Reviving the pond-based blue-Infrastructure of the age-old city Cumilla through conservation and typological development.

Submitted by

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Master Thesis

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Advisors

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1. Abstract

Water was the center of civilization. The oldest settlements that we know of today were built around water sources. With the increased urbanization, these water sources are now under threat due to land shortage within cities.
Comilla is an old historic town built at the bank of the Gomoti River. Many eras had left their shreds of evidence through various artifacts. Few of these artifacts are Ponds (Pukur, Dighis) scattered around and deeply integrated within the city's urban fabric. These historically rich pieces of nature are contained to facilitate us with our cultural, religious, economic, and other day-to-day needs. The density of these ponds' scatteredness in the city of Comilla is surprisingly higher than any other city (more than 100). This fact alone is enough to preserve these water bodies from extinction. This unrecognized image of the city is losing its value. Unplanned city development resulted in a grey city where there is no breathable space. Pollution and densely built buildings now also face adverse effects of Global warming. Heat urban effect and flooding in monsoon is getting bigger of a problem every year. Public well-being is at a threat as there are not enough public open spaces. Existing open spaces are exhausted by overpopulation and cannot perform appropriately in terms of function and ecosystem services. Urban biodiversity is decreasing because of losing habitats.
In this thesis, I have tried to investigate the existing Blue-Green-Infrastructure and people's opinions about these natural elements. The city's blue infrastructures, especially the ponds, hold the solution to a resilient future city. With the placemaking concept, I tried to transform these water bodies into active open spaces where people can experience nature and interact with it more extensively on both community-scale and city scale. Thus, the reviving the title "Blue city Cumilla" through preserving urban wetlands with various design suggestions.

Keywords: Ponds, Pukur, Dighi, Blue-Green-Infrastructure, Sponge city, Urban resilience, Landmark, Placemaking.

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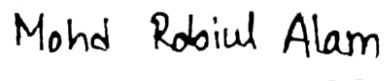
Mohd Robiul Alam



3. Declaration of authorship

I certify that the material contained in this Master Thesis is my own work and does not contain unacknowledged work of others.

1. Where I have consulted the published work of others this is always clearly attributed.
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3. This dissertation has not been submitted for the award of any other degree or diploma in any other institution.

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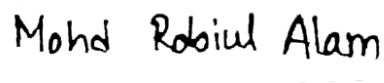

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1. Introduction

1.1.Dighi, Pukur and the city Cumilla

Dighi (equivalent to a pond) is a water body with a particular area and depth criteria depending on its function. The RAMSER convention has defined wetlands as “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.”(Eklund, n.d.). This definition puts Dighi and Pukur in the convention but does not define it as a more cultural element. Dighi means a deep and sizeable stagnant water body that has been dug for a particular purpose. The larger of these bodies are called Dighi, while a smaller version of Dighi is called Pukur (Ameen, 2020). Most of these are human-made, while others were shaped from their previous natural formations. Whether human-made or natural, they are now part of our rich culture. Bangladesh is an agricultural floodplain with a tropical savanna climate that contributes to a substantial yearly rainfall that flows through more than 405 (BWDB, 2011) of rivers and their distributaries along their way to the Bay of Bengal enriching the whole land depositing silts, and keeping the soil moist. The modern world is transforming our surroundings with modern solutions. Thus, old needs and meanings are also changing. While most of the Dighis are serving their purpose in the sub-urban areas and villages, urban water bodies are losing their purpose. Unplanned urbanization made a lot of these disappear.

Nevertheless, whatever purpose they were made, now they are part of more important things which are not readily perceivable. They are intertwined with culture, history, ecology, environment, and many other aspects of a city. Conserving them with concern to all these factors will be the crucial move towards a rich, healthy, and a sustainable future city

Age-old city Cumilla with all its historical glory has another and most unrecognized feature. Its water bodies. Cumilla city, with its urban sprawl, has a surprising number of Pukur, Dighis, dead river bend, and other water bodies inbred within. These are part of the city’s Blue-Infrastructure and providing ecological services to the city.

