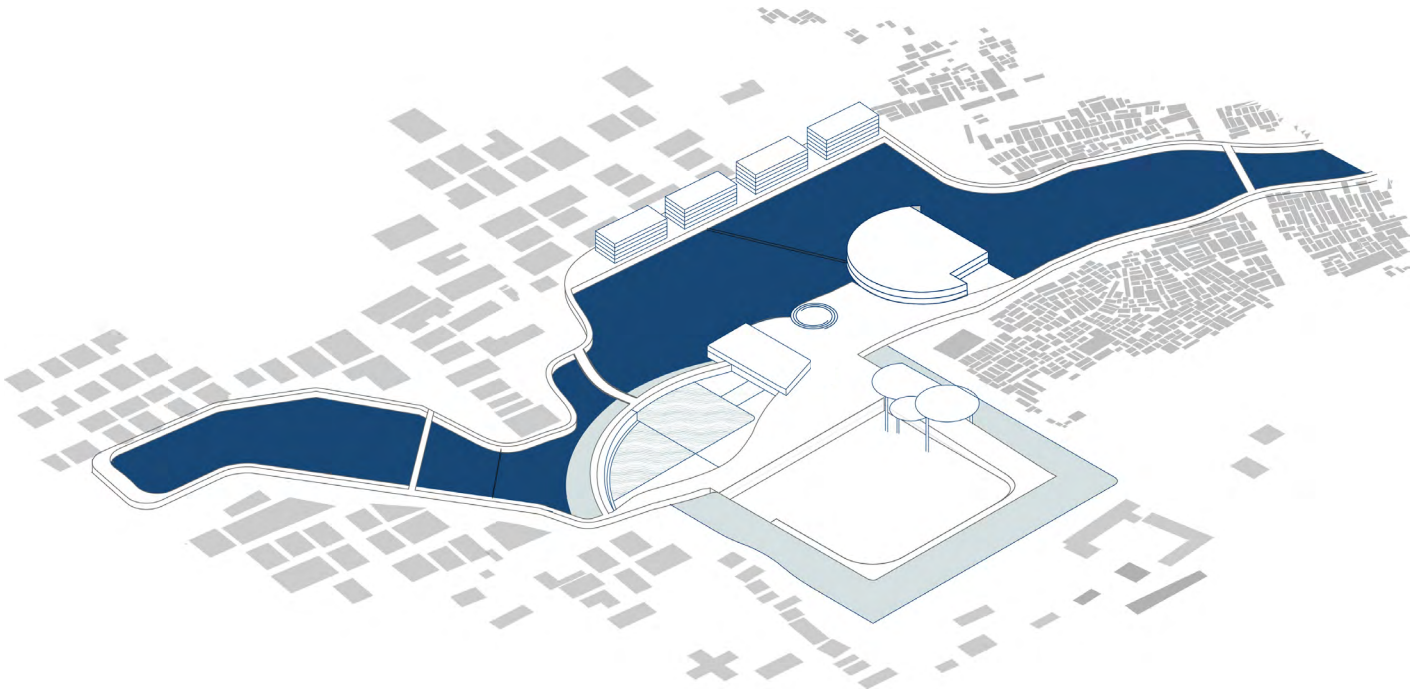


Figure 5.6: View of the architectural elements

ARCHITECTURAL ELEMENTS

In a broader sense, the proposal is to intervene in two ways. The first is connecting the segments of the fragmented Banani Lake and providing social housing for the displaced residents at the edge of the lake. Next are the landscape and architectural interventions, which comprise four main design elements that will accommodate water in different ways:

1. An embankment (Figure 5.7) built around the Banani Lake to allow for a larger retention capacity for stormwater in the canal. The embankment will have slopes, greeneries, and walkways. The goal is not to create a wall that will separate the city and the water, but rather to create an intermediate space that will hold the water out of the city while also allowing people to come close to the water.

2. A community center/Bath (Figure 5.8) collects and filters water and provides clean water for bathing.

3. A mosque (Figure 5.9) allows water to flow through the building. The built-in gutter around the perimeter lets water flow through, and windows provide views of the canal.

4. A sunken plaza (Figure 5.10) (formerly the T&T playground) retains its function while also providing a basin for water retention during heavy monsoon rain.

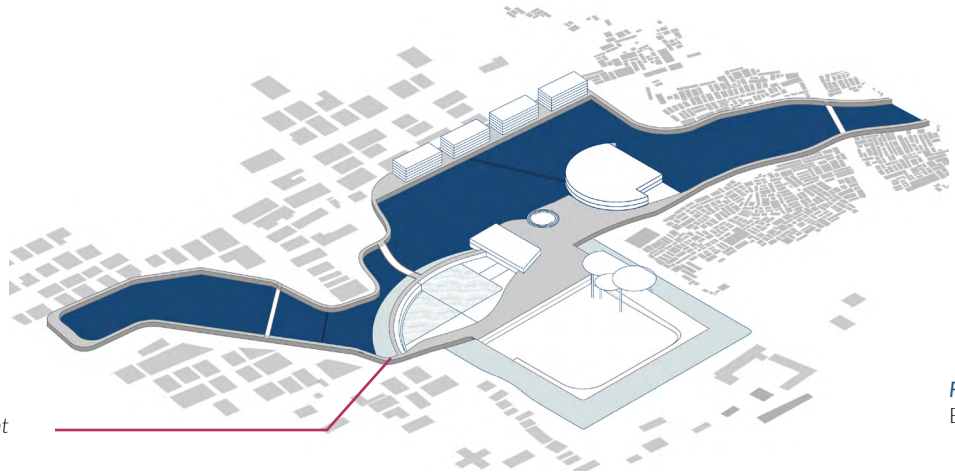


Figure 5.7: Design element: Embankment

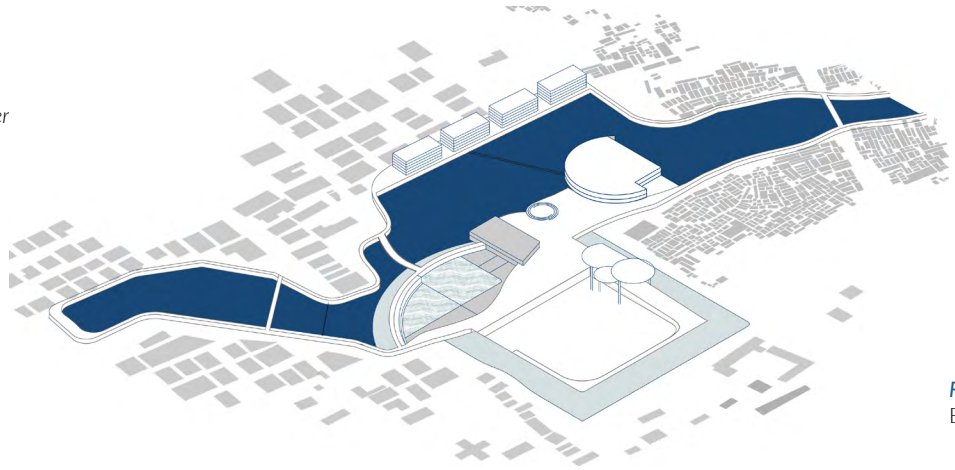


Figure 5.8: Design element: Bath/ Community Center

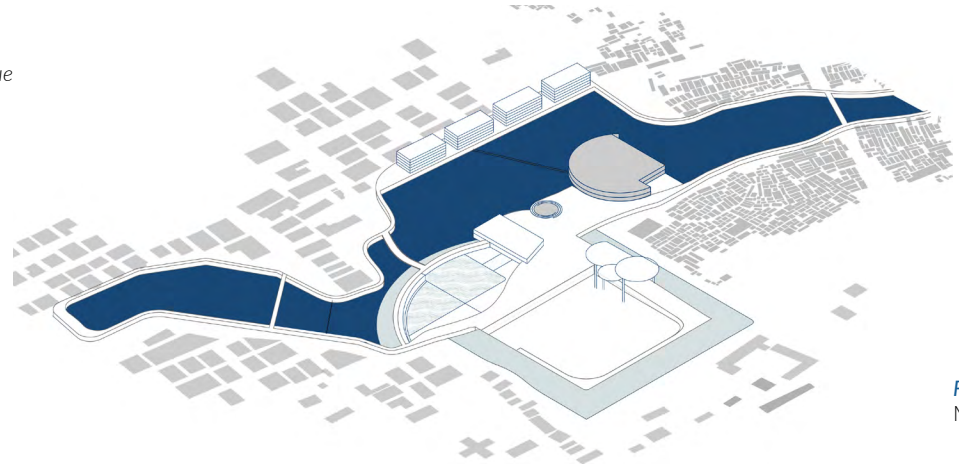


Figure 5.9: Design element: Mosque

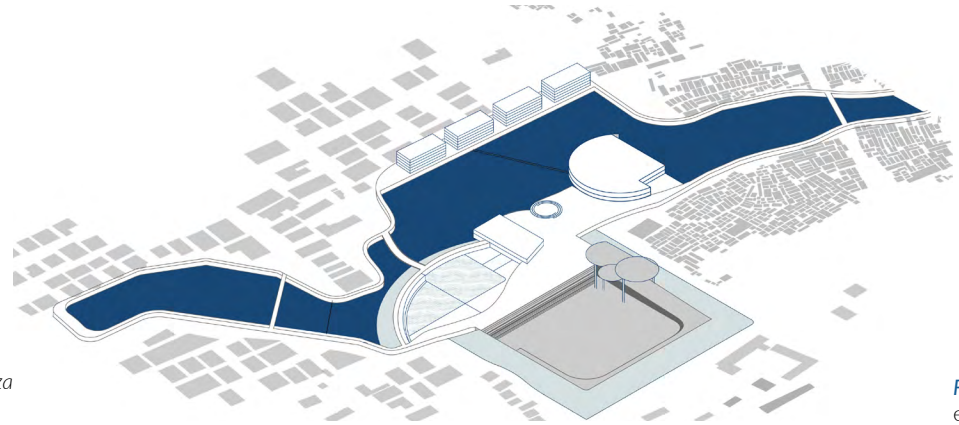


Figure 5.10: Design element: Sunken Plaza

DISPLACEMENT

In the earlier chapters of this thesis, we saw that for a city to progress, some sacrifices are required. In a dense city like Dhaka, this sacrifice comes in the form of sacrificing land. Some informal settlements will be displaced in this process. The previous chapters touched on the rights to the city. The residents who will be displaced have the right to the city, to be able to walk to work and to be able to live where everyone else is living. The design proposes relocating them into government housing very close to where they lived before. What will be lost in land area will be made up for in height.

Concerning the monetary aspects of social housing, the first thing to clarify is that these informal settlements are not free for the residents, and thus relocating them to more formal housing will not suddenly force them to pay rent. The Karail Slum is illegally built on government property, but owned by the richer and politically influential people within the slum. The rest of the residents pay rental fees to live in the informal settlement. With the displacement and the introduction of social housing, the slum residents will pay rent to the government instead of hoodlums.

Figure 5.11 shows the phases of interventions to be carried out on the current site.

Relocation: New housing will be constructed along the edge of the lake as shown. This will be occupied by the residents who will lose their homes due to part of the slum being broken down.

Breaking down: The Banani Lake has become narrower over the years due to encroachment. With encroachment, the efficiency of the canal in draining water has decreased. Thus, to increase the functionality of the canal, some of the informal settlements will have to be relocated to new housing built on the edge of the canal as shown in the diagrams.

There is a swamp north of the canal as shown in Figure 5.11. It was originally part of the canal, but due to encroachment, the circulation of this swamp has been cut off. The swamp is now a breeding ground for mosquitoes. Some lands will be broken down to form part of the canal, and in exchange, this swamp will be filled up to provide flexible open space for the residents in the area. Dhaka is a very dense city, and these kinds of negotiations could help people preserve their regular activities.

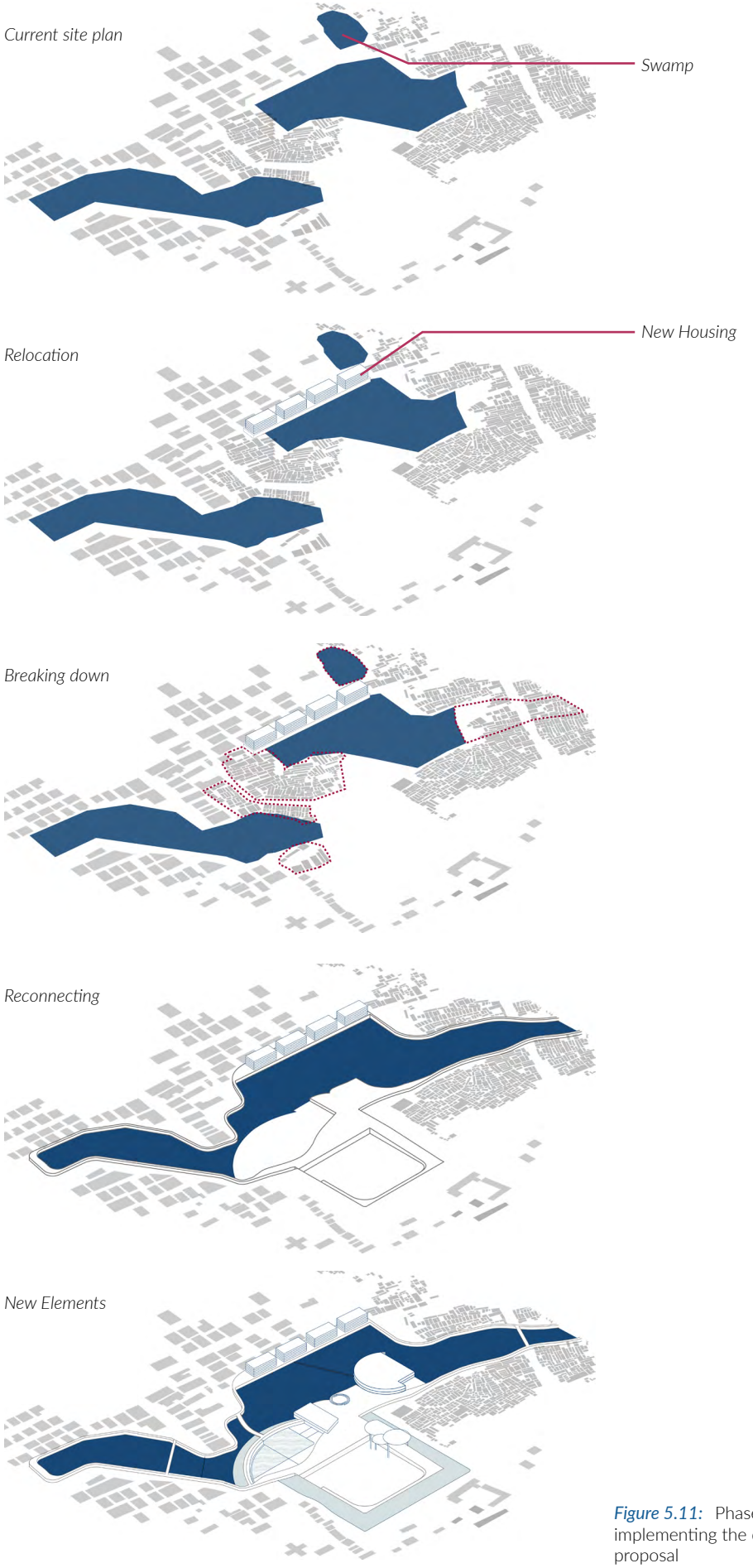


Figure 5.11: Phases of implementing the design proposal

Reconnecting: By breaking down some of the informal settlements and removing barriers, the fragmented Banani Lake will be reconnected to Gulshan Lake and the rest of the proposed canal system to form a continuous drainage path, eventually connecting to the rivers surrounding Dhaka[1].

New Elements: Architectural elements will be introduced to the site. The intervention will include an embankment, a water retention plaza, a community center, a public bath, and a mosque.

Figure 5.12 is a flood map derived from elevation data. It is not an accurate map. As mentioned earlier, flood mapping in Dhaka was not available, and I used the available data to create maps. From personal observation, news articles, and photographs, I assumed that the level of water does not rise higher than knee height (0.25 meters) in the Banani Mohakhali area during regular heavy rainfall.

The water in Figure 5.12 occupies a total area of about 60,000 square meters. With an average height of 0.25 meters, the total volume of the water would be 15,000 cubic meters.

The enclosed canal in Figure 5.13 will include a two-meter embankment/ promenade. The canal that is visible in the drawing has an area of 45,000 square meters. With a two-meter embankment, the canal will be able to carry an extra 90,000 cubic meters of water. This is five times higher than the assumed level of waterlogging that happens annually.

The arrows in Figure 5.14 show the movement of water in the system during floods. The presence of pumps, active during flood events, along the embankment facilitates the movement of water into the canal. The functioning of the pumps is crucial in making the design successful. The pumps failing is an issue and will be discussed in the conclusion of the thesis.

1 Refer to Figure 2.1 to see the location of the main existing lakes (canals) in Dhaka. Refer to Figure 3.22 to see the map of the proposed canal connection through the city.

Figure 5.12: Site Plan- diagrammatic simplification of waterlogging around the area.

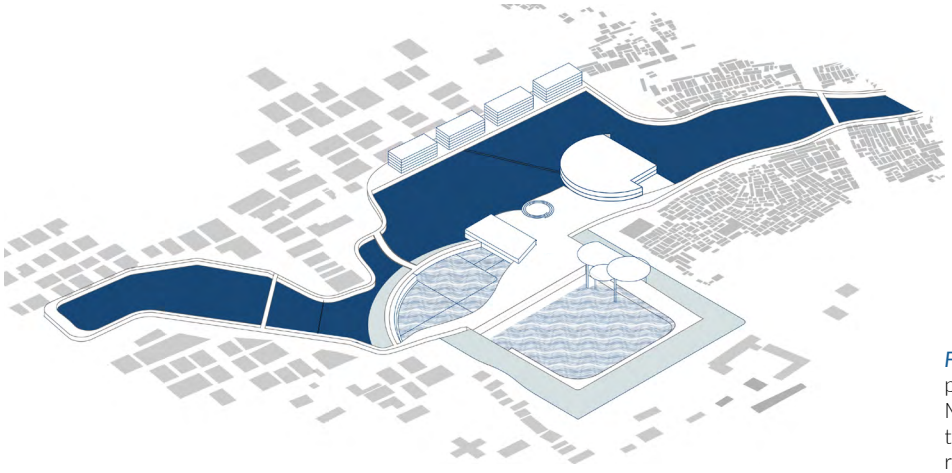


Figure 5.13: Proposed public space during Monsoon. The sunken plaza turns into a water rention reservoir.

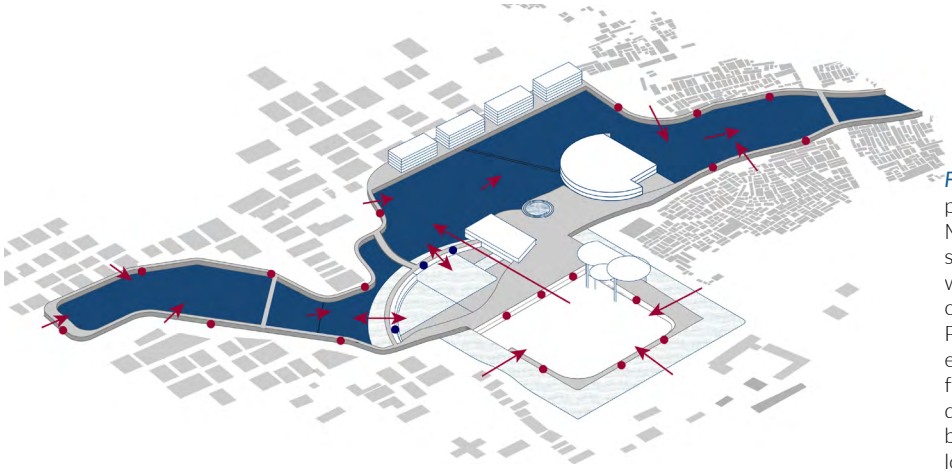


Figure 5.14: Proposed public space during Monsoon. The arrows show the movement of water from the city to the canal and sunken plaza. Pumps present along the embankment boundaries facilitate the flow of water during a flood. The red and blue dots show potential locations for pumps.

- *One way valve pumps rainwater from the city to the Water Retention Plaza and the canal.*
- *Pumps and UV treatment tank filter water from the canal and bring it into the Bath.*

WATER EVERYWHERE

Water exists in three forms in the design:

The presence of water at all times: Some elements will always contain water: the bath, the ablution space, the rain garden, and the canal itself.

The presence of water during rain: Some spaces will accommodate water when it rains, such as the sunken water retention plaza, some features inside the mosque, and parts of the community center.

The absence of water at all times: Some spaces will always have a non-permeable character: the concrete ramp walkway and the embankment.

CONNECTIVITY

The design connects people, architecture, city, and water.

People and water: The canal is usually filled with garbage and the flow of water is hindered. By incorporating a sacred space such as a mosque and an ablution space, as well as daily ritual space such as the bath within the canal, the intention is that the people will see water as a pure element and not an area to dispose of garbage or to take over to build housing.

Ground and water: The sunken retention space is semi-permeable and it allows for water to seep slowly into the ground, eventually recharging Dhaka's groundwater level. At present, the water level is 60 meters below ground, and it is being depleted every year since 85% of Dhaka's water comes from groundwater.

People and people: The site for the proposal is at the edge of the two economic classes in the city, and it has the potential to connect people in the space. People living in the slum are not just someone's maids or drivers; they are also people who pray, who bathe, and who play. This edge is an attempt to allow people to mix stripped of their income and profession.

RITUAL

The proposed activities in the space revolve around rituals. There are religious rituals and daily rituals. The programs in the design proposal include praying, ablution, and bathing. Ablution is a particular way for Muslims to cleanse themselves before prayer. The specificity extends to the order and the number of times in which the hands, feet, face, ears, nostrils, and neck must be washed. Muslims pray five times a day. It is a time for them to connect to their God, to forget their earthly values and possessions. Bathing and ablution are acts of cleanliness that are also important in Islam. Eid prayer is a ritual Muslims also follow when they gather together on the morning of Eid to pray.

Figure 5.15 - 5.18 are photographs of some of these rituals.

Figures 5.19 - 5.24 are sections through the site during dry and wet seasons.

Figure 5.15: Ablution space in Mayor Hanif Jame Masjid in Dhaka by Shatotto.

Figure 5.16: Women washing dishes, clothes and vegetables.