1.2.Problems, Challenges, and Necessity

However, no matter how rich the cityscape is with water bodies, continuous unplanned development raised more land within the vicinity. Insensibility towards the city’s environmental features and mass unawareness, people are filling up these water bodies. Then there is political and public greed. Deposition of domestic waste and surface water contamination is the most common form of water pollution. While some of the rainwater run-off blends with these water bodies contaminating the water, most of the stormwater goes to sewage, and thus groundwater recharge is at threat. The city has many landmarks and urban hotspots which are exhausted due to serving the larger population with less than adequate area and features. Every cultural event and other public conglomerations are now a public hazard. Dense urban growth gave away no space to breathe in for the city dwellers. So, the few open spaces that the city still has been trampled by thousands of people beyond their capacity. But these Dighis are the only open spaces within this

concrete jungle that have an unlimited opportunity. However, due to delaying authority and lack of public awareness, these potential urban features are becoming a burden.

1.3.Current Situation

Although these water bodies are protected under Bangladesh Water Act 2013, Ramsar Convention 1971 and, Bangladesh environmental protection act(revised) 2010, The Bangladesh megacity, Divisional Town and Municipal Areas of District Town and The Country's All the Municipal Area's Playground, Open Space, Garden(park) and natural water reservoir Conservation Act, 2000; There are no clear guidelines how to implement these protections. Thus, the number of these historically rich and important landmarks is diminishing in number.

Many campaigns and volunteering efforts have been seen in previous years to preserve these urban features. However, due to insufficient research and data, their claims do not get proper ground for discussion. Complex access to information systems and inadequate public information databases is another reason for these responsible townsfolks failing in their campaign and public ignorance.

1.4.Scopes

Conservation, preservation, and restoration of these Urban wetland features will improve the city's ecology and, in succession, macroclimate. Wetlands are the most productive ecosystems, and countless species of plants and animals depend on them for survival. They support a high concentration of fishes, amphibians, reptiles, birds, mammals, and invertebrate species (Khan et al. 1994). Opening up the potential of these water features as urban open spaces will improve the city dwellers' physical well-being, and it is essential for their mental health. A well-designed solution will activate the city's blue-infrastructure creating opportunities, connect people to culture and history, and add up to the sustainability of the city of the future. Summing up all, creating a new identity to the age-old city of Cumilla.

1.5.Methodology

My hypothesis and finding its solution requires an inductive method to form a new solution that rises from the context based on the analysis.

First, a thorough literature review is conducted. I explored the theories of blue-green infrastructure, urban ecology, wetland dynamics, open spaces, and public well-being from published media in the form of journals, research papers, theses, magazines, news articles, books, documentaries, reports, Information from Govt. documents, websites, NGOs and other organizations. After creating a basis, I studied and summarised two case studies. The literature reviews and case studies helped me to devise a roadmap for the thesis further. These previous steps defined which type of data I needed and which questions I needed to ask. Both primary and secondary data are used to analyze the site, and a simple random sampling is used for the questionnaire survey. For the analysis, a combined qualitative and quantitative method is conducted after the analysis results are discussed, which laid the foundation for my design solution.