Figure 5.17: Women bathing.

Figure 5.18: Eid prayer.

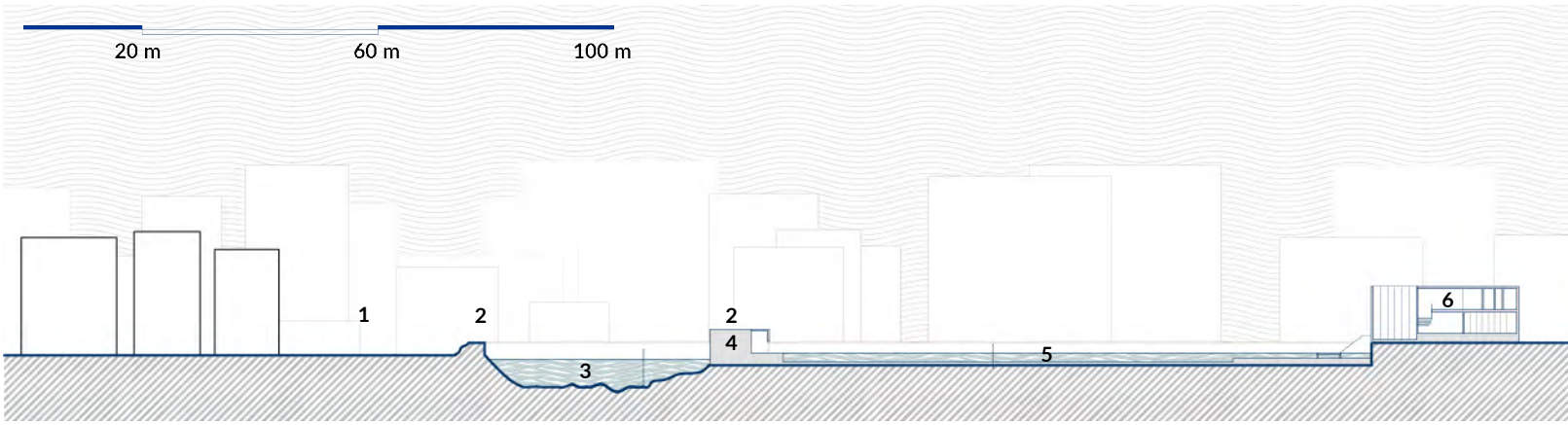


Figure 5.19: Site Section A 1:1250. Refer to Figure 5.5 for section cut markers.

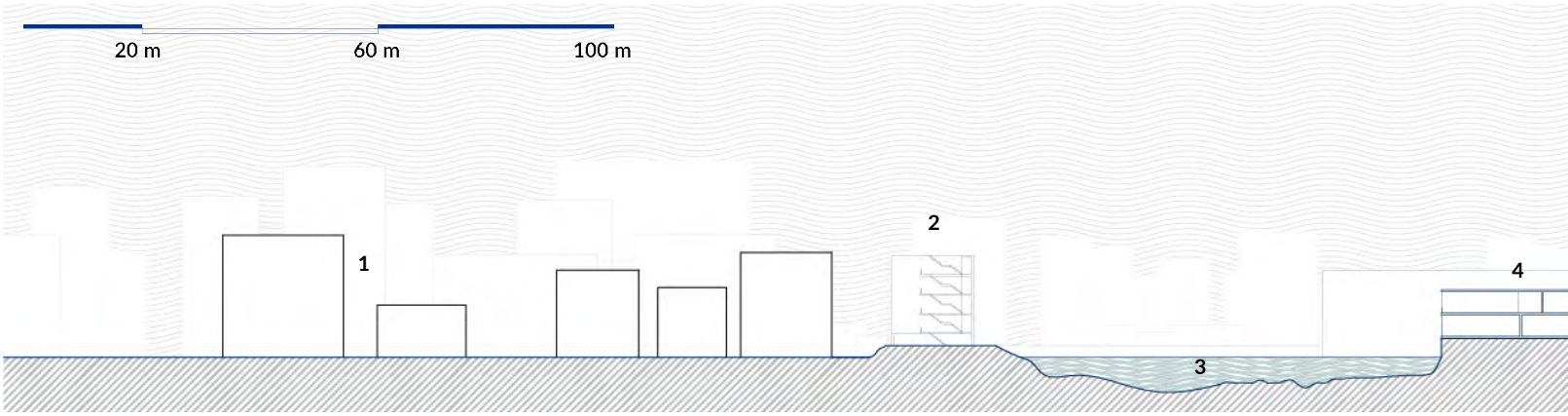


Figure 5.20: Site Section B 1:1250. Refer to Figure 5.5 for section cut markers.

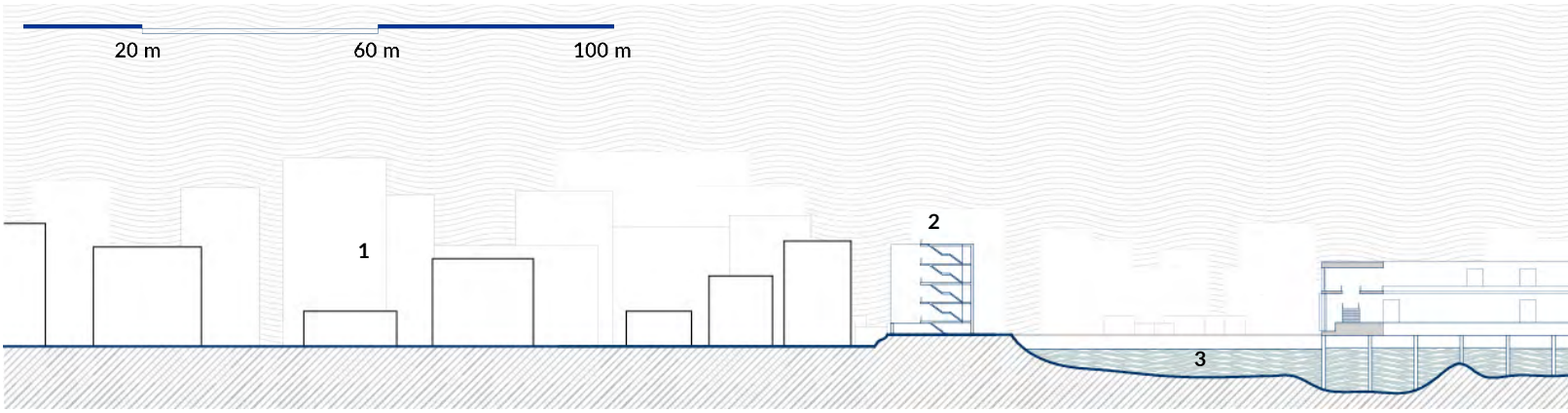
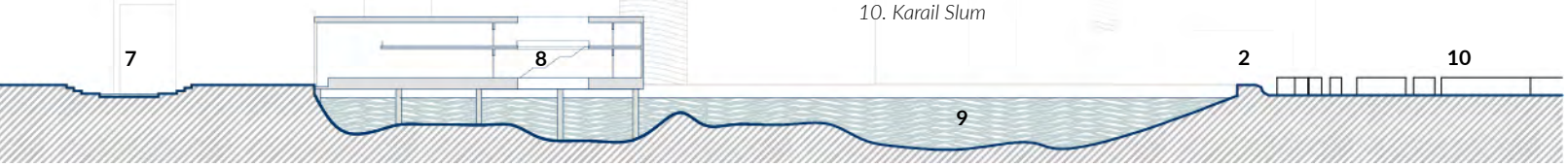


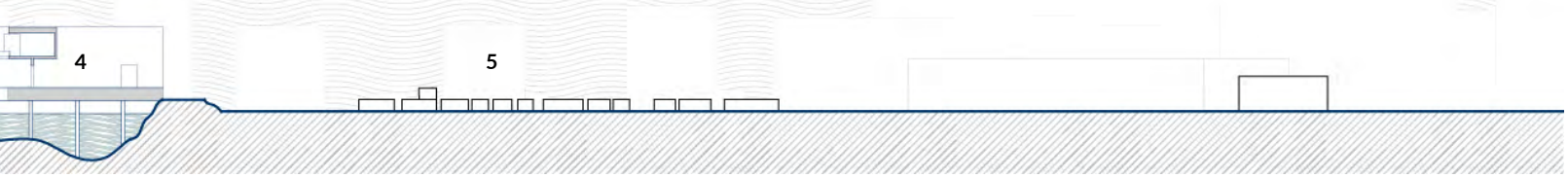
Figure 5.21: Site Section C 1:1250. Refer to Figure 5.5 for section cut markers.

1. Banani
2. Walkway/ Embankment
3. Banani Lake (Canal)
4. Shower/Change Room for women
5. Natural Swimming Pool
6. Community Center
7. Ablution Space
8. Mosque
9.Banani Lake (Canal)
10. Karail Slum



1. Banani
2. Half House (social housing)
3. Banani Lake (Canal)
4. Community Center
5. Promenade
6. Sunken Plaza
7. Rain garden

1. Banani
2. Half House
3. Banani Lake (Canal)
4.Mosque
5. Karail Slum



Water from the city side will be pumped into the canal using one-way valve pumps. Arrows in the following three diagrams show the direction in which the water will be pumped during flooding. This will take the water away from the city into the canal and reduce flooding in the city.

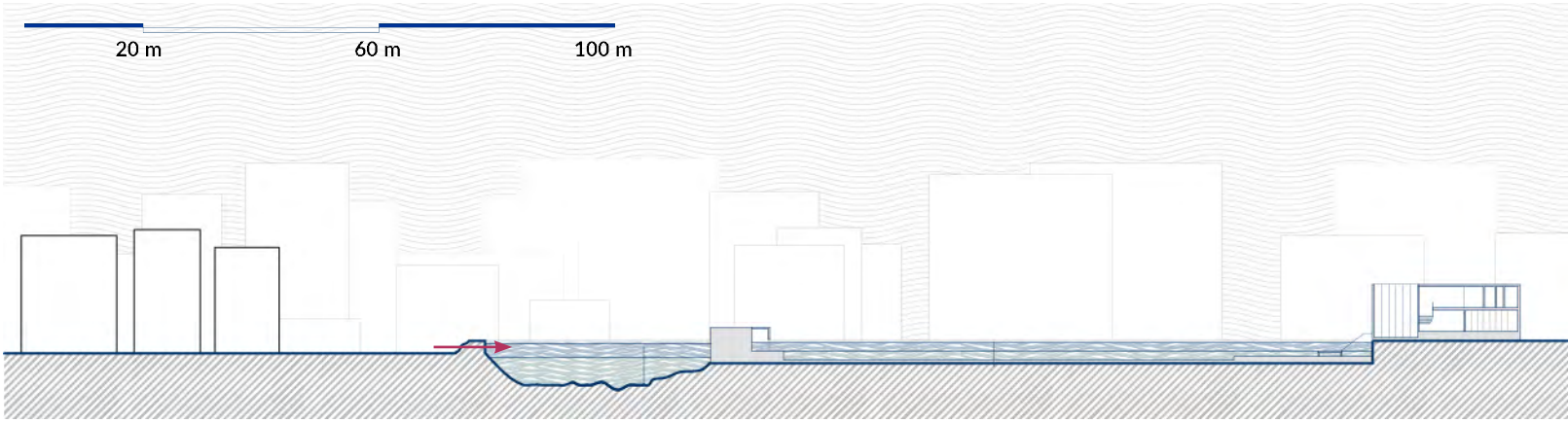


Figure 5.22: Site Section A during heavy rainfall. Refer to Figure 5.5 for section cut markers.

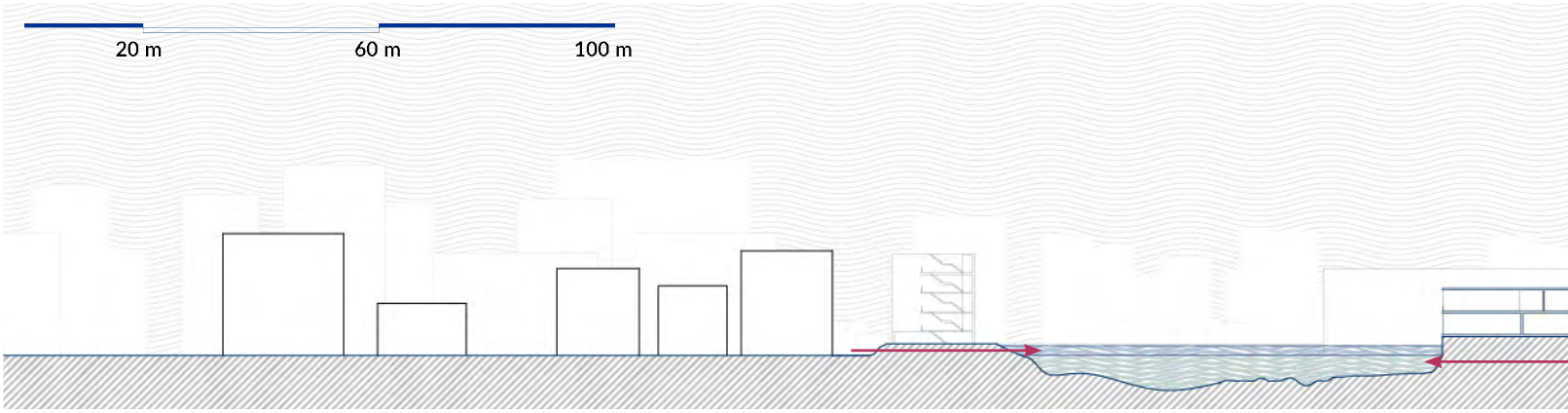


Figure 5.23: Site Section B during heavy rainfall. Refer to Figure 5.5 for section cut markers.

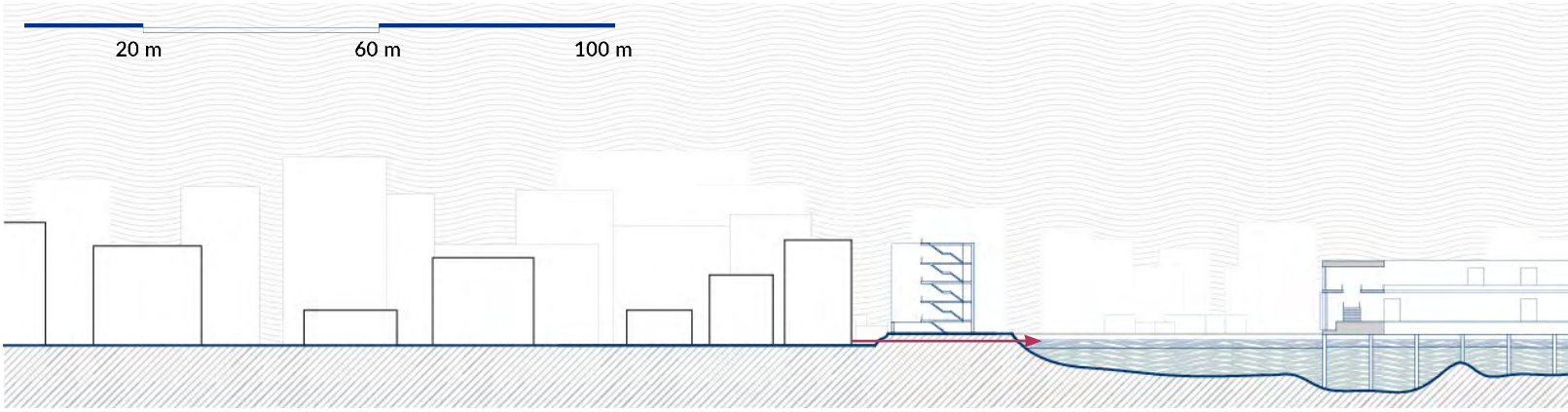
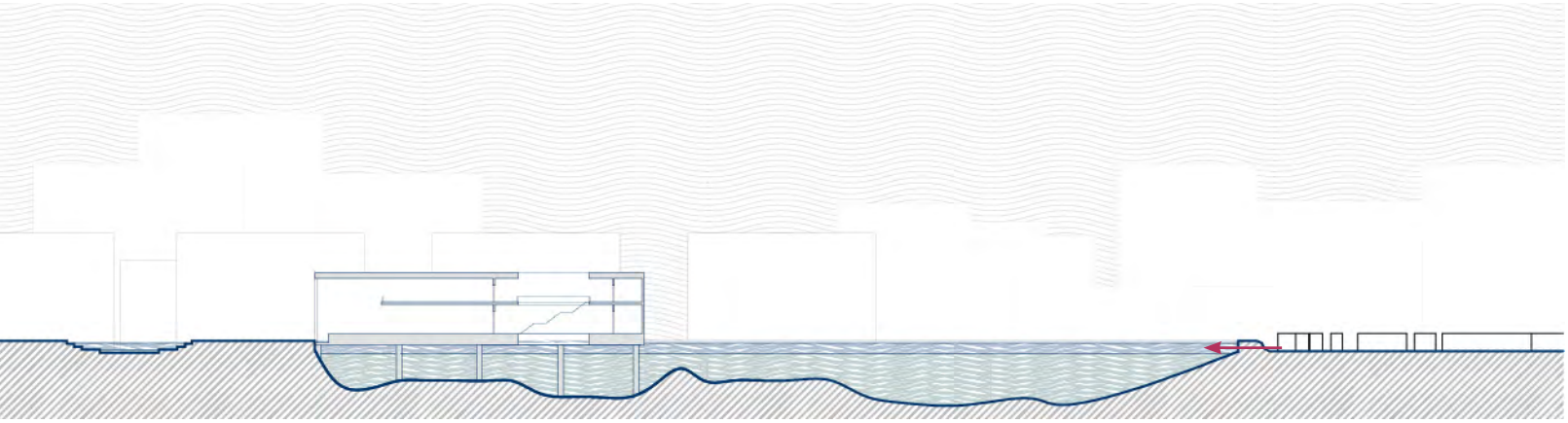
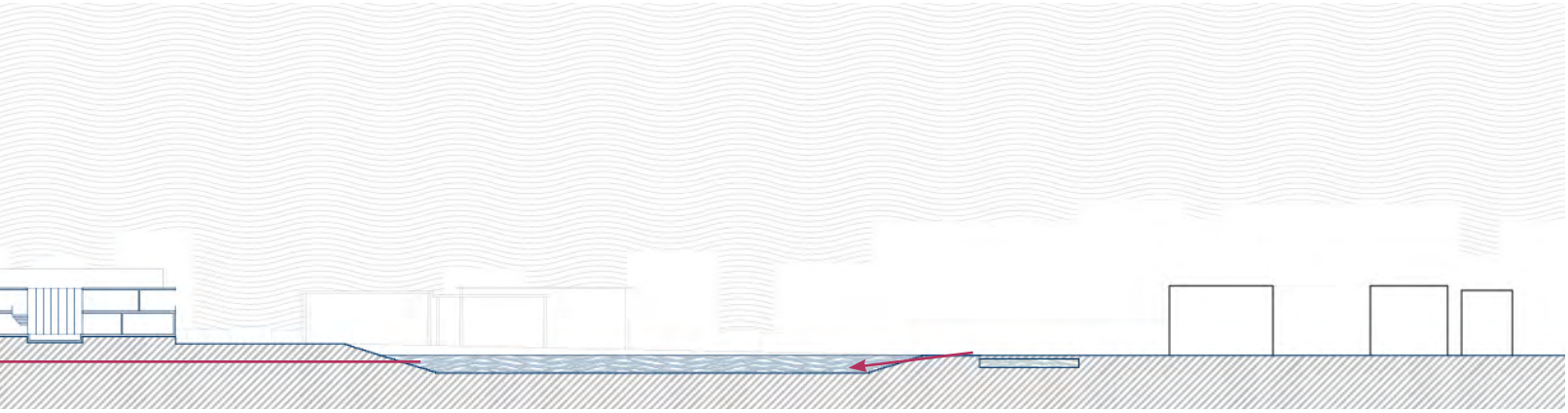
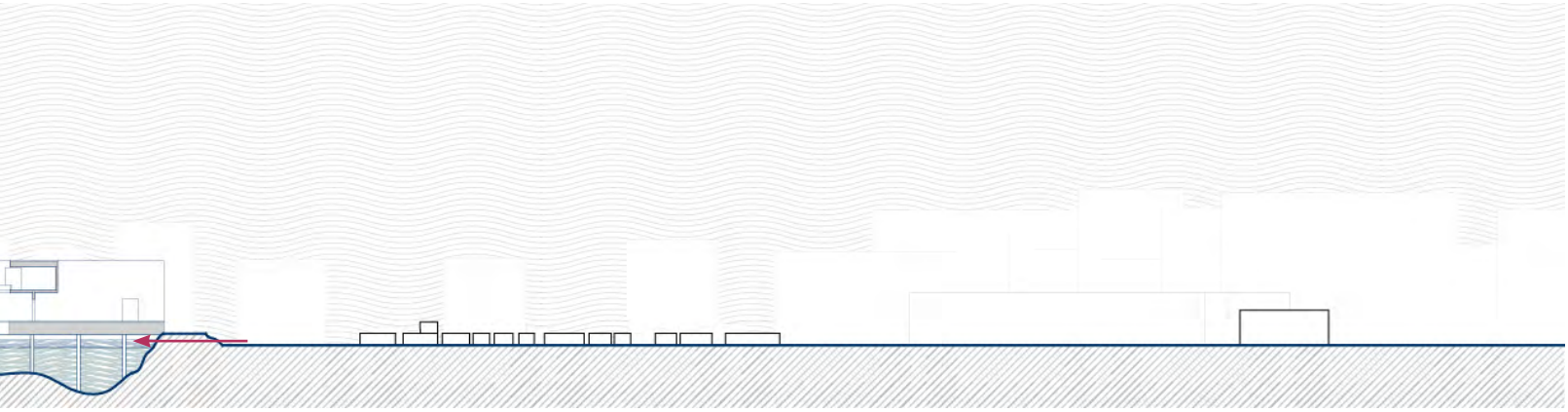


Figure 5.24: Site Section C during heavy rainfall. Refer to Figure 5.5 for section cut markers.







BELOW GROUND

In this proposal, designing the ground is as important as designing above ground. As discussed in earlier chapters, clay covers the top of Dhaka's soil. Clay is not good at absorbing water thus creates a less permeable ground surface for the water. This design proposal will have three different levels of permeability in its intervention (Figure 5.25). A few of the aspects will have water on the surface at all times such as the bath, the water courtyard in the community center and the wetlands. A few of the surfaces such as the embankment and the ramps leading to the embankment will be completely impermeable to water to facilitate their use during monsoon. The sunken plaza and the rain gardens will have the layers of clay removed from the ground to allow water to be absorbed into the ground. These spaces will accommodate water during rain. Figure 5.26 shows the current ground condition in the site as well as the ground modified for use as a non-porous surface as well as semi-porous surface.