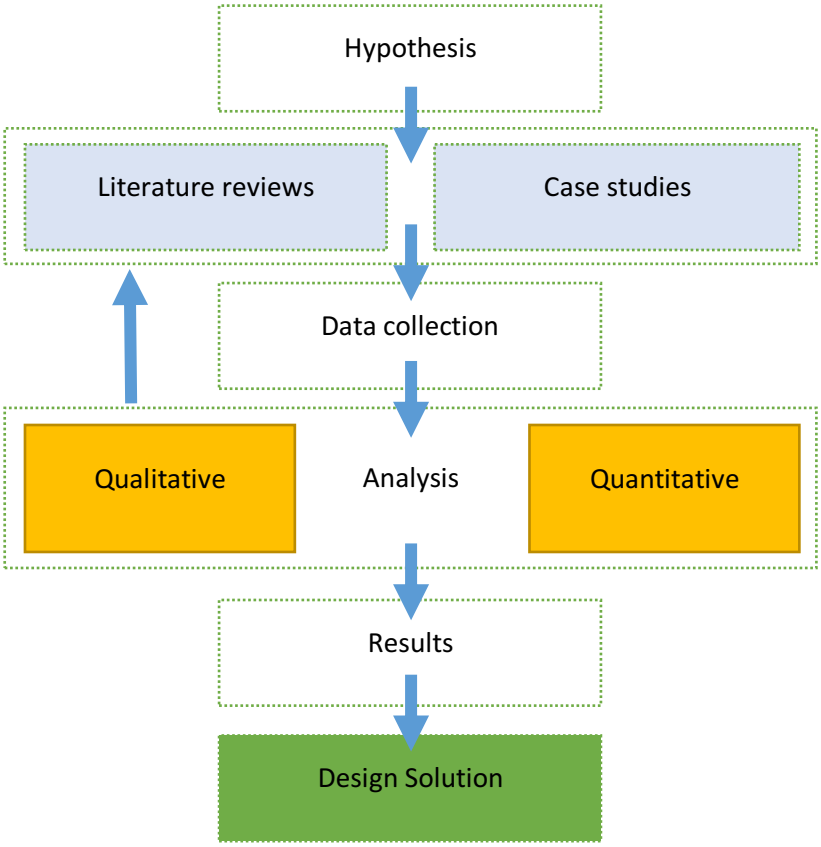


Figure 1.1:Methodology Diagram

2. Literature Review

2.1.Blue-green infrastructure

According to the Environment Directorate General of the European Commission

"Green Infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. This network of green (land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life. It also supports a green economy, creates job opportunities and enhances biodiversity."(*Ecosystem Services and Green Infrastructure*, n.d.).

Apart from the European Union, Green-blue infrastructure (GBI) is becoming more of a buzzword in the current urban design language. Landscape architects, urban planners, urban ecologists are now testing the possibilities of green elements in the cities to regulate urban climate, city environment, and public well-being. Blue-green infrastructure is a network of natural and near-natural urban forms that directly affect the urban environment's quality. BGI elements in the city include

Parks
Rivers
Street trees
Gardens
Rain gardens
Hedgerows
Downspouts
Urban woodlands
Multifunctional farming
Wildlife overpass
Green alleys
Seedbed
Fish ladder
Beehives
Biodiversity-rich greens
Green walls
Green roofs
Blue roofs
Low-impact development (LID)
Protected wetlands
Ponds
Bioswales

2.2.Blue Infrastructure

Water is the element of life. It surrounds us, it is part of us, and almost everything regulates around water. Civilizations have been built around water sources. Cultures and religions are based on them. Water delivered every necessity we can ask for. Over time this relation became thinner as we moved to a more industrial framework thus detaching ourselves from nature and fragmenting these natural elements. These cities' fragmented water elements still work as blue infrastructure and provide their ecosystem services, but they lack efficiency.

Urban blue infrastructure denotes the water elements, like rivers, canals, ponds, wetlands, floodplains, water treatment facilities in the city, and effective utilization of this system with the city green network creates the green-blue infrastructure (GBI) system. Well-maintained interconnected Blue infrastructures with their full potential will contribute to the city climate by evaporation, air filtration, rainwater retention, groundwater recharge, biodiversity, and human health. Sealed hard surfaces that reflect heat to the atmosphere and stop water from infiltrating to the ground are the main culprit of the Urban Heat Island effect (UHI). On the other hand, the city's blue elements can do the opposite and create a harmonic scenic urban living providing ecosystem services in the background. Water is the element of life, and in an urban setting, water creates an oasis for the small biodiversity a city has.

Blue infrastructure is almost a new concept related to green infrastructure. As awareness rises in the professional field, people become more interested in blue and blue-green infrastructure for climatic adaptation.

Ecosystem services provided by BI include

Reduce flooding

Replenish drinking water

Recharge of groundwater

Filter waste and improve water quality

Improve urban air quality

Source of employment

Heat absorption

Biodiversity

Recreation and human well-being

2.3.Ecosystem Services

Ecosystem services is a new widely used term used formerly as Environmental services, coined in the 1970 report of the Study of Critical Environmental Problems 1970. Man's Impact on the Global Environment. MIT Press, Cambridge. 319pp)
Ecosystem services are the goods and services provided by temperature regulation, air quality regulation, stormwater run-off mitigation, noise reduction, recreation, and so on.

As listed in Millennium Ecosystem Assessment, 2005, this diagram shows the fields and the varieties of ecosystem services concerning public well-being.

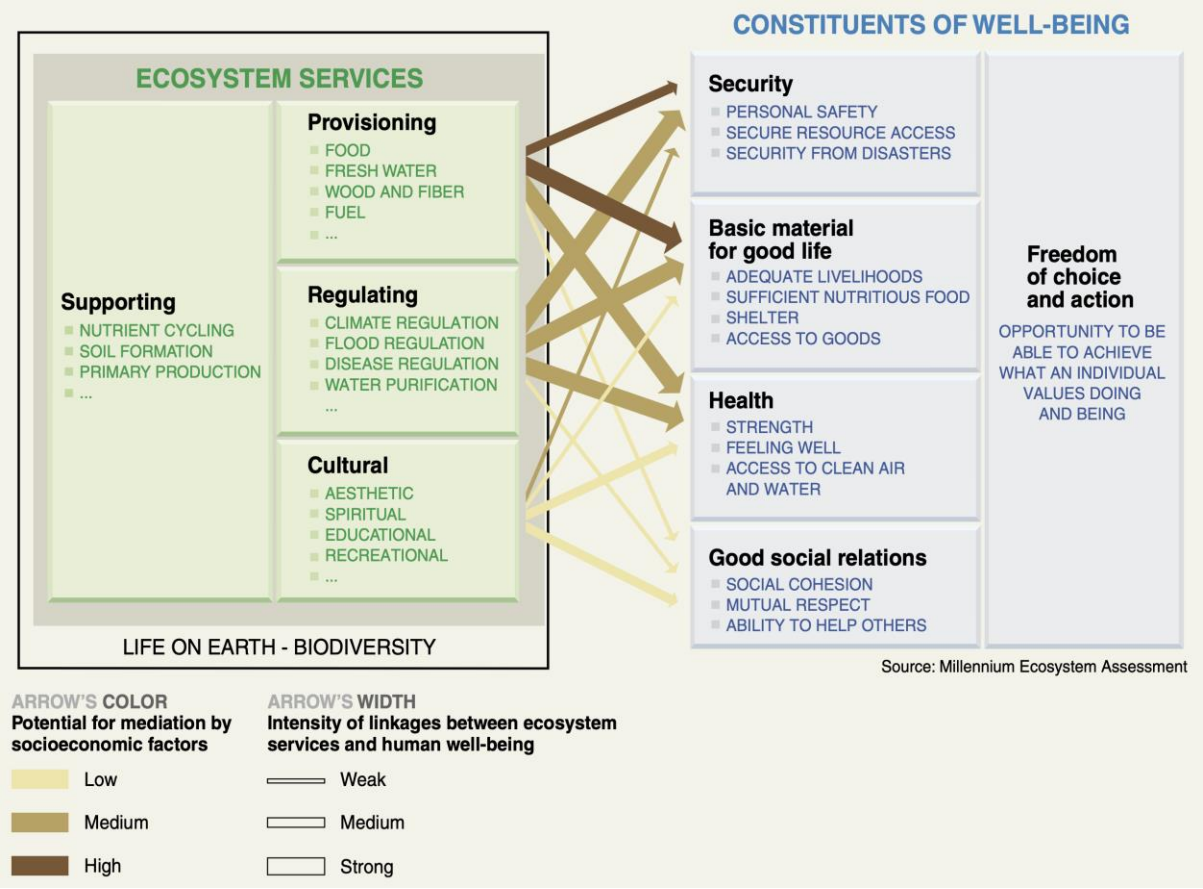


Figure 2.1: Ecosystem Services and Human Well-being: synthesis

(Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.)

These ecosystem services provide the urban environment with near-natural benefits. It connects to our part of the soul that connects us to nature. Everything then comes around to the topic of sustainable cities. The sustainable city concept is one solution we have to face the monumental crisis of the current world. More and more people are moving into the cities in a more challenging world of climate change and environmental disasters. It has been estimated that 68% of the world population projected to live in urban areas by 2020 (UN DESA, n.d.). As the cities are growing, it is now our top priority to focus on sustainable cities and, in turn, blue-green infrastructure.