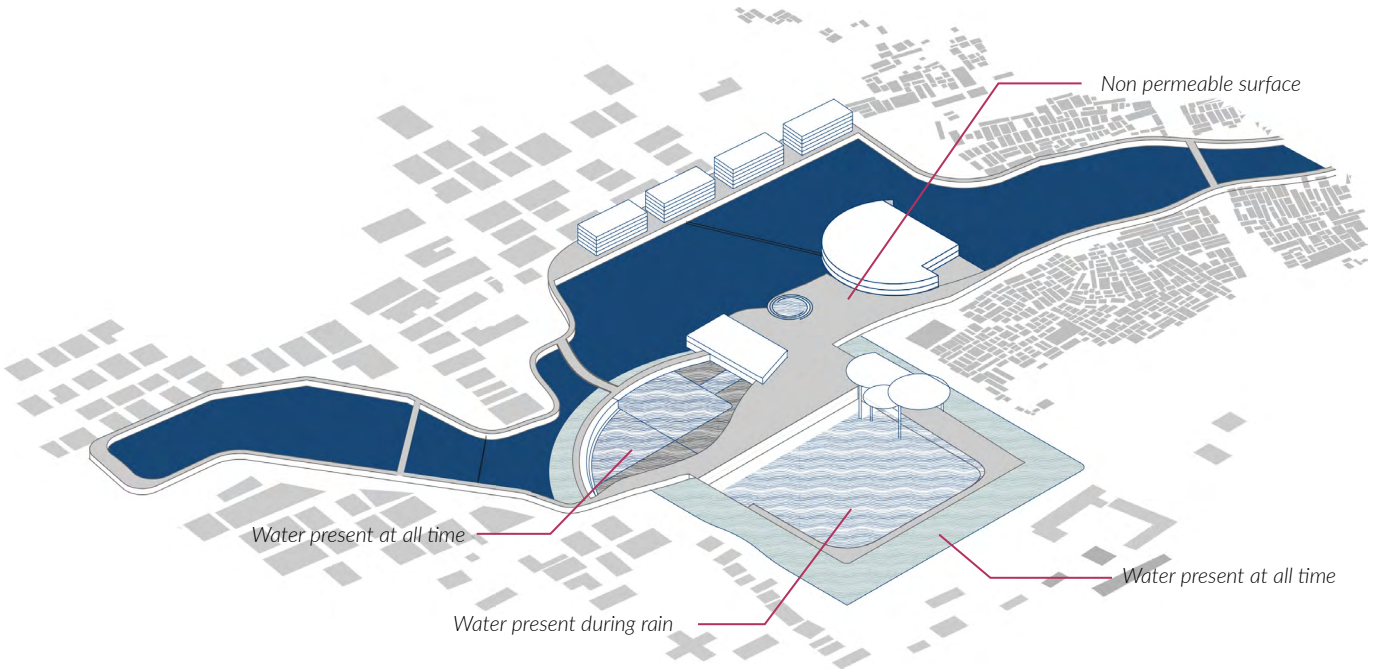
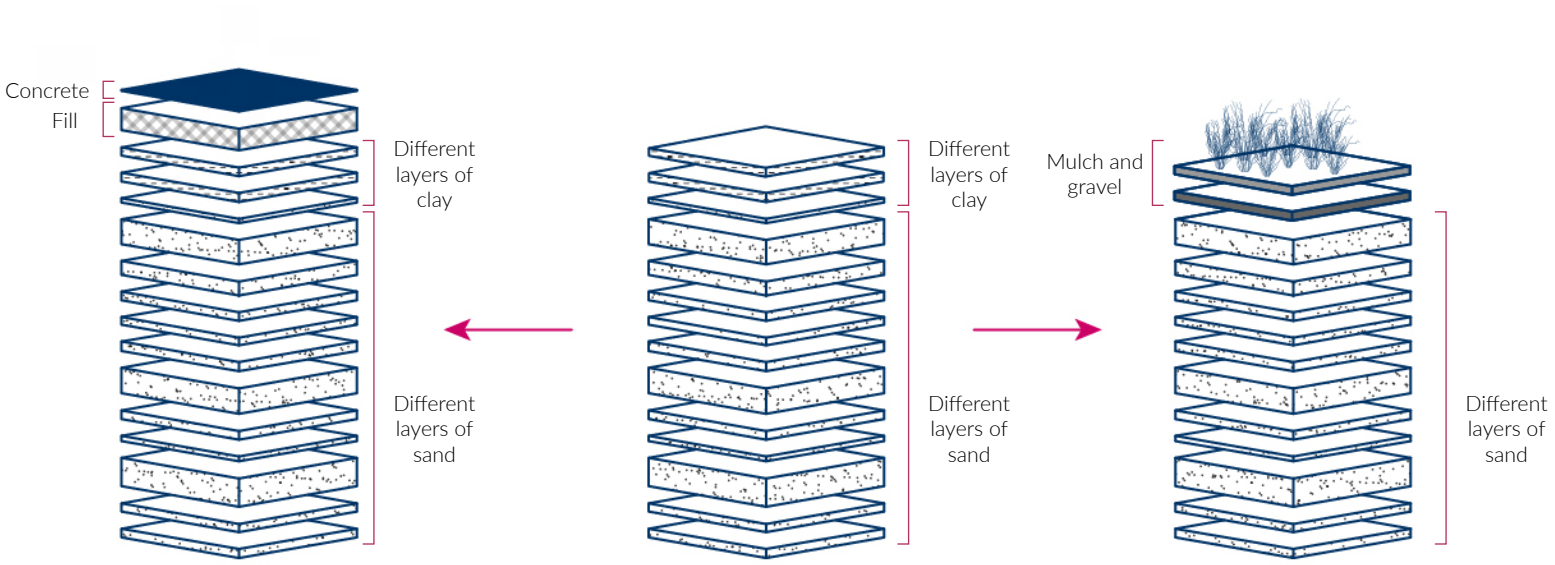


Figure 5.25: Surface permeability in the design proposal

Layers added on the ground during construction of interventions

Current ground condition

Layers of clay removed from the ground and layers of mulch and gravel added to the ground



Embankment and rampway from the sunken plaza will be covered in fill materials to add height to the surface. Concrete will be added on top to create a non permeable surface for year long use including monsoon season.

The first few meters of the ground currently is made of clay. Clay is not good at absorbing water.

By removing the first few meters of soil which are composed mainly of clay, the sand layers will be exposed. The sand layers are better at allowing water to seep through deeper into the ground. Mulch and gravel will be added on top to create raingardens and semi permeable surfaces (such as the one in the sunken plaza).

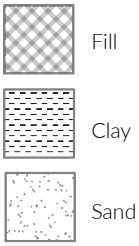


Figure 5.26: Sections through soil layers before and after the proposed interventions.

EMBANKMENT

Currently, the water at the Banani Lake (canal) is almost at grade level. When it rains, water naturally overflows into the city. One of my responses to increasing the stormwater retention capacity of the city is to build an embankment around the canal that will allow the canal to hold stormwater in a more substantial capacity during monsoon. A promenade and architectural interventions along the embankment will invite the people of the city up to the elevation of the promenade and provide an environment to enjoy the lake year-round. Frequent steps up and down the embankment and a wide promenade on the embankment with landscaping will extend the city life into the embankment. At this scale on this site, the embankment will connect the city and the people to the different architectural elements: the mosque, the bath and community center, and the water-retention sunken plaza.

Figures 5.27 and 5.28 are views of the two sides of the embankment. Concrete blocks will be used to stabilize the slope of the embankment. Examples of these kinds of sloped structures can be seen in Figures 5.29 to 5.33 which are images of flyovers constructed through Dhaka. These flyovers have slopes supported by concrete blocks. These concrete blocks (Figures 5.31 and 5.32) have circular openings that allow the plants to grow through. This gives the embankment a soft green look and stops it from looking like a barrier.

Figure 5.34 is a plan showing how different public spaces can be positioned along the embankment to continue the city space onto the embankment. Figure 5.35 is a section through the proposed embankment and Figure 5.36 is a detail of the sloped embankment.

The contradiction of building an embankment will be elaborated more in the conclusion.

Figure 5.27: The city on one side of the embankment

Figure 5.28: Stairs, walkways and public spaces connect the city to the water despite the embankment

Figure 5.29: Green plantings on the walls of the flyover in Dhaka.

Figure 5.30: Green plantings on the highway walls create a peaceful corridor.

Figure 5.31: Concrete blocks line the wall. The openings through the concrete blocks allow greenery to grow.

Figure 5.32: Close up of the concrete blocks supporting the slope.

Figure 5.33: Buildings on the other side of the flyover. As can be seen the flyover does not affect the light or privacy of the buildings since they already have walls built around them.

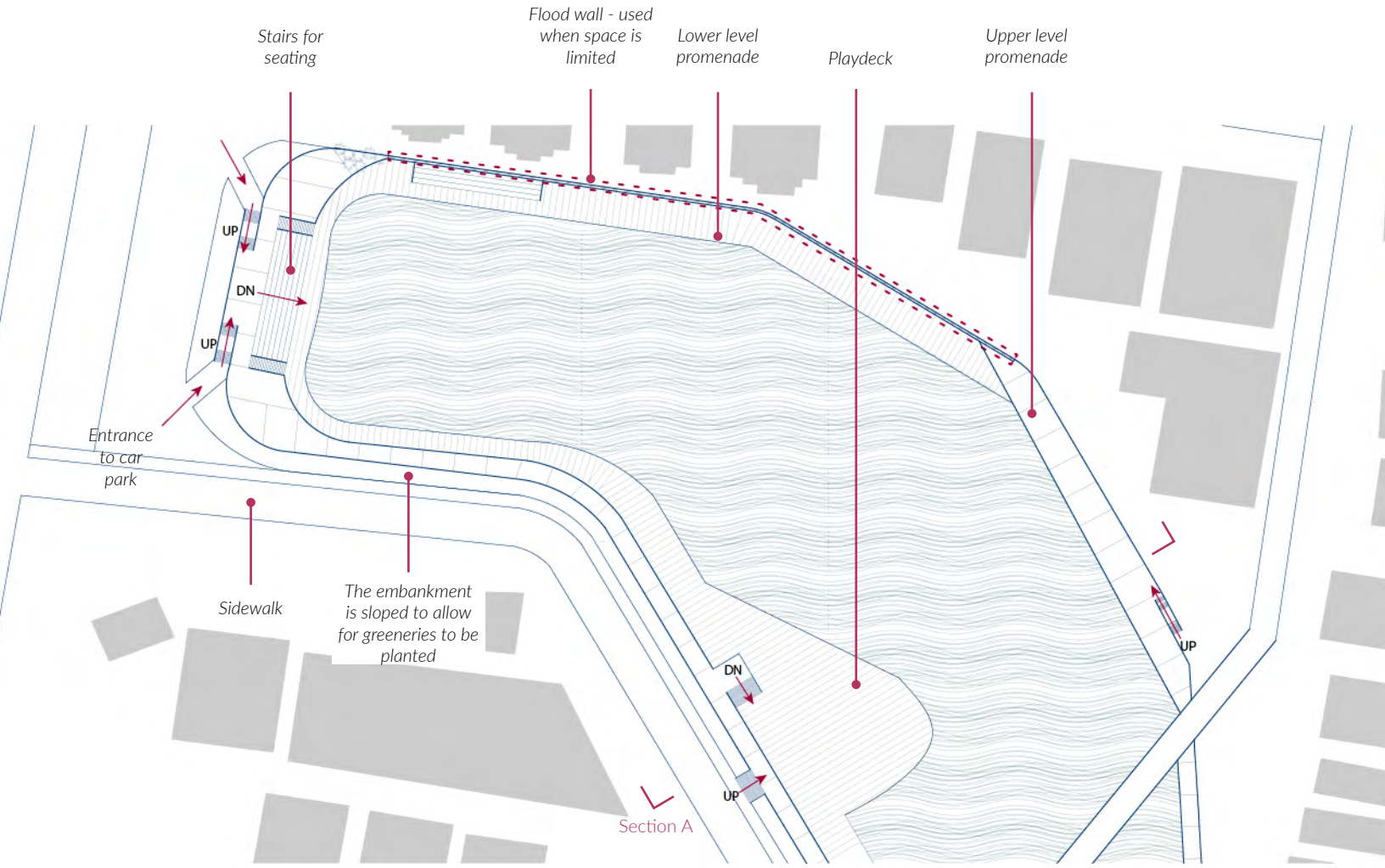


Figure 5.34: The aim of the embankment is not to separate the city from the water but to manage rainwater overflow. Promenades at different levels will create wider range of spaces for interaction of the people with water.

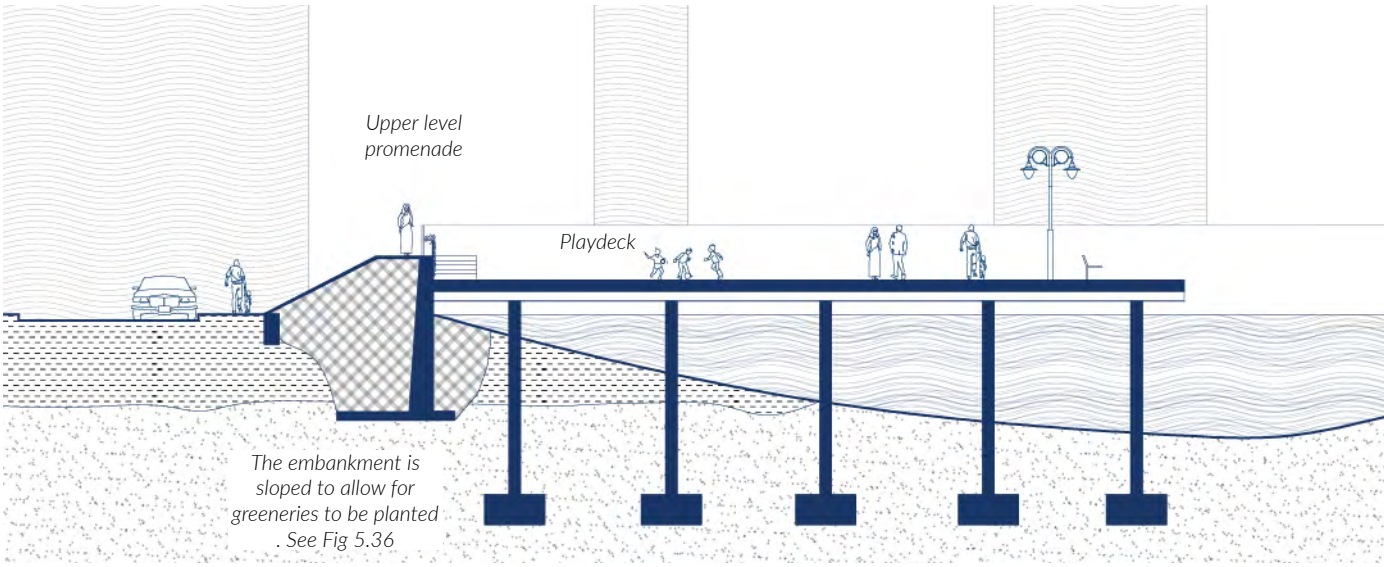


Figure 5.35: Section A

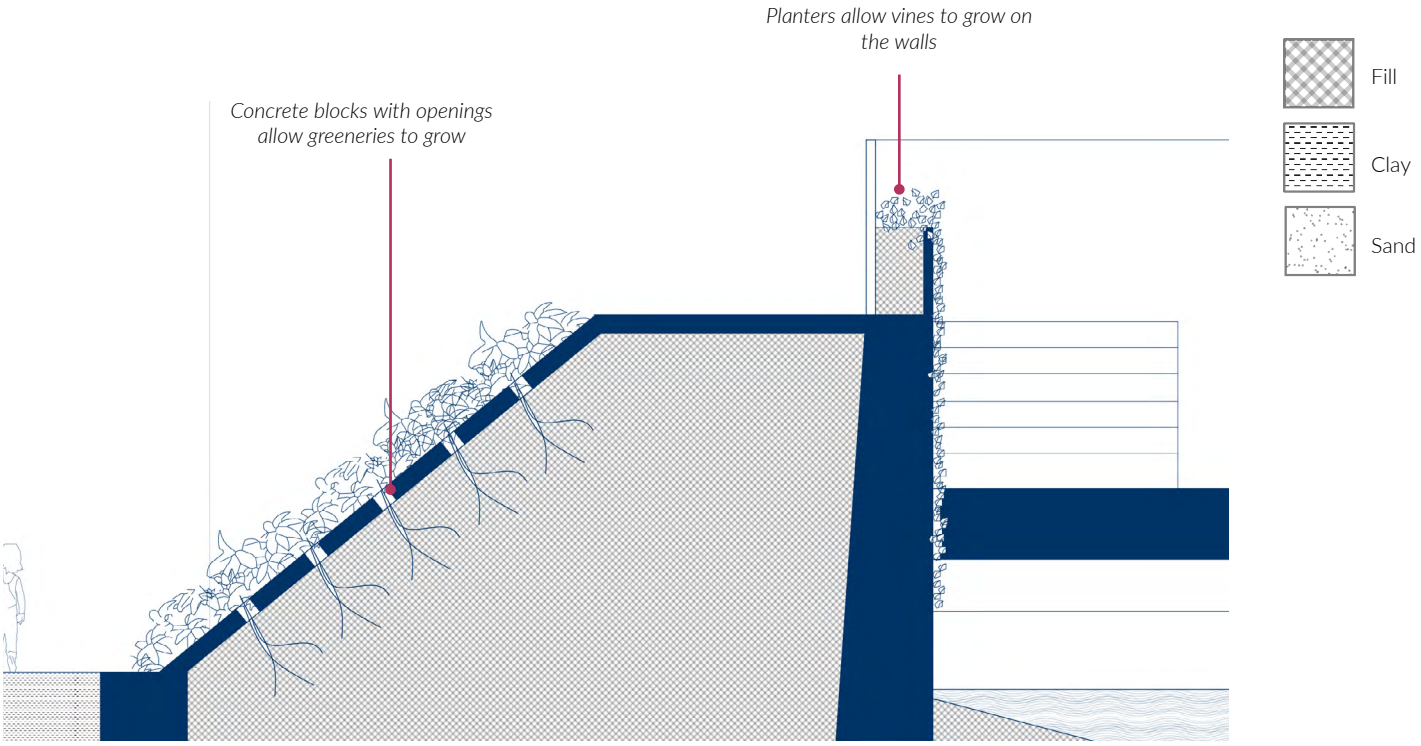
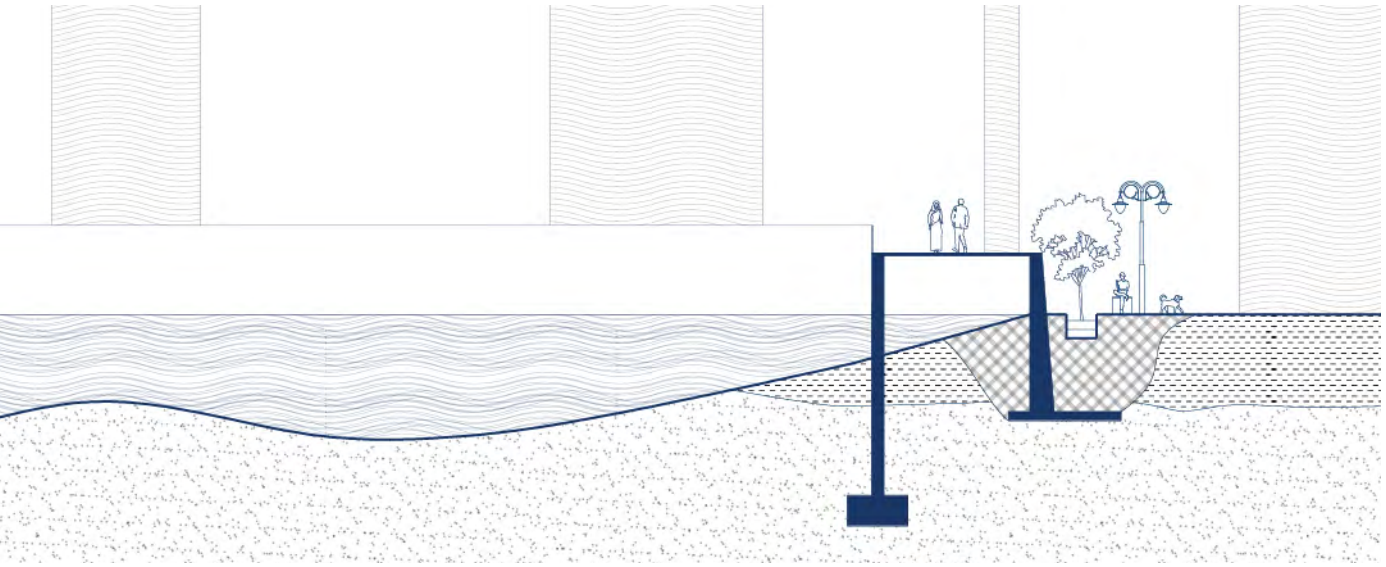


Figure 5.36: Sloped Embankment detail. Concrete blocks are shown in Figures 5.31 and 5.32.



COMMUNITY CENTER AND BATH

Figures 5.37 and 5.38 show views inside the bath and the community center. Figures 5.39 and 5.40 are plans of the design proposal. Figures 5.41 and 5.42 are sections through the design proposal during dry and wet seasons.

Bathing in the river is an old custom and ritual, and this portion of the thesis discusses reviving that tradition in a modern environment. The residents of Karail live in adverse conditions, frequently without proper water, bathing space, or privacy. Part of the design proposal is a bathing pool for everyone. The community center beside it will house all the support programs. The water from the canal will be filtered through a natural regeneration pond and then through UV filters before being pumped into the bath. After use, the water will be pumped back into the regeneration pond for filtration. The regeneration pond in between the canal and the bath will use a filtration system consisting of gravel and phytoplankton to filter the water. Then the water will be passed through UV filters inside the bridge before returning to the bath. Figure 5.43 is a diagram of the filtration process.

The bath will be divided into two sections – one for men and children and one for women and children. An opaque glass wall will divide the pool, while letting water freely move through gaps at the bottom. This will ensure that women and children are safe while in the bath. Private showers and change rooms will be available in the women and children's section as well. The glass wall is not present for privacy but mostly for safety and security.

The community center itself will house programs such as exhibition space and a café upstairs, and offices and change rooms downstairs. The functions of this building will be loosely held to allow the building to turn into a shelter when necessary. A courtyard surrounded by a double glass wall will be at the center of this building. The glass wall is an attempt at connecting people to water again and providing a poetic view of the water.

During flooding, the bath will be submerged and closed to the public. The women's showers will be slightly submerged during a flood and will thus need to be wet floodproofed. Wet floodproofing is a technique that ensures that when the flood water enters the premise, it does not cause any damage to the interior. The showers will have no furniture, durable hooks for hanging clothes, durable shower fixtures, and water-resistant interior finish. After flooding, they will also need to be adequately cleaned since flood water will be contaminated and will carry sediments, debris, and dirt.

Figure 5.37: View of the natural pool with the community center in the background

Figure 5.38: View inside the community center on the ground floor

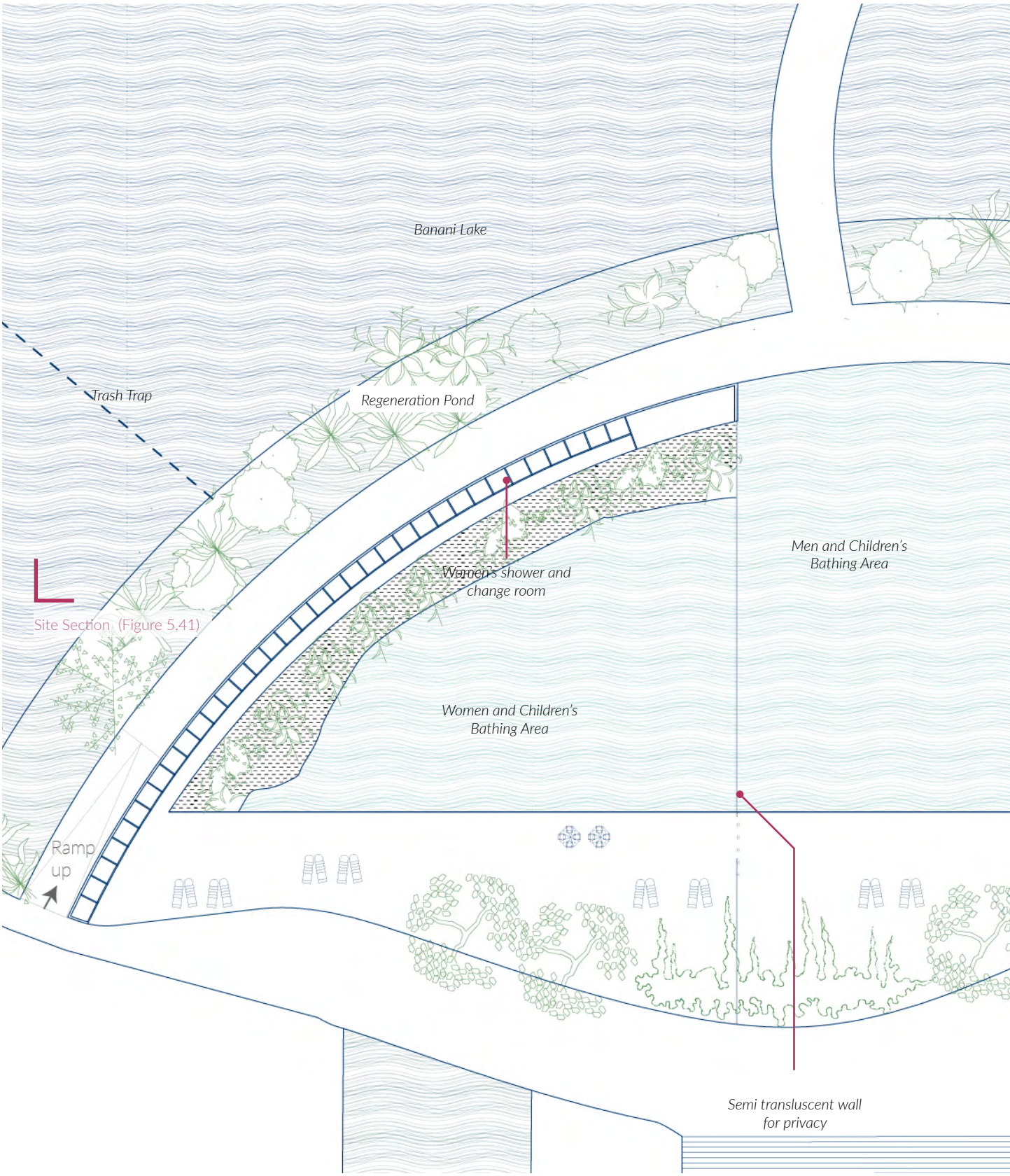
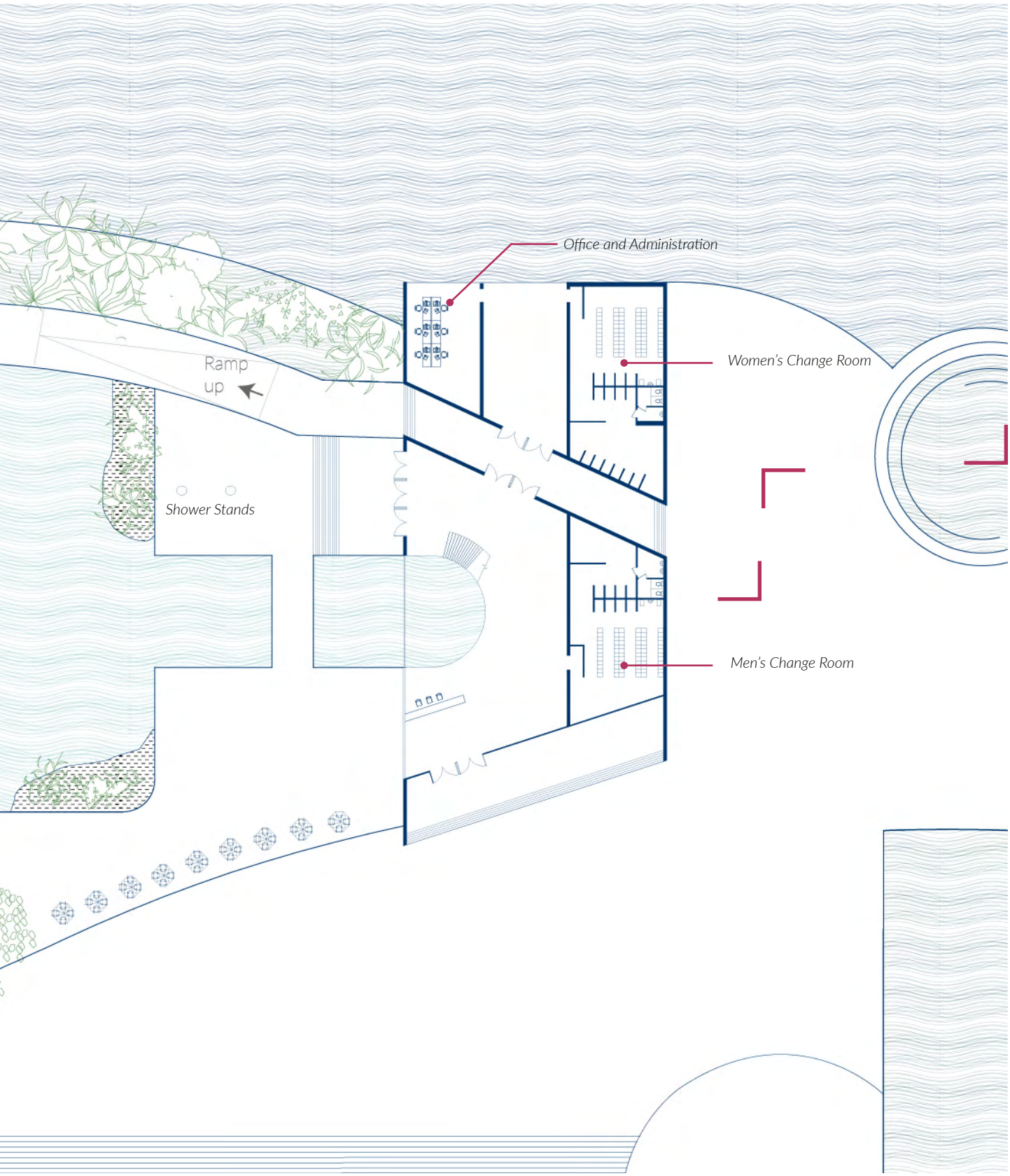


Figure 5.39: Ground floor plan - Bath and Community Center


Office and Administration
Women's Change Room
Ramp
up
Shower Stands
Men's Change Room

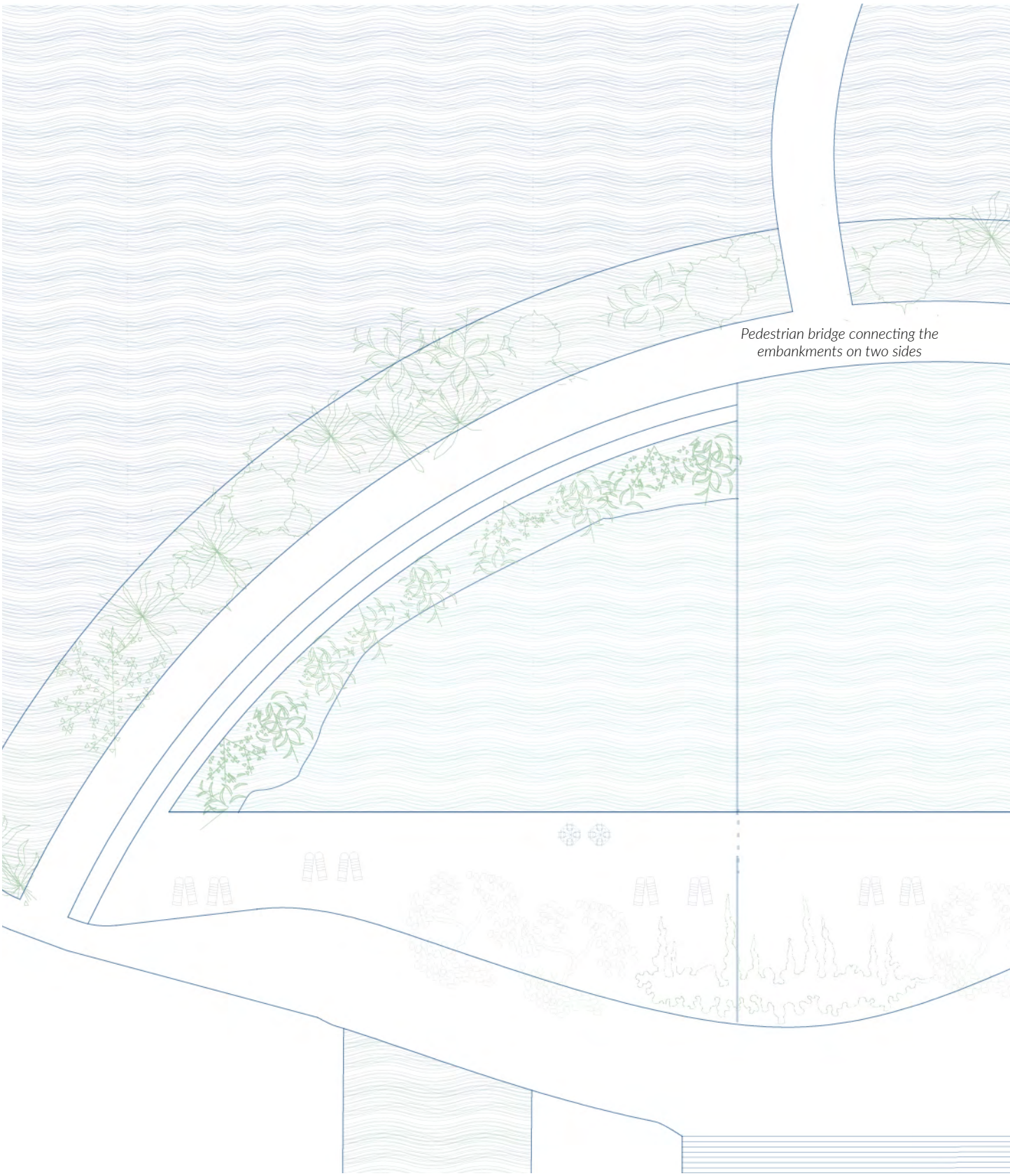
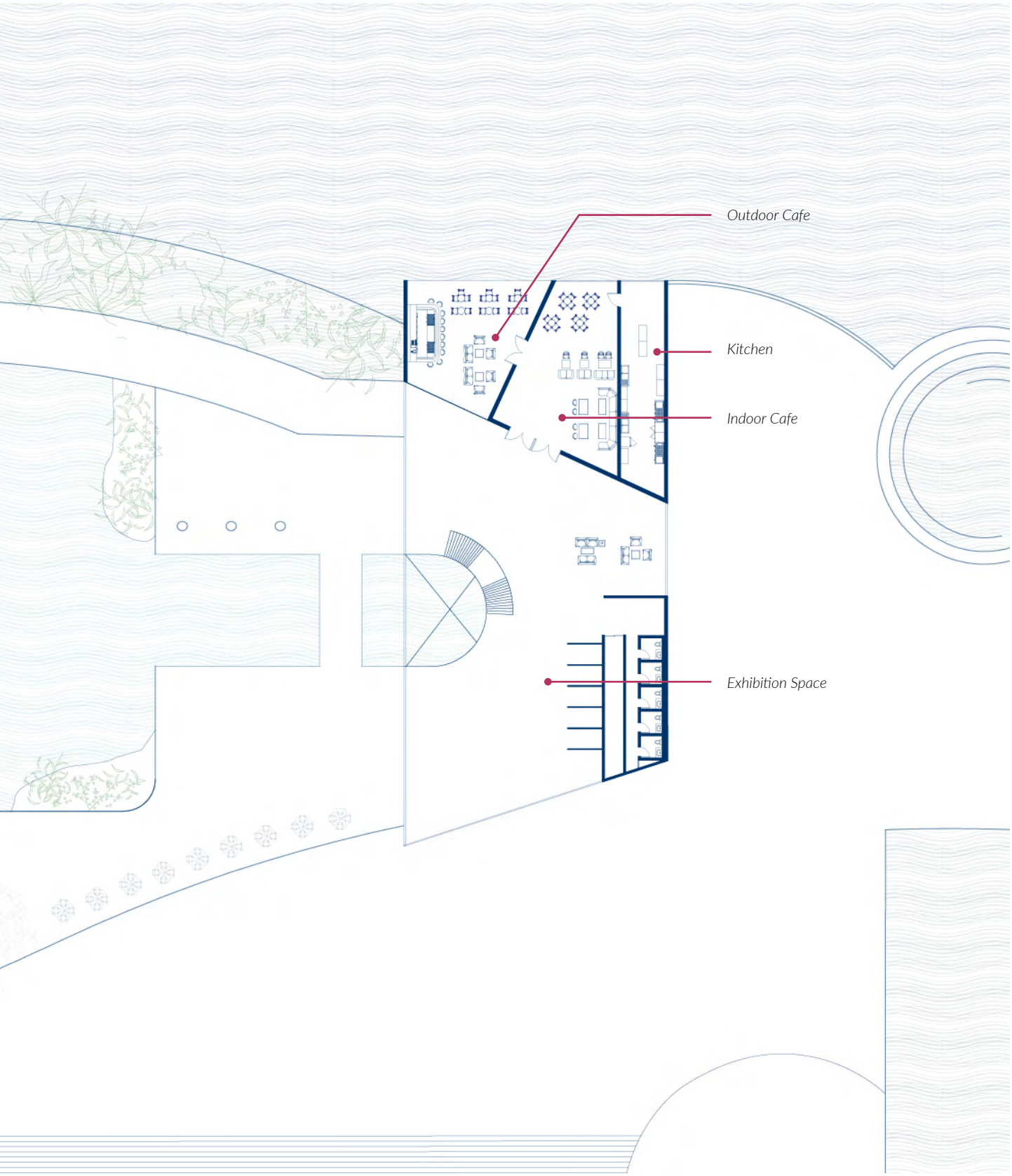


Figure 5.40: Upper floor plan - Bath and Community Center


Outdoor Cafe
Kitchen
Indoor Cafe
Exhibition Space

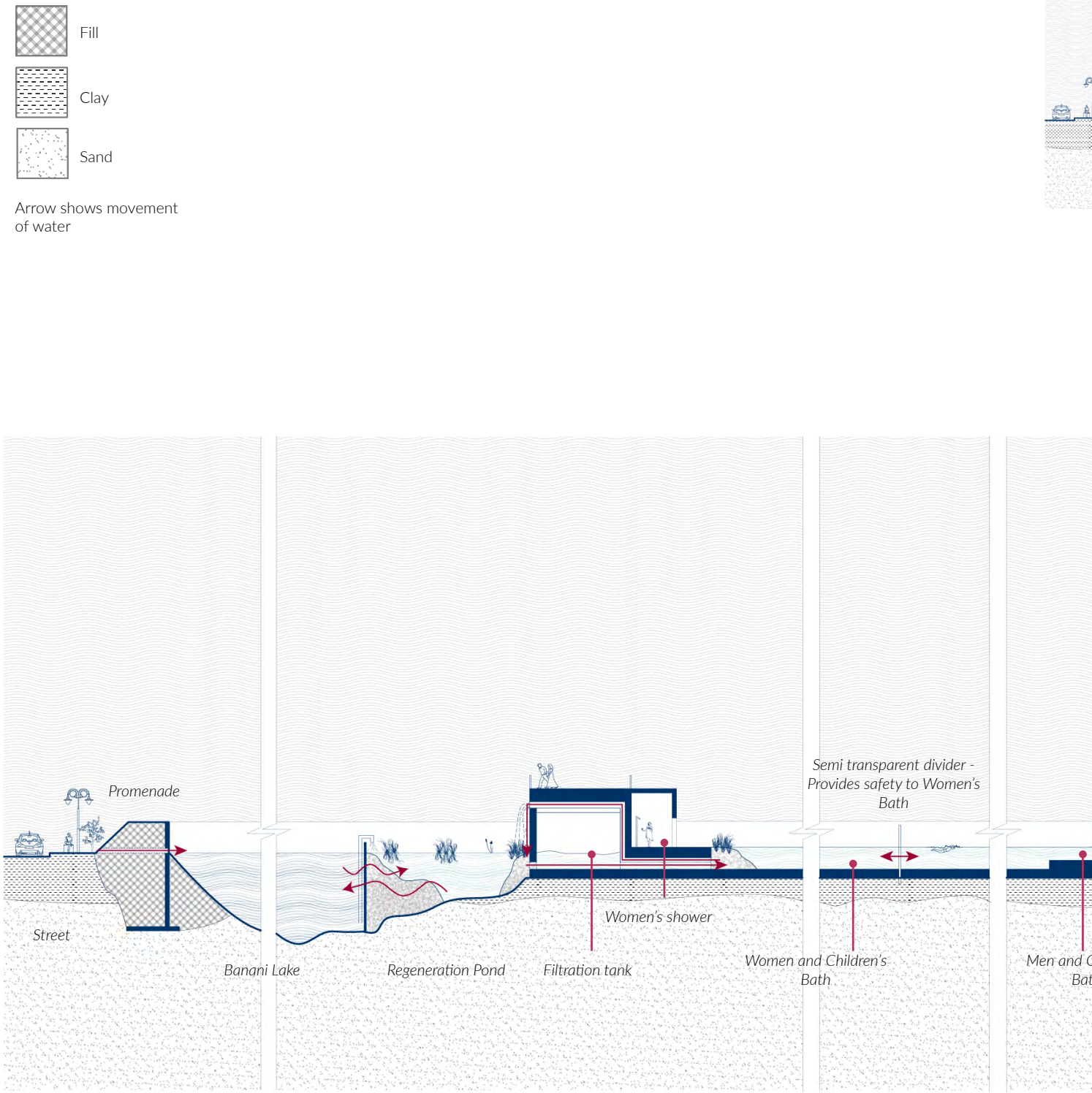


Figure 5.41: Section through the Bath and Community Center

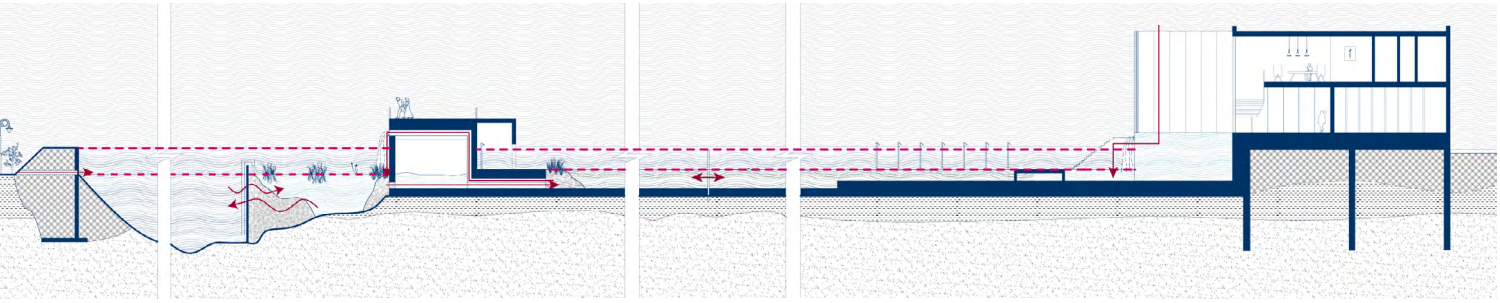
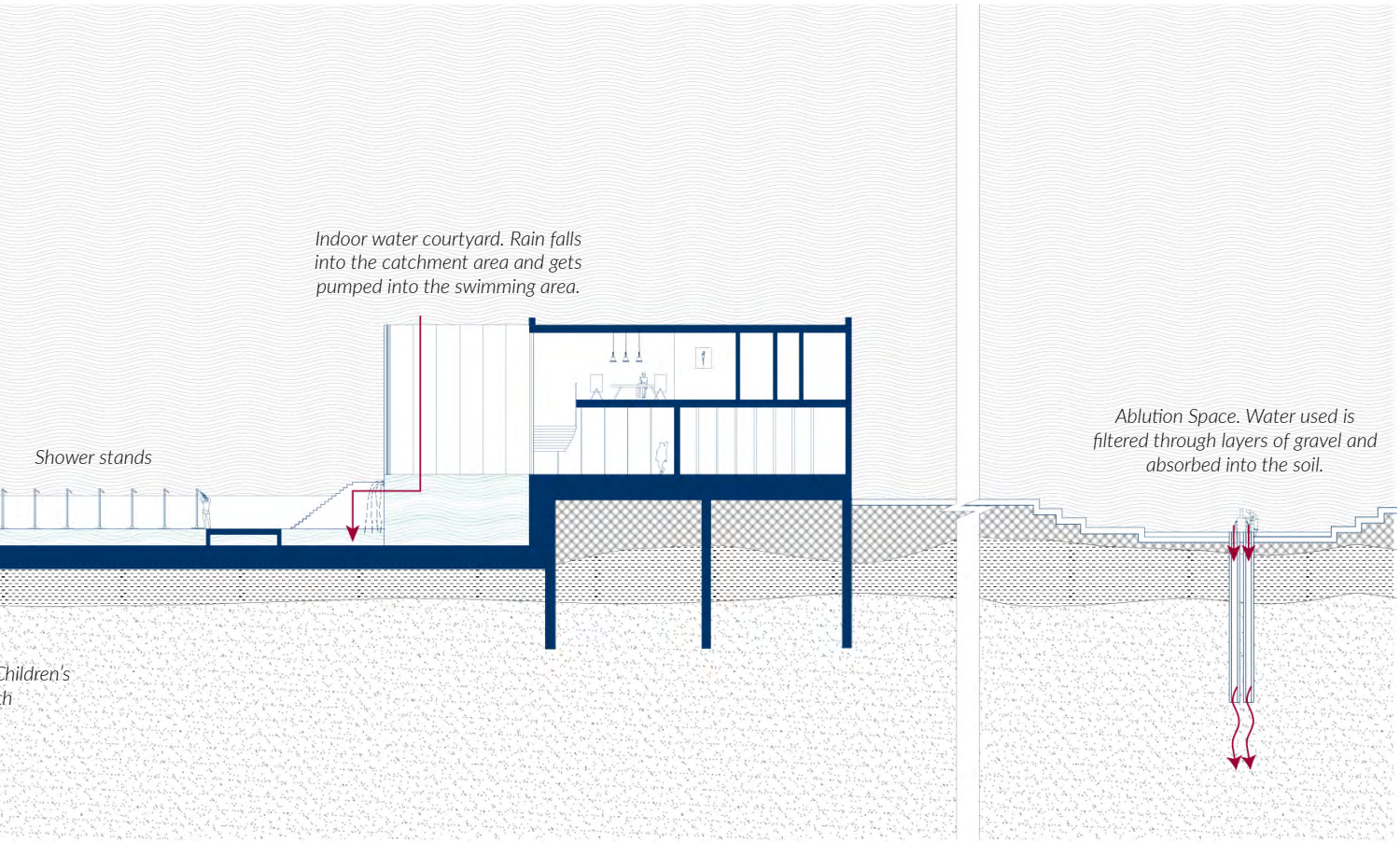


Figure 5.42: Section through the Bath and Community Center during flood.