2.4.Urban Open Spaces

The city develops with buildings and streets to give shelter and movement to its inhabitants. While these are the necessity for economy and development, there are other kinds of elements we live for. Open spaces are that part of the city where people go to celebrate life. Endless monotony and formality of our life are broken into bits of happiness in these spaces. According to Marilyn Myers (1975) (Myers, 1975) "Open space is a land or water area with its surface open to the sky, consciously acquired or publicly regulated to serve conservation and urban shaping function in addition to providing recreational opportunities."

Urban open spaces include green spaces, water bodies, parks, streets, fields, natural landscapes, etc. It is a place for recreation and relaxation. People socialize here, play games,

attend concerts, do yoga, read books, and the list goes on—activity changes by the types of open spaces. Going out and spending time in these spaces is not the only benefit, but even looking out from the window to all the happy faces or nature is beneficial. RS Ulrich, in his classic paper, reported that post-surgical patients whose hospital windows overlooked trees, rather than a brick wall, recovered more rapidly and required minor pain relief (Urlich, 1984).

Figure 2.2: Factors affecting Public Health (https://2016-2017.nclurbandesign.org/2017/01/urban-design-public-health-and-wellbeing/)

From Prof. Tim's lecture on Urban Design, Health and Wellbeing, Kuntal Rami (2017) summarised some of the issues that need to be removed for a healthy built environment. (Rami, n.d.)

1) Physical Issues
   - Air Quality
   - Water Quality
   - Traffic/Car Accidents
   - Noise Pollution

2) Social Issues
   - Detachment from Nature
   - Fear of Crime
   - Lack of privacy
   - Over Population

More open areas mean more chances of soft, permeable surfaces for rainwater run-off. It keeps the groundwater recharged and the land fertile. Fertile land yields food, clean air, natural beauty, and reduces temperature. It encourages people to socialize through healthy bonding and physical activity. The world population is increasing, and more and more people are concentrating in the cities. Rapid urbanization has isolated people from nature (Wilson, 1984). Proper utilization of existing open spaces and creating new scopes will increase opportunities and reduce the city's alienation effect.

2.5.Planning Approach

In their research, Friederike Well and Ferdinand Ludwig explored the multifunctional planning approaches of the Blue-green infrastructure solution. They investigated the scope of the two-sided approach in planning projects of different dimensions that will strengthen the synergy and thus reach good climatic impact and resource-efficient.

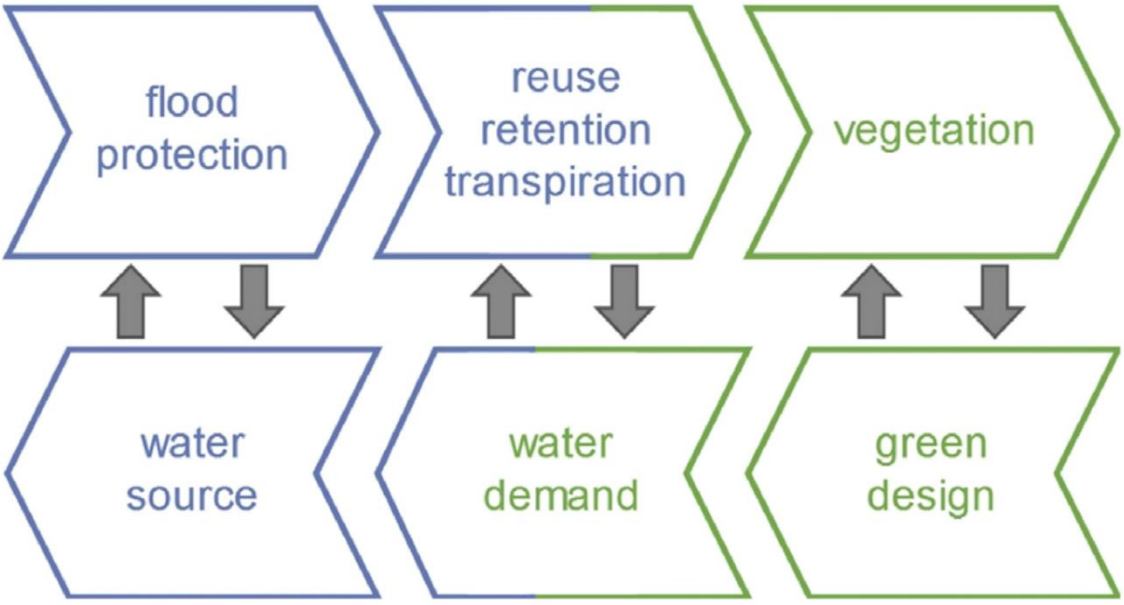


Figure 2.3: BGI: Combining blue and green motivated planning approaches into one integrated strategy. The procedure is already established on the urban and landscape scale but not on the building scale. (Blue-green architecture: A case study analysis considering t