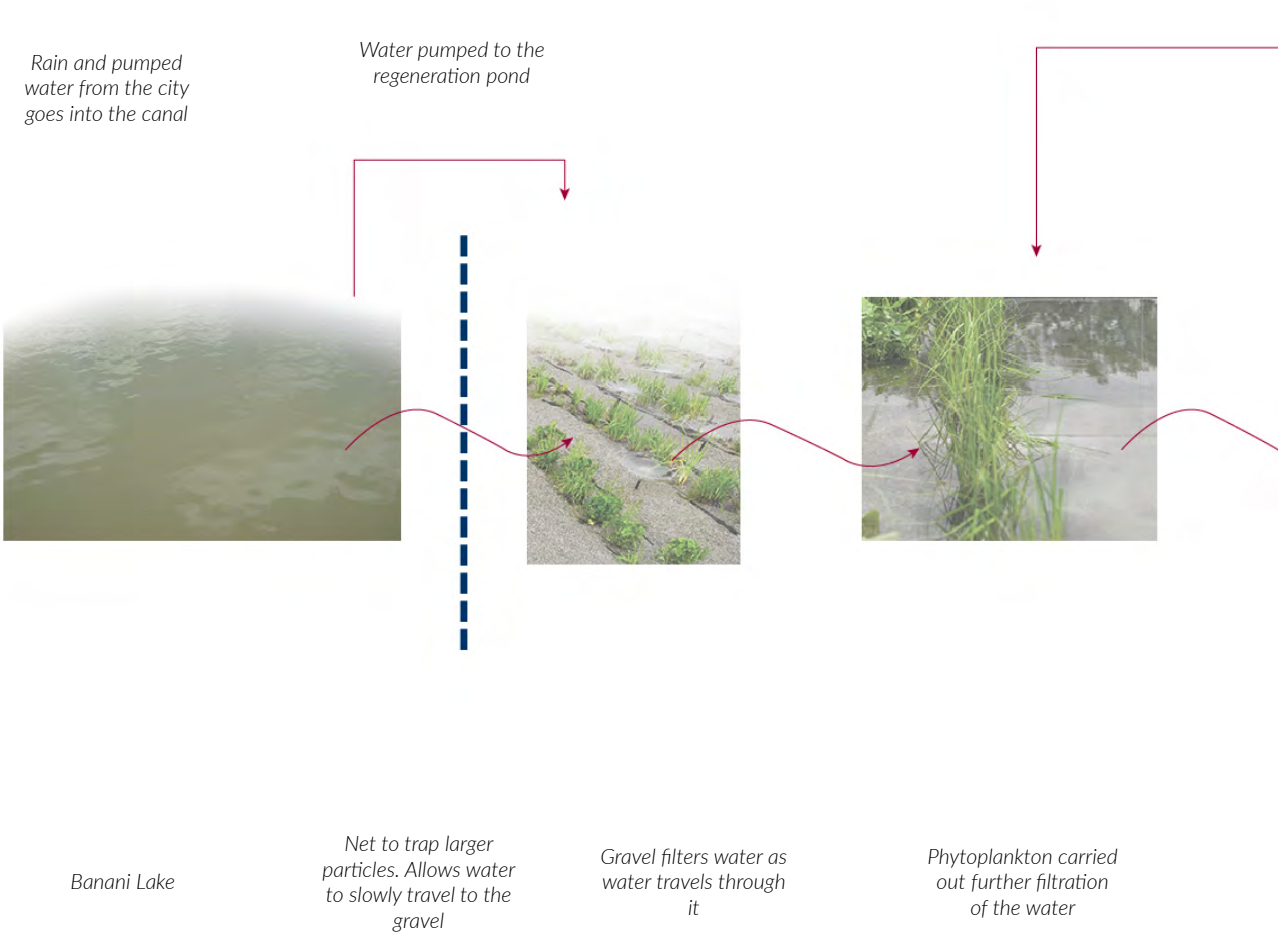
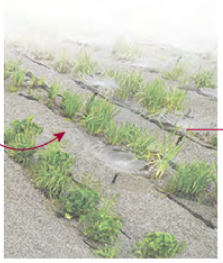
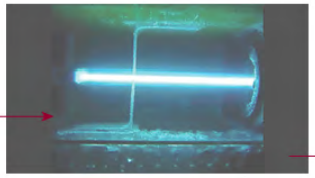


Figure 5.43: Filtration process

Used water is pumped back into the regeneration pond for purification





Gravel filters water as water travels through it again

Filtration tank located under the pedestrian bridge filters water using UV lights

Clean water is pumped into the bath

MOSQUE

Figures 5.44 and 5.45 show views inside the bath and the community center.

A mosque is a sacred space for prayers for Muslims. Mosques often also serve as locations for important rites of passage in life such as marriages and funeral services. For many, a mosque inspires equality, modesty, and humility. For this design intervention, a mosque appeared to be a perfect place to connect people to water and a place to inspire change, responsibility, and awareness. This design was inspired by Carlo Scarpa's Querini Stampalia Foundation (Figure 5.46) in Venice. In this building, Scarpa organized tunnels and passages to allow water to enter the building.

The proposed mosque will be built on stilts on the edge of the Banani Lake right at the edge of the Karail Slum. This position was chosen to facilitate the breaking of socioeconomic barriers between people. It is in a location close to the residents of the slum as well as the residents of the affluent households. Architecturally, four elements are connecting the people to the water described in the following paragraphs.

1. Like Scarpa's design, this mosque will allow rain water to enter the edge of the building through a gutter system. The windows will be operable like fins and they will close off the building from water once the water inside the building reaches a certain level. Again, this is to connect people to water during prayer – a time Muslims consider a time of extreme vulnerability and extreme strength.

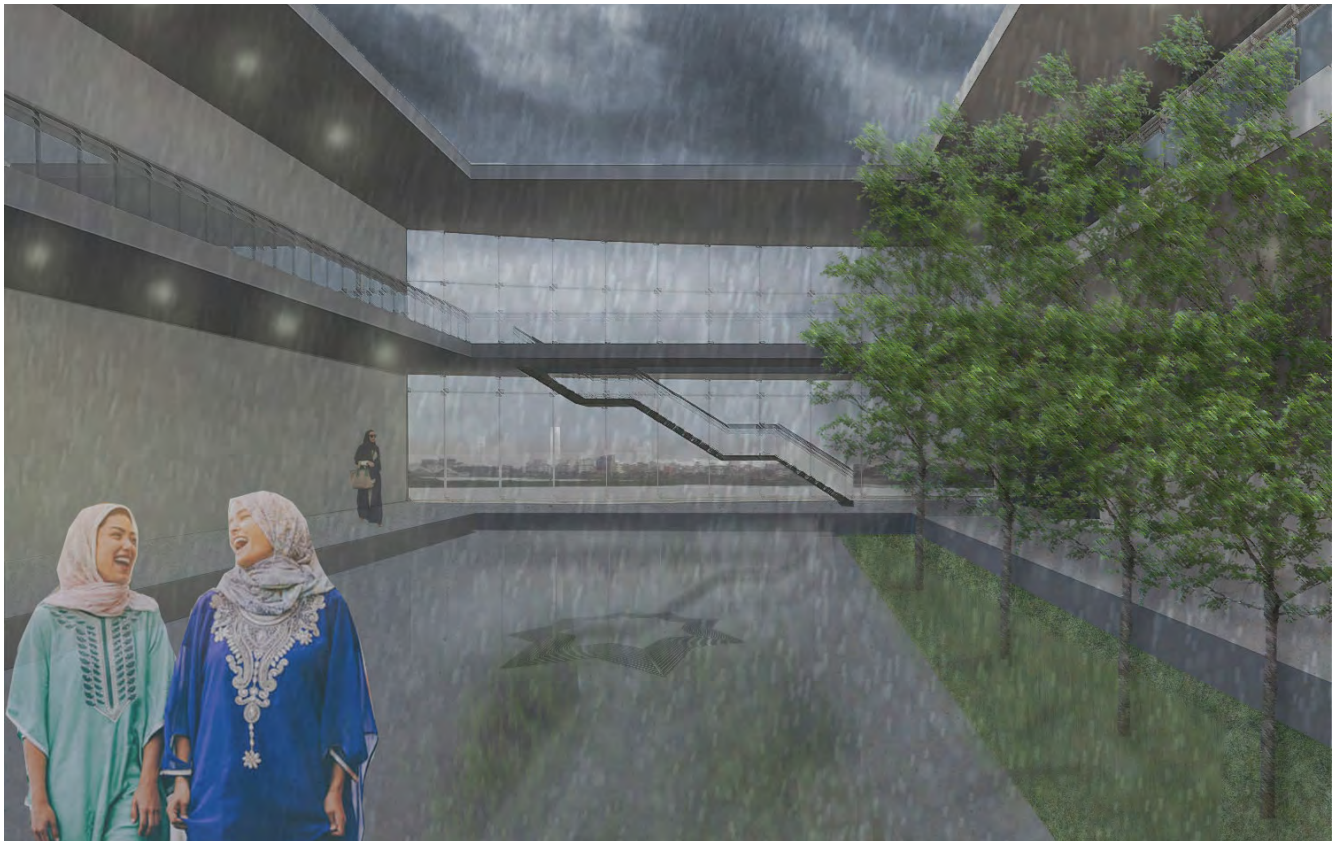


Figure 5.44: Mosque - Interior Courtyard

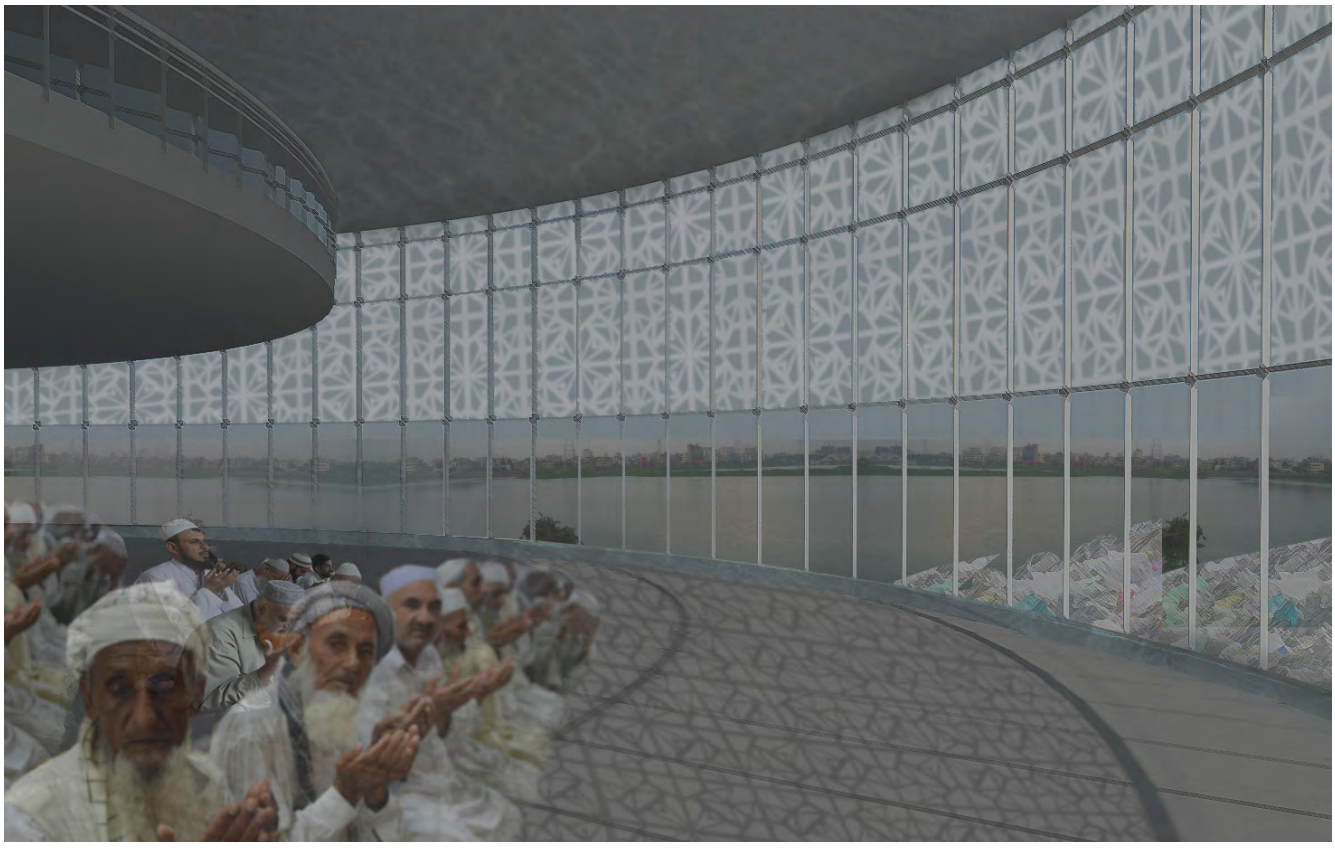


Figure 5.45: Mosque - Prayer Space

2. Large windows facing west (the direction that Muslims face to pray) will expose the building to the canal. A net (example shown in Figure 5.47) will be strategically placed along the canal to stop garbage from floating to the canal. This difference between the clean water and the impure water will be visible from the prayer space. The hope is to evoke people's awareness and consciousness about their actions and to show how the actions of a few can directly affect everyone in the community, in this case by robbing them of the purity and cleanliness they desire while praying. Everyday the net will be cleaned of the trapped garbage.

3. The ablution space outside the mosque will have a reverse water well covered by mulch and gravel. This will facilitate the seepage of water into the ground. Ablution (described earlier) is a necessary step before praying, and after people carry out this ritual, water will be returned to the ground.

4. The central courtyard will have an open roof to allow rain to fall freely inside the mosque. This will allow the people to enjoy the rain and to connect with rain while themselves being covered by a roof. An intricately designed drainage system in the courtyard will return this rainwater to the lake.

Figures 5.48 and 5.51 are plans of the design proposal. Figures 5.49, 5.50, 5.52, and 5.53 are details of the gutter and ablution space. Figure 5.54 is a section through the design proposal during wet seasons.

Figure 5.46: Carlo Scarpa's Palazzo Querini Stampalia in Venice. This building was designed to allow water into the building.

Figure 5.47: Trash trap used in San Juan River in Manila. Similar net will be proposed to be used in this design.

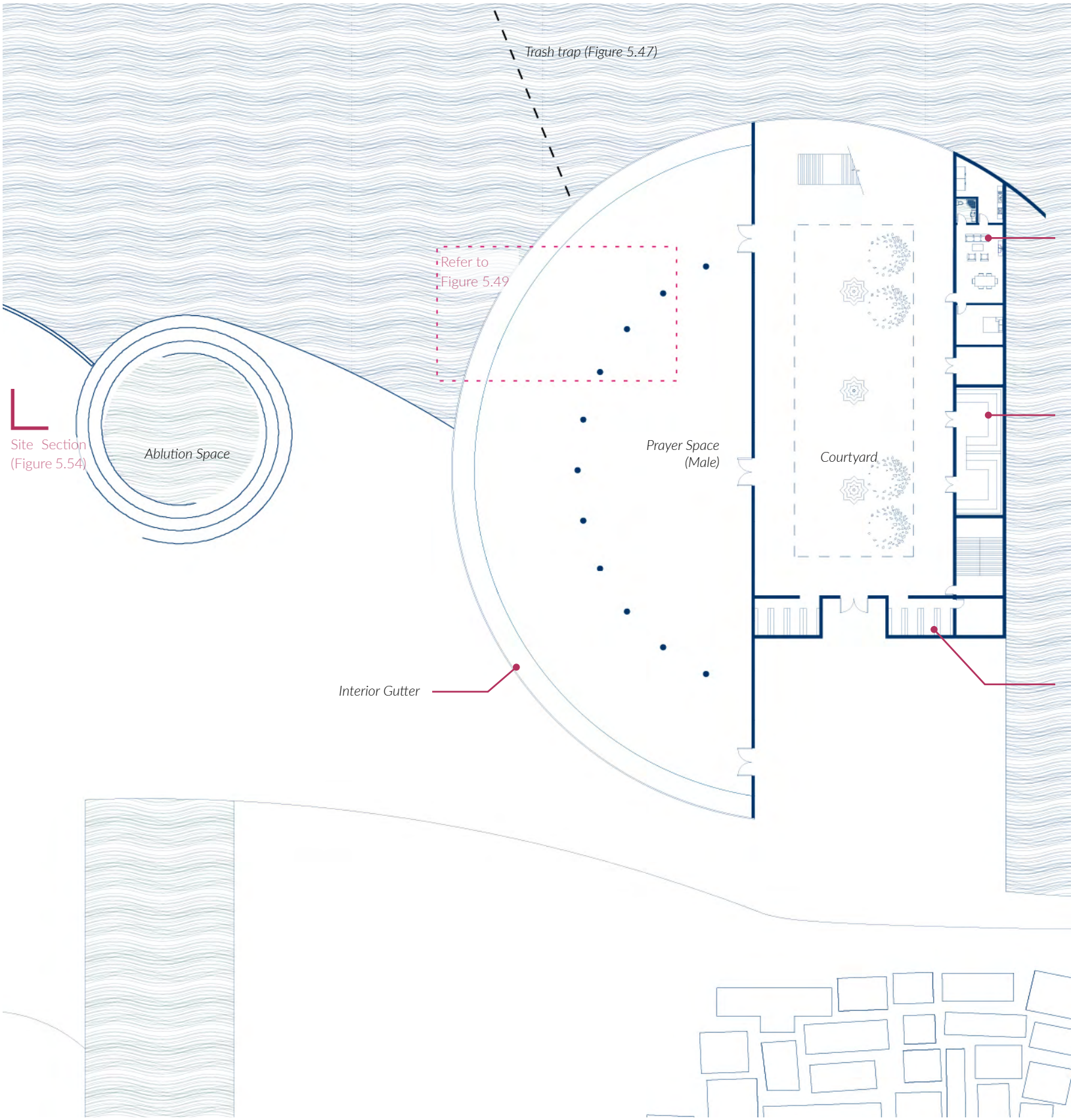
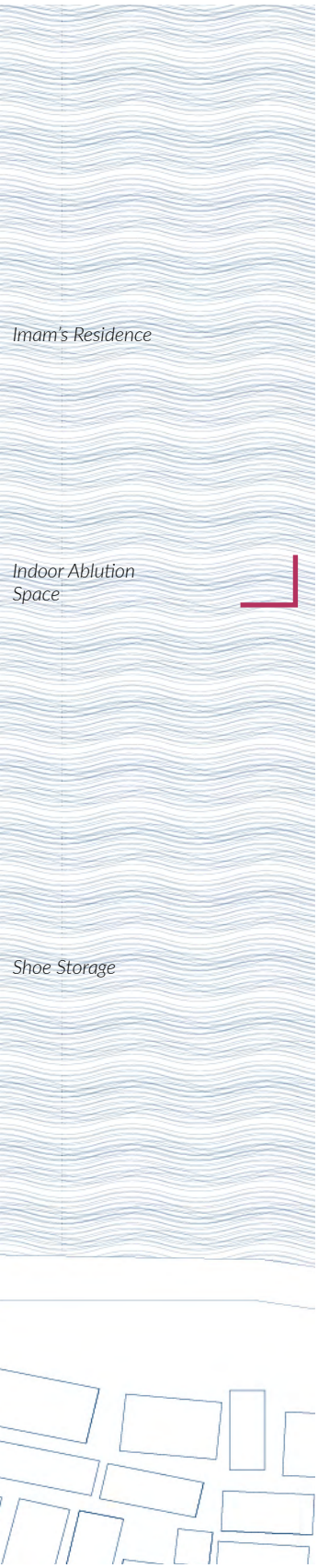


Figure 5.48: Ground floor plan - Mosque.



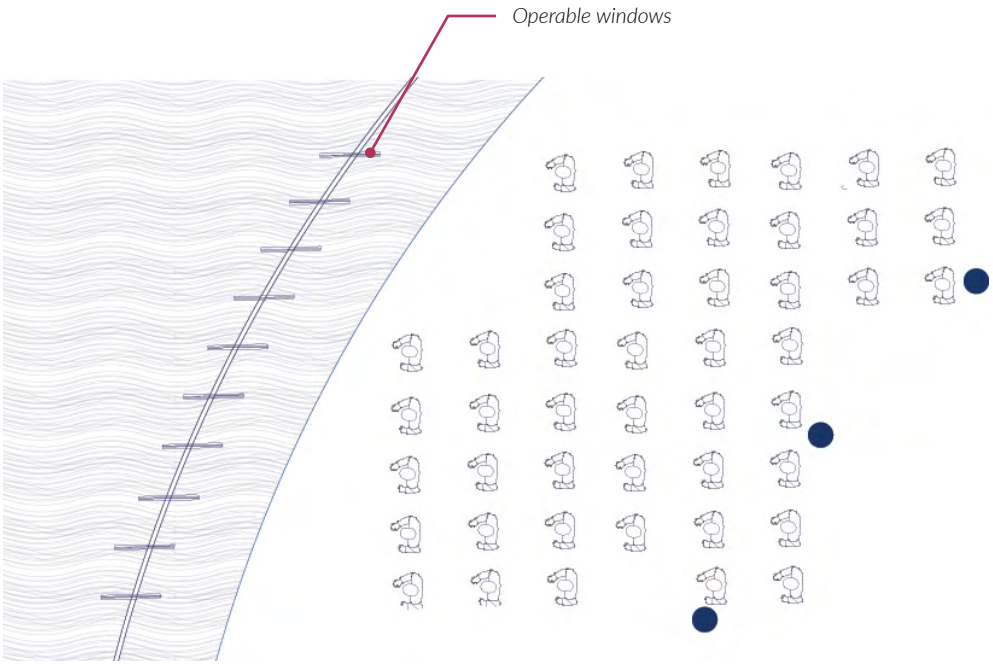


Figure 5.49: Operable windows allow water to come into the building and fill up the gutter surrounding the prayer space.

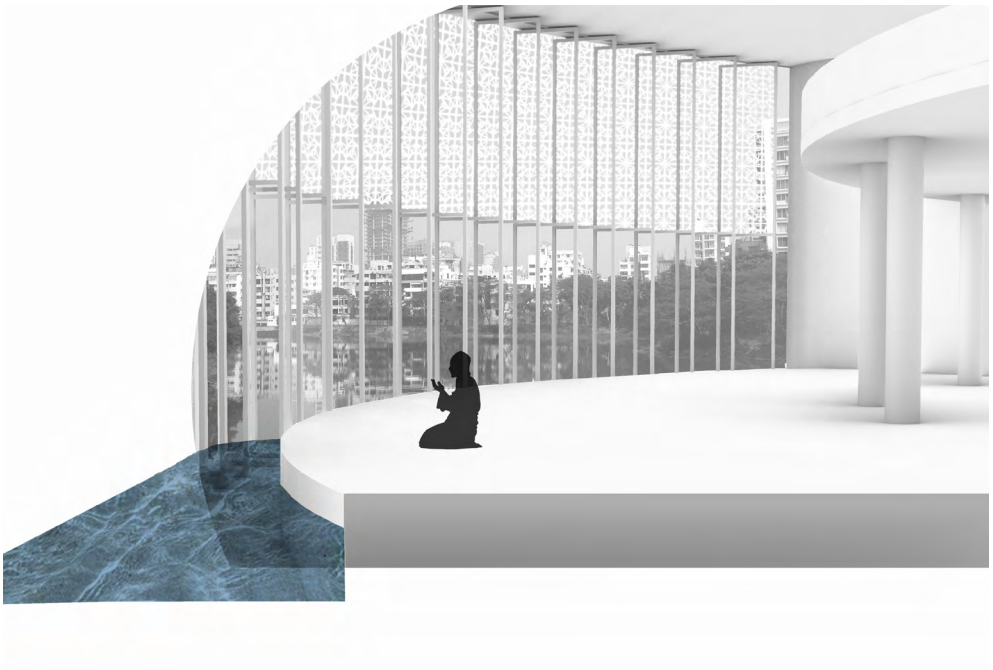


Figure 5.50: Operable windows allow water to come into the building and fill up the gutter surrounding the prayer space.

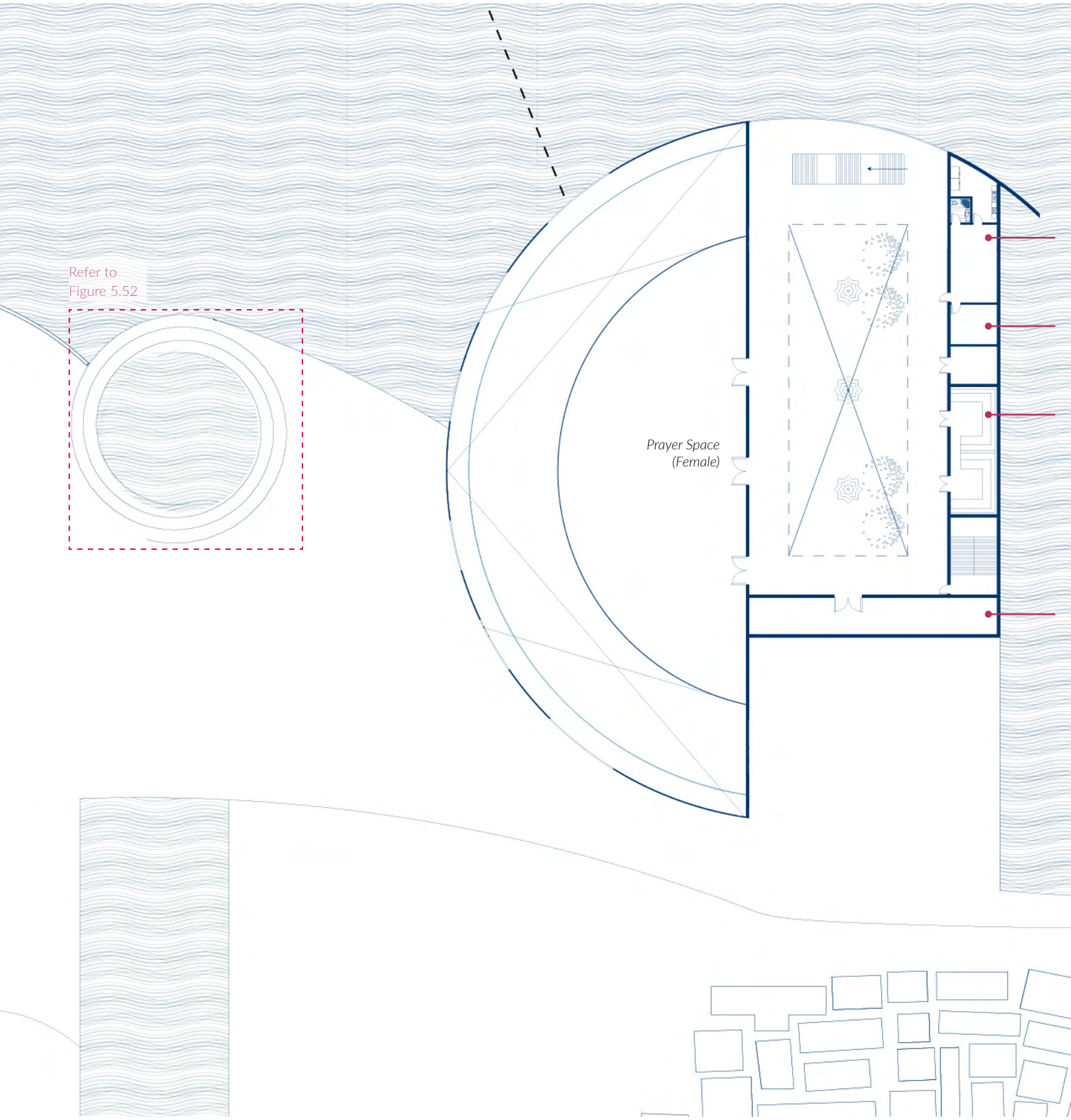
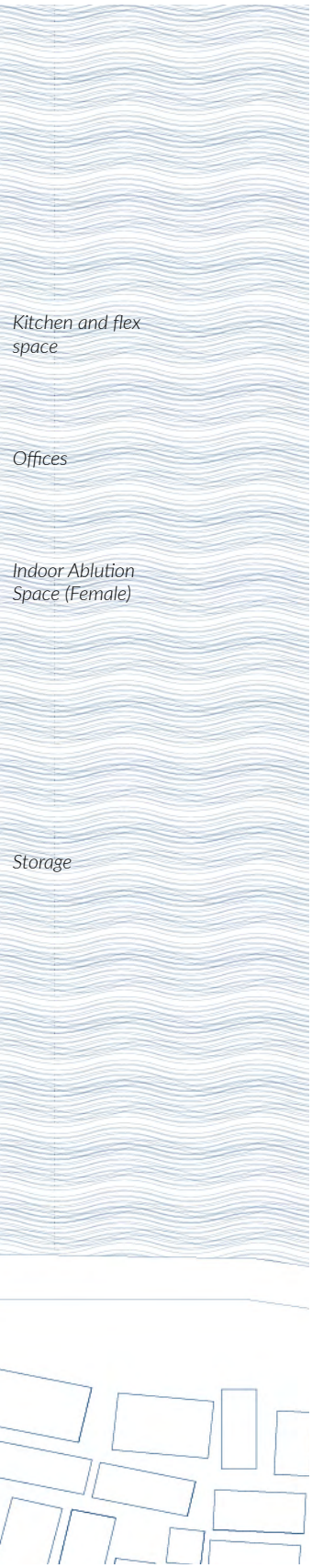


Figure 5.51: Second floor plan - Mosque.



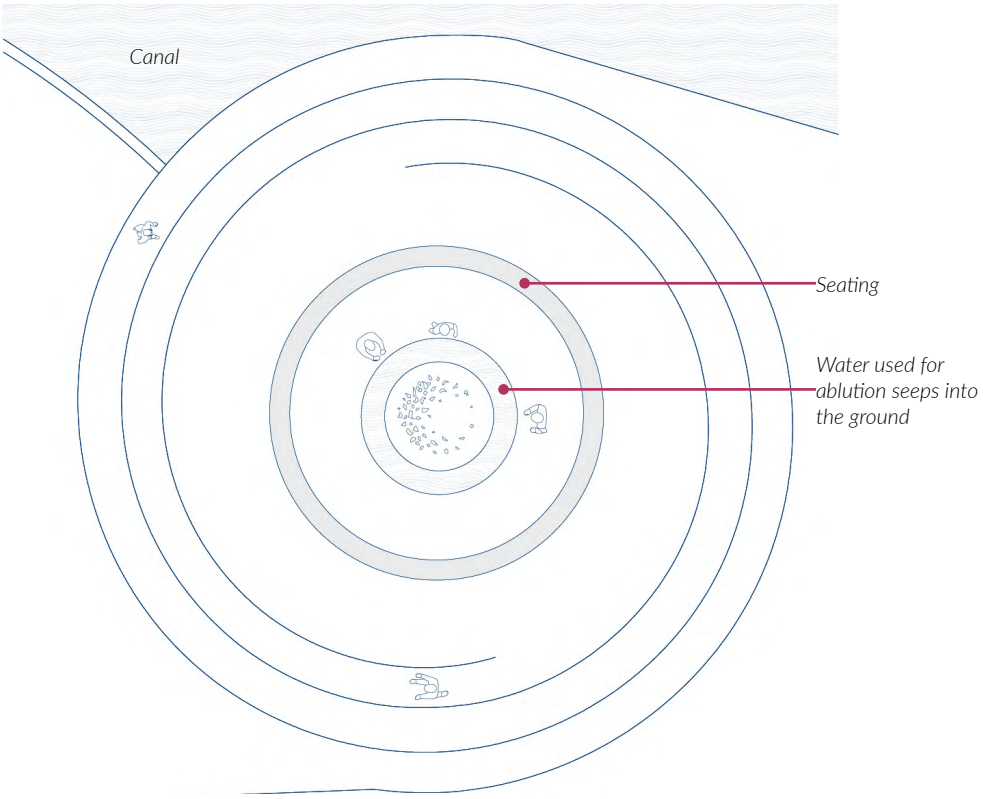


Figure 5.52: Outdoor ablution area.

Figure 5.53: View of the ablution space

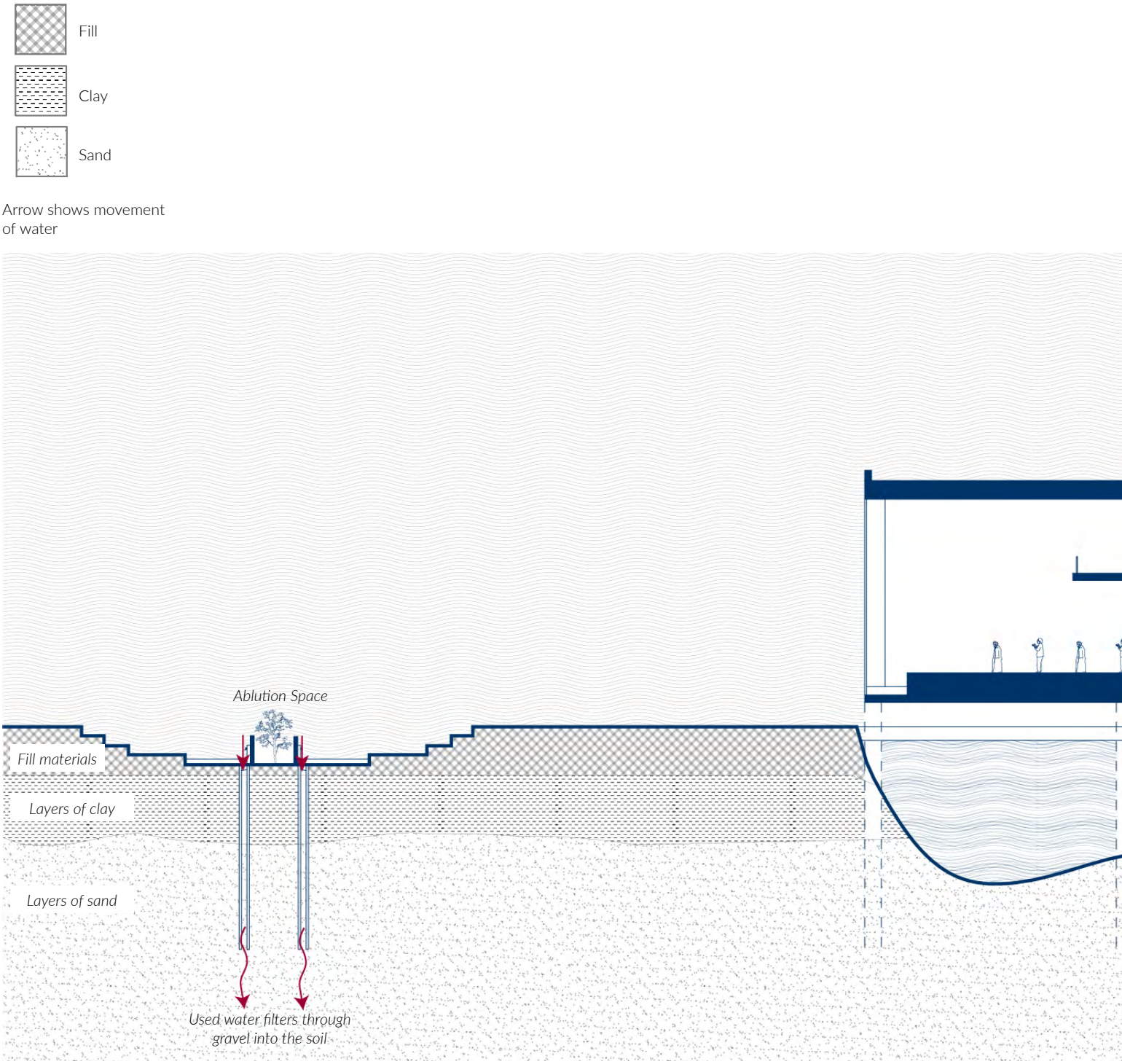
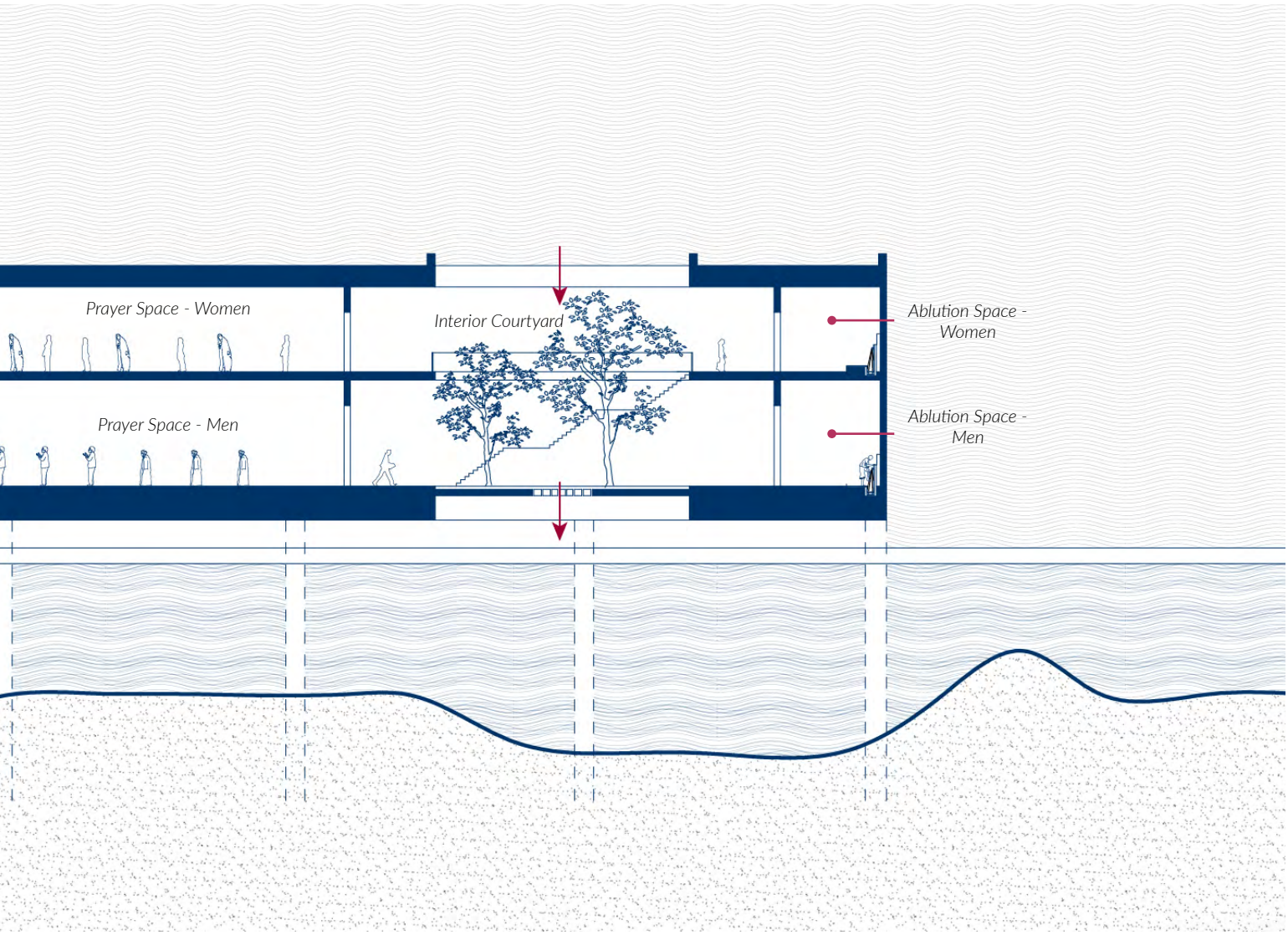


Figure 5.54: Section through the mosque (see Figure 5.20 for section marker).


Prayer Space - Women
Interior Courtyard
Ablution Space - Women
Prayer Space - Men
Ablution Space - Men

WATER RETENTION SUNKEN PLAZA

Figure 5.55 is a view of the sunken plaza. Figure 5.56 is the plan of the proposed plaza. Figures 5.57 - 5.59 are photographs and diagrams of the semi permeable pavers and rain garden currently in use in different existing projects. Figures 5.61 - 5.63 are sections through the sunken plaza.

Maidan is a South Asian term for a large, outdoor, public gathering space where various activities take place: parades, meetings, fairs, and prayers. A maidan is one of the inspirations for this space in addition to the precedents mentioned in Chapter 3. The water-retention plaza will replace the T&T playground. The square will retain most of the footprint of the playground so that the same activities can take place. In addition, the plaza will act as a water-retention basin during heavy rainfall. Recently the T&T playground lost its formal entrance. The only way to enter the playground is through holes in the walls (preventing the playground from being taken over by transports or being used as a dumping ground for construction materials, as can be seen in a nearby school shown in Figure 5.60). The design of the sunken plaza with its change in elevation will prevent access of vehicles to the square.

The current topsoil of the city is clay. Clay does not absorb water well. Below the layer of clay is sand. The sunken plaza will penetrate the clay and expose the sand. The ground will be lined with semi-permeable pavers so that water can slowly seep through the layers and make its way to the groundwater level.

Rain gardens surrounding the sunken plaza will also hold water during the monsoon and they will slowly release the water through their layers of plant roots, gravel, and mulch into the soil. Finally, the excess water in the sunken plaza will slowly drain into the canal through pumps.