In the detailed report from (Gehrels et al., 2016), they assessed and showed how the practical use of urban blue and green Infrastructure (BGI), both at the street and city level, can contribute to a liveable and healthy city. Functional use of blue-green infrastructure at the street and city level can contribute to a liveable and healthy city. As they termed “Adaptive

circular cities," the design principle, shown in the below infographics, gives information about the effectiveness BGI system to deliver ecosystem services. Another diagram

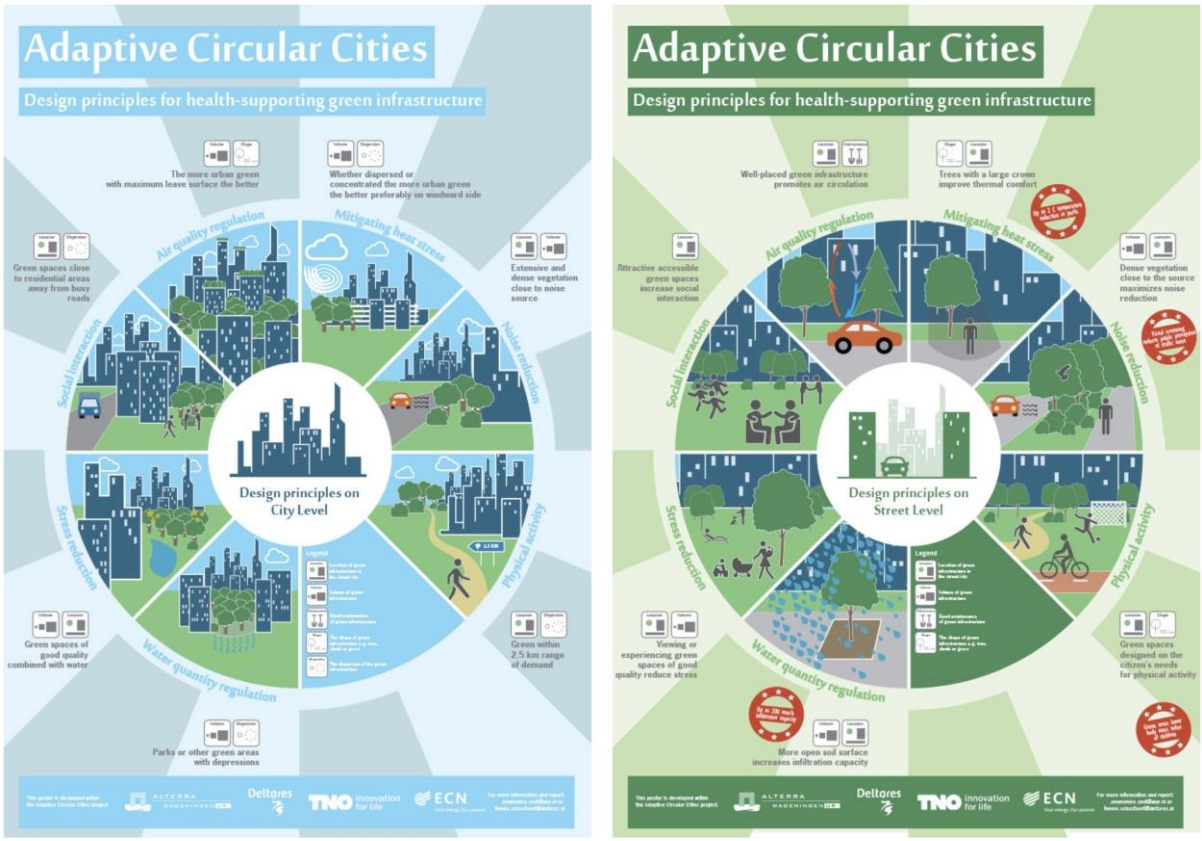