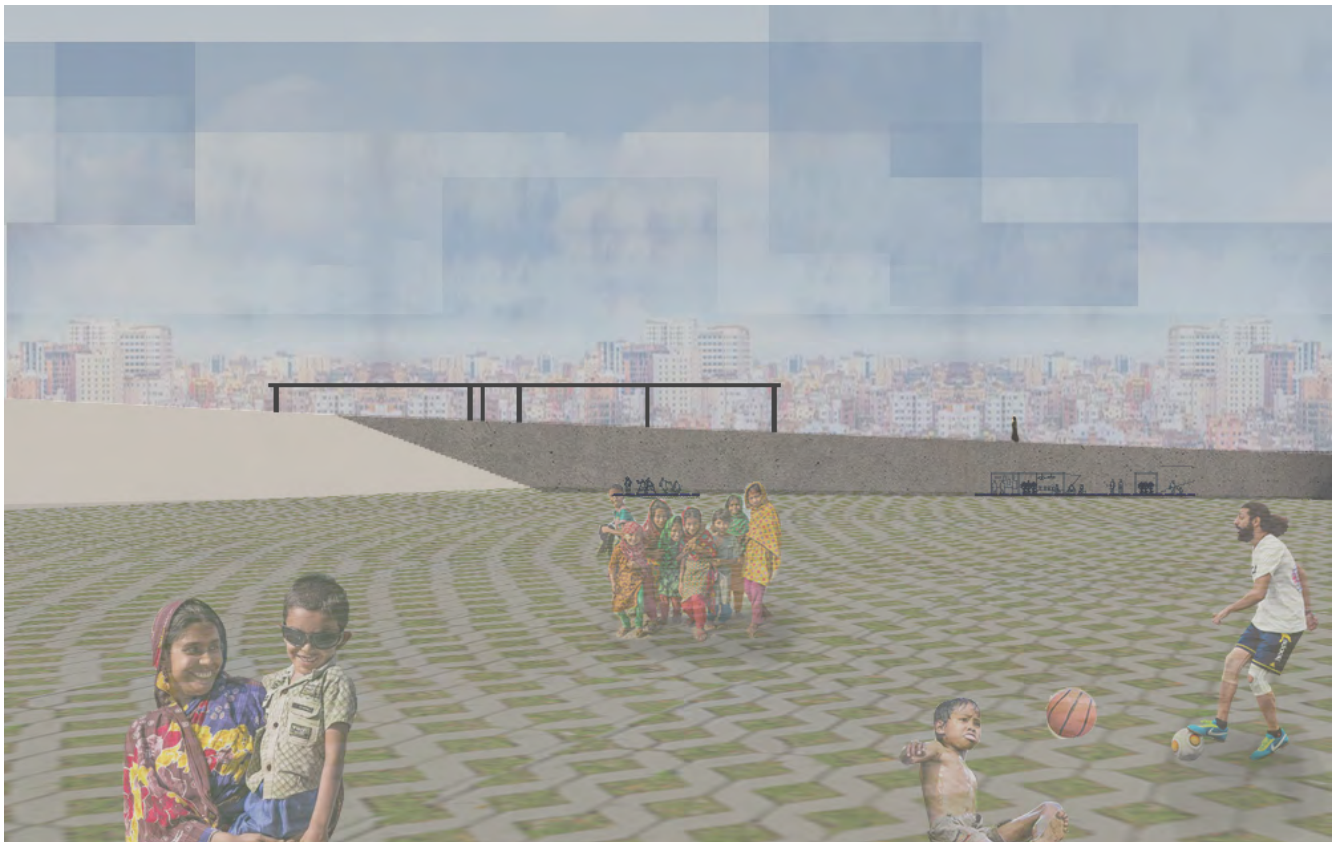


Figure 5.55: Maidan (Sunken Plaza).

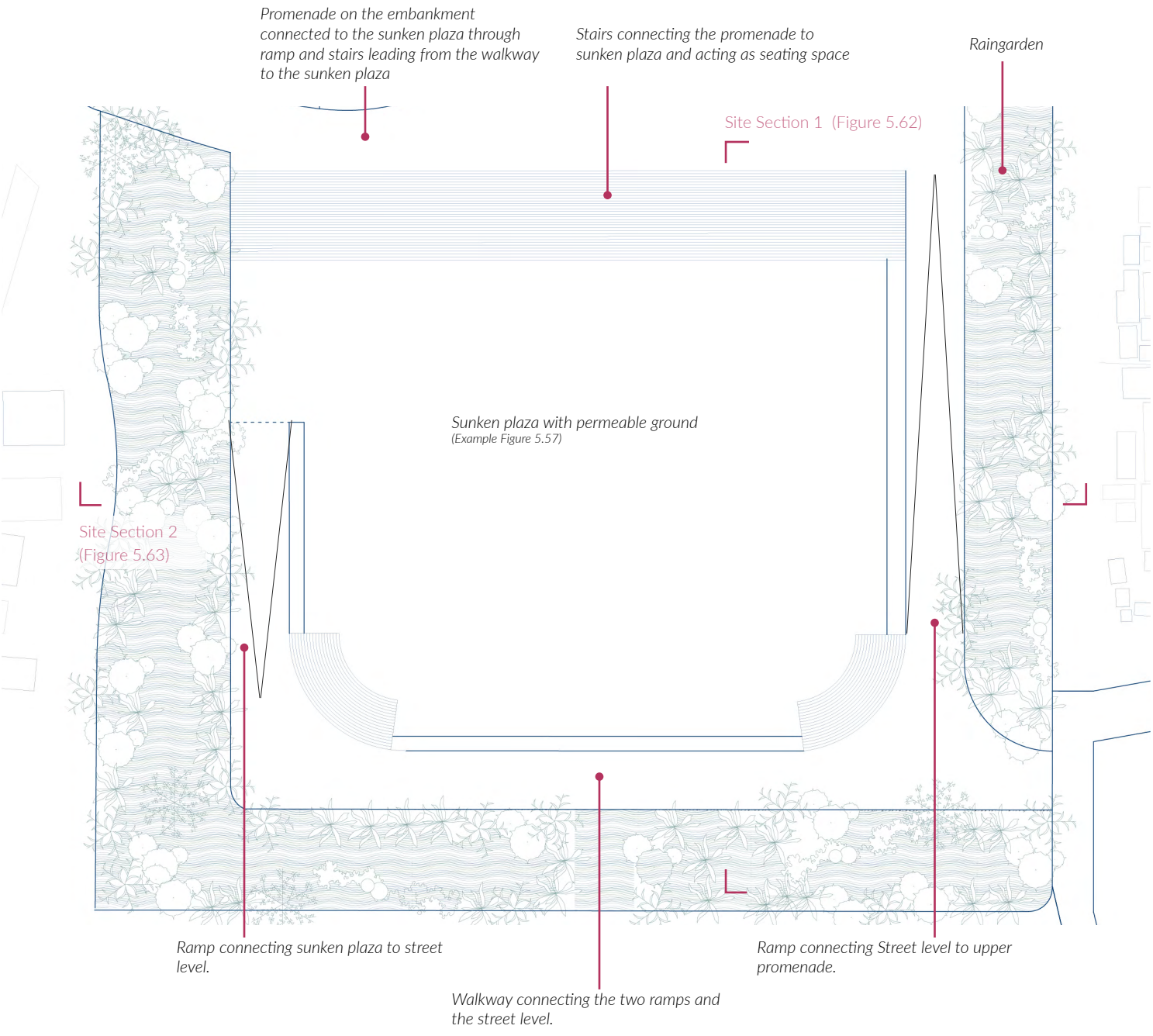


Figure 5.56: Plan - Sunken Plaza.

Figure 5.57: Permeable interlocking concrete pavers.

Figure 5.58: Raingarden.

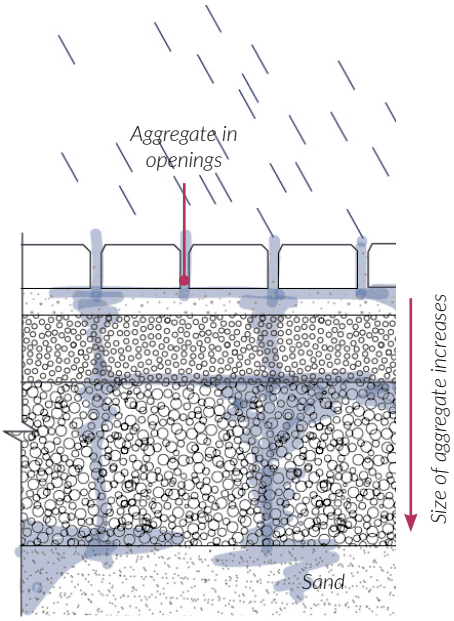
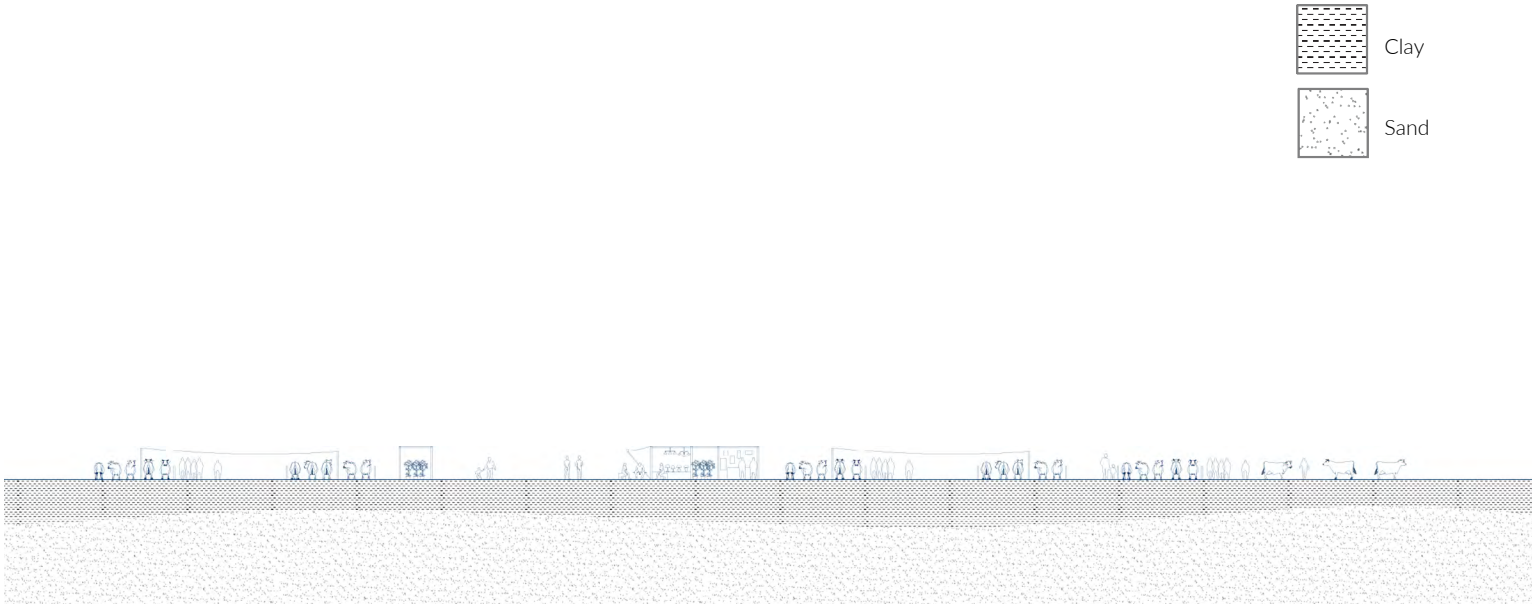


Figure 5.59: Layers in permeable pavers.

Figure 5.60: Construction material is seen to have taken over the school's playground.



Current Condition.

Removing the layers of clay exposes the sand for better absorption of water into the ground.

Figure 5.61: Soil layers before the introduction of the sunken plaza.

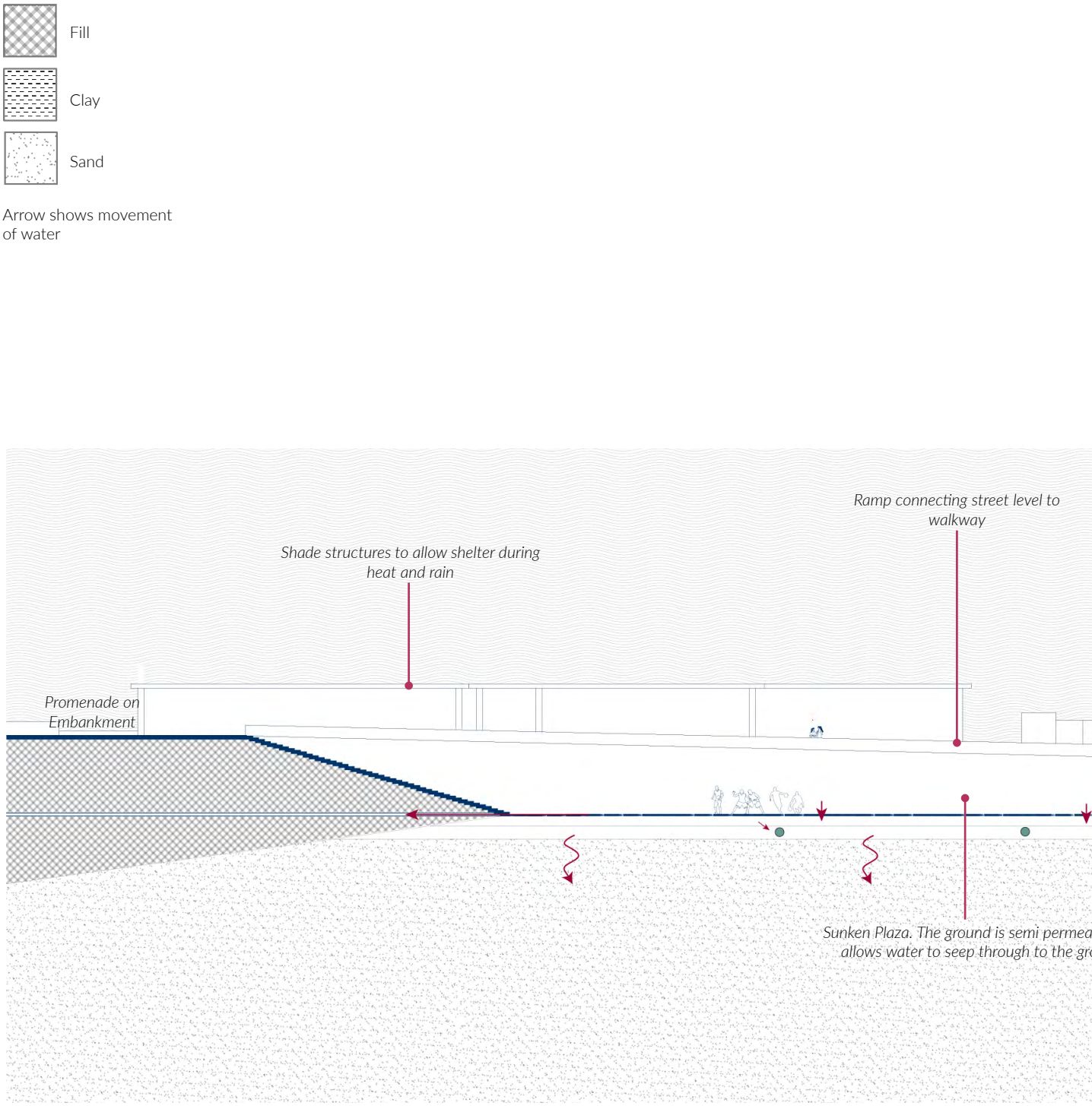
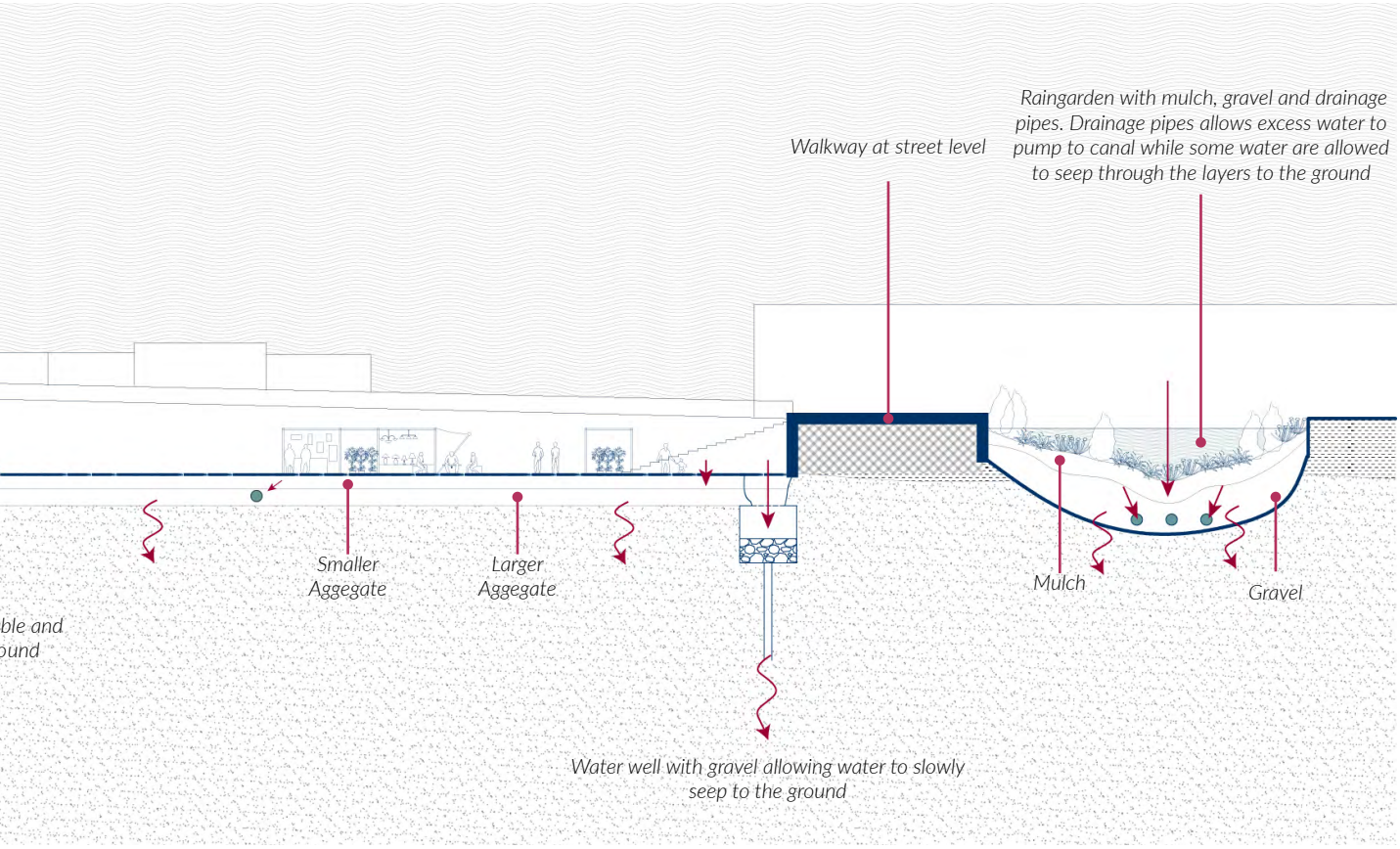


Figure 5.62: Section 1 - Sunken Plaza.


Walkway at street level
Raingarden with mulch, gravel and drainage pipes. Drainage pipes allows excess water to pump to canal while some water are allowed to seep through the layers to the ground
Smaller Aggegate
Larger Aggegate
Mulch
Gravel
ble and
ound
Water well with gravel allowing water to slowly seep to the ground

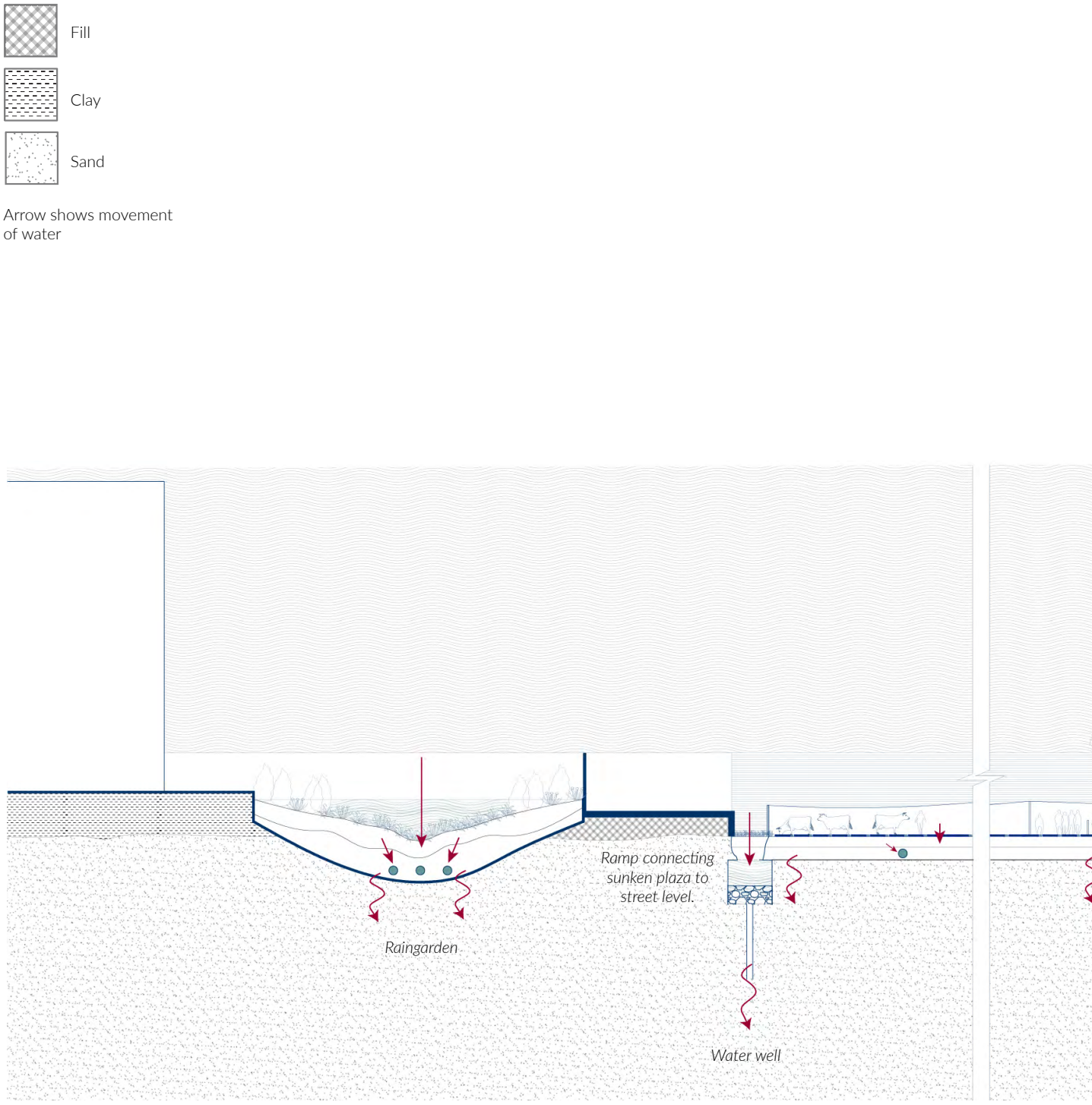
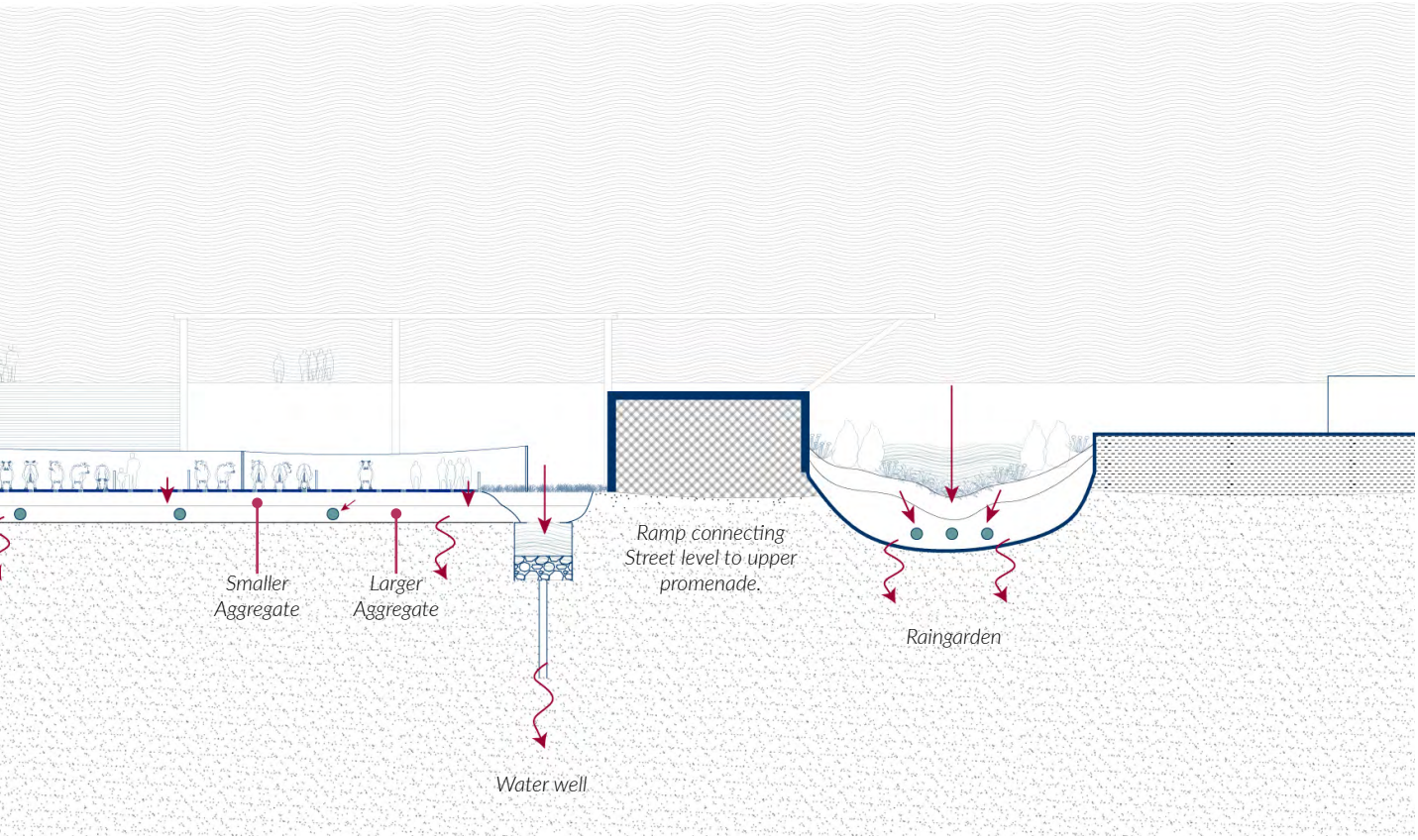


Figure 5.63: Section 2 - Sunken Plaza.


Smaller
Aggregate
Larger
Aggregate
Ramp connecting
Street level to upper
promenade.
Raingarden
Water well

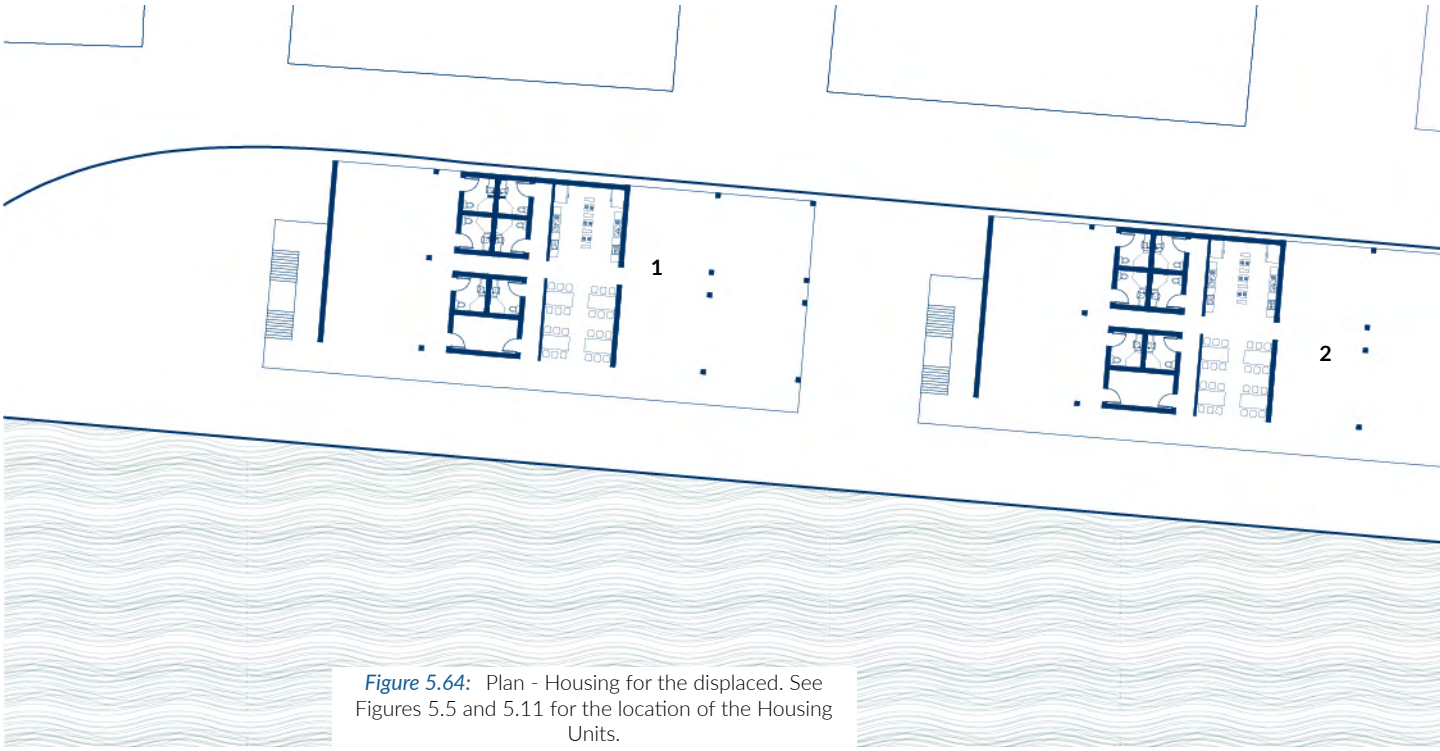


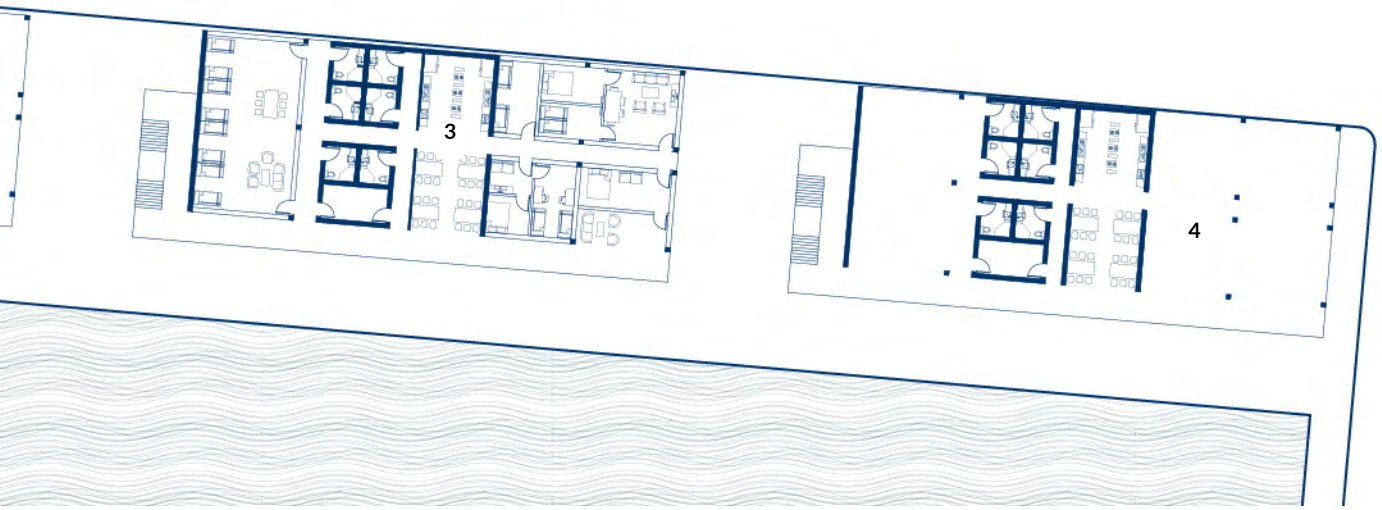
Figure 5.64: Plan - Housing for the displaced. See Figures 5.5 and 5.11 for the location of the Housing Units.

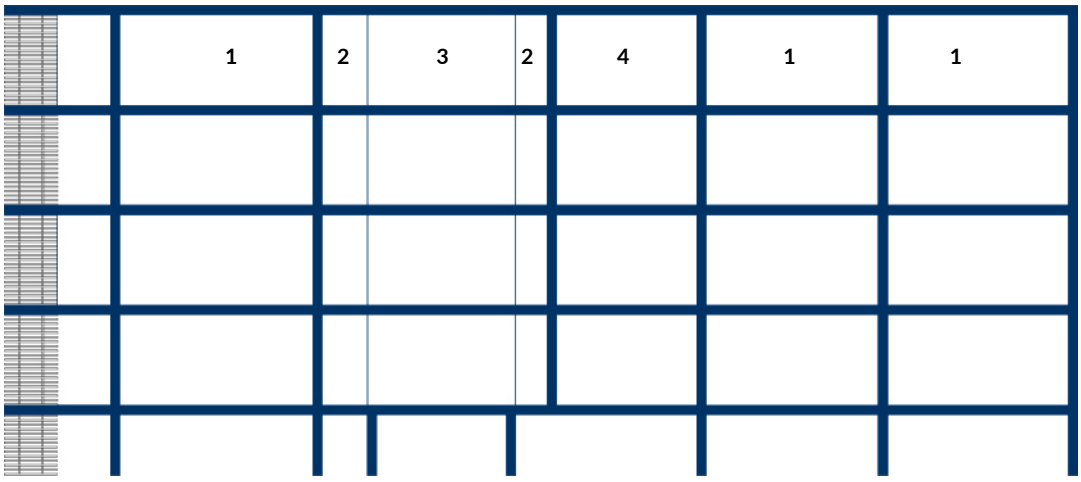
THE DISPLACED

While social housing for relocated residents is not the focus of this thesis, the thesis would be incomplete without a discussion about it. One option for housing is a semi-permanent structure on the edge of the canal. This structure will consist of floors and columns, and residents will be given materials (such as tin and bamboo) to build walls on the square footage they can afford (the proposal is for social housing, and as such, the hope is that it will be subsidized by the government). The housing structures will have already built kitchens, bathrooms, and shared space. This kind of housing is already prevalent in Bangladesh, and it is known as mess housing, in which several people share kitchens and bathrooms. Tin and bamboo on more solid structures can also be observed in many other parts of the city.

Diagrams 1, 2, and 4 in Figure 5.64 show the core structure, while diagram 3 shows variations that residents can achieve. Figure 5.65 is a section of one of the four proposed housing structures.

1,2,4-Half House
3-Variation of possible allocation of space





1 - Open space for rent
2 - Corridors
3 - Bathrooms
4 - Kitchen and common space

Figure 5.65: Section - Housing for the displaced.

6. CONCLUSION

Many agencies, architects, and the government have been trying to solve the concerns of flooding in Bangladesh. It is one of the biggest crises that Bangladeshis face every year, and people have been actively involved in the discussion and in implementing solutions. However, the problem persists, and therefore the debate and the search for the answer is ongoing. This thesis, "Poetics of Water," is another contribution to this continuing discussion.

A majority of this thesis is research about flooding and Dhaka in its urban, geological, and social context. The main objective behind these chapters was to view the different contexts as a whole to understand the problems and think about solutions. Another aspiration was to document the research in a comprehensive format so that it could be available to others looking for similar information.

The first big challenge faced at the beginning of the work was the inability to find information. Different government agencies in Bangladesh lack coordination and transparency. Many of the agencies have their websites, but they do not have much content. Sending requests for data is not always successful either: emails are not always answered, and phone calls end up in fruitless transfer from one to another. For example, during my research, searching for a 100-year flood map of the city resulted in a series of phone calls with no one having the answer or knowing who has the data.

Another limitation of gathering information was the lack of agreement between different sources regarding data. For example, the population[1] of Karail slum and the elevation[2] of Dhaka were inconsistent in different sources. In the end, the thesis chose to use the information that appeared to make the most sense based on the most reliable sources.

After exploration and analyzing the city, I studied different successful projects in other countries as well as attended a summer program at TU Delft in the Netherlands to learn more about flood mitigation designs and strategies.

1 For example, a survey by BRAC in 2014 estimated the number of residents to be around 55,000 people (Korail. 2014. http://www.brac.net/sites/default/files/factsheet/new/Korail.pdf). An article published by Dhaka Tribune in 2014 stated that the population of Karail was 78,000 people. (Abu Mahmud, "Karail slum dwellers fearing scarcity of drinking water," Dhaka Tribune, January 29, 2014)

2 See Topography and Soil Condition section on page 63 and beginning of page 64.

These are included in the thesis. They are helpful precedents that have heavily influenced the design proposal at the end of this work. However, the fact that they are located in different geographic locations and different cultural and economic contexts needs to be kept in mind.

The precedents considered in this thesis are located in North America, Europe, and Australia. The socio-economic conditions of these countries are different than those of Bangladesh. The primary religion of most people in Bangladesh is Islam. Their lifestyle is more conservative than the west due to Islamic influence as well as South Asian traditions. Women and men usually maintain physical distance between them, and public plazas are used with caution since these places are often unsafe, particularly for women and children. The economic disparity is also wide, and the different social classes do not mingle outside of necessity.

The most significant difference between the countries with the successful design precedents mentioned in the thesis and Bangladesh is possibly the country's governance. I have experienced that the government projects are improving. However, the level of coordination and transparency required for the tasks to be successful is not the same as the places mentioned above. There is still corruption in the process from design to construction, and political loyalty and influence of different agencies interfere with the successful completion of the projects.

At the "Planning and Design with Water" program at Delft, the coordinator had mentioned that "Bangladesh is the Netherlands of the East"[3]. The message from the program was that the Netherlands has the money and the knowledge to research flood mitigation, and they wanted to share their findings so different countries could help themselves. While the intention is beneficial, before adapting any strategies from other countries, the difference in socio-economic structures as well as the geography and geology of each country should be kept in mind.

3 Roberto Rocco, "Planning and Design with Water," Department of Urbanism, TU Delft, July 20, 2018.

The final part of my thesis is a design proposal. The proposal has several aspirations. It also has limitations and challenges. The main limitation arises from what the thesis discusses at the beginning of the essay – the problems with embankments. I acknowledge that building a levee is not the best solution to the problem of flooding. The western embankment in the city has caused the problem of waterlogging in the city. The ambition behind the proposal for the embankment was to increase the capacity of the canal to hold stormwater during heavy rainfall. Given the density of the city and the frequent flooding it faces, the primary objective was to increase the stormwater retention capacity of the city without causing too much relocation. Building an embankment around a continuous canal that would connect the city to the rivers surrounding it appeared as one of the options.

The embankment comes with its limitation. First, it creates a boundary between the canal and the people. Previously it has been discussed how the embankment would connect the people to the canal. However, here I also acknowledge that the embankment will create a boundary at the ground level between the city and the water. The other more considerable limitation is perhaps the chance that the embankment might fail. If there is a break in the levee during a flood event, the city will flood. The longer the embankment takes to fail, the higher the risk to the society. Currently, the people in Dhaka are accustomed to flooding. If the city does not experience flooding for a few years, people will slowly get acclimated to the new life, and suddenly, when it floods, the effects will be more disastrous for human life and urban fabric.

The second biggest challenge of the proposal is that the success of the design depends on the proper functioning of the pump system. When it rains all over the city, the pumps located around the canal must drain the water into the canal. One of the reasons the western embankment built in 1988 has not been successful is the poor maintenance of the pumps and sluices located around the embankment. Dhaka has a history of its pumps failing; thus, depending on pumps to drain out the water may pose challenges.

Dhaka is changing. More people are becoming conscious and educated. People are keeping the city clean now and becoming aware of their actions. I visit Dhaka every December, and every year I see a better Dhaka. The streets are more hygienic than before. The people are more conscious of their city. The mayor of the city has been doing an excellent job of improving the city. The pumps and the sluices had failed in the past because of human action, but human activity is changing now, and the people are learning.

An example of a recent successful project by the city is the Hatirjheel Lake project (Figure 5.66). The location of the Hatirjheel Lake is outlined in Figure 2.1. The project was designed and coordinated by a few different firms and consultants in Dhaka and executed by the Bangladesh Army. The Hatirjheel project is a wetland restoration project intended to protect the city from rain-fed flash floods as well as to restore the waterfront of the city to the people. It takes up a large part of the city, and it is always kept clean and beautiful. A series of roadways and bridges crosses along and across the project, and the design also features public walkways, amphitheaters, and restaurants along the lake. The views from the elevated roadways and the bridges are always beautiful. It is currently one of the few places that people enjoy as an open outdoor space. The water in the lake is clean, and the public areas are well used.

The Hatirjheel project shows that keeping the pumps and the proposed project functional and well maintained is possible. The challenge that would

Figure 6.66: Aerial view of the Hatirjheel Lake project in Dhaka.

be unique to the site I chose is the 50,000 people living in an informal settlement in the periphery of the project, but that is the reason this site was chosen. The economically deprived people in the society need facilities such as the bath and the mosque and the public plaza more. This brings me to the final point in the discussion regarding the limitation of the design proposal – the behavior of the people.

The design proposal in the thesis is ambitious about the social interactions that will take place at the site. The whole design is driven by different cultural and social needs, and the actions of the people and the elements are placed to increase the interaction between the different social classes.

The three main architectural elements in the final chapter of the thesis are all public buildings. The mosque, the bath, and the sunken plaza are all places for social and religious gatherings. The reasons for choosing the T&T playground as the main site for the design has been discussed in depth in the thesis. The aim of bringing together different social classes might have different success in the different elements. The bath would probably be the place with the least success in bringing together the different classes of people using them. The lifestyle disparity between the poor and the middle-income people is wide. The people living in the informal housing are going to benefit from the bath and the community center – since they often bath in the alleyways with no privacy or proper facilities. People living in proper housing, however, will probably not chose to go to the bath. They have their running water and privacy and will not use the bath to cleanse themselves. While the bath may not bring together people of different social classes, it is still going to provide a clean, safe, private environment for people to bath, socialize and enjoy themselves while having access to clean water. In this, I see the success of the bath.

The part of the design that I see to be most successful in bringing everyone together is the mosque. A middle-income person may not go to a bath with his driver, but they will pray together. Dhaka is often called the “City of Mosques”, and five times a day, there are prayers in the mosques. Furthermore, everyone prays together in the mosques forgetting their economic and social disparities. As seen with recent projects, the sunken plaza will also likely be used by everyone without social distinction coming in the way of its usage. In recent times, more people in Dhaka have become conscious about the social inequality that exists in the city and are consciously trying to bridge the gap as a society as well as through individual actions.

This thesis mentions several flood mitigation strategies and some would be more successful than others in creating a resilient city. The embankment would perhaps be the least resilient of all. The proposed embankment around the canal is one of the ways for protecting the city, given its current density and urban fabric.

Other ways to approach the issue of flooding would be to improve and expand the current pumps and sluices on the western embankment so that they are functional in pumping out the water into the surrounding rivers. Breaking down all the embankments altogether would be an interesting proposal to look at as well. Breaking down barriers cancels the risk that they will fail or the need to rely on pumps and sluices. Breaking down the embankment would open new ways to view the issue of flood mitigation. One of the ways to look at it might be to increase the water retention capacity of the city by creating or restoring a lot more wetlands, water retention basins, and permeable ground. With each proposal comes new sets of problems. Trying to increase wetlands and public basins would be difficult in a dense city like Dhaka, with few empty spaces and a need for more land for human settlements. Still, every method is worth discussing and analyzing and in the end, everyone could be working together to come up with the best solution for the city.

The design proposed in this thesis is an imaginative response to bringing people closer to water. The numbers used in the design are not absolute, correct numbers – they are there to represent an idea and to give it some form of clarity and practicality. The design would be significantly improved by input from experts, people with knowledge on technology, engineers, and the people of Dhaka.

In Dhaka, people go on with their lives in rain, in water up to their knees, in water filling up the stores. Water is still everywhere in Dhaka. This thesis questions how water should be present in the city. It aims to bring water to people, water to the earth, and people to the water.

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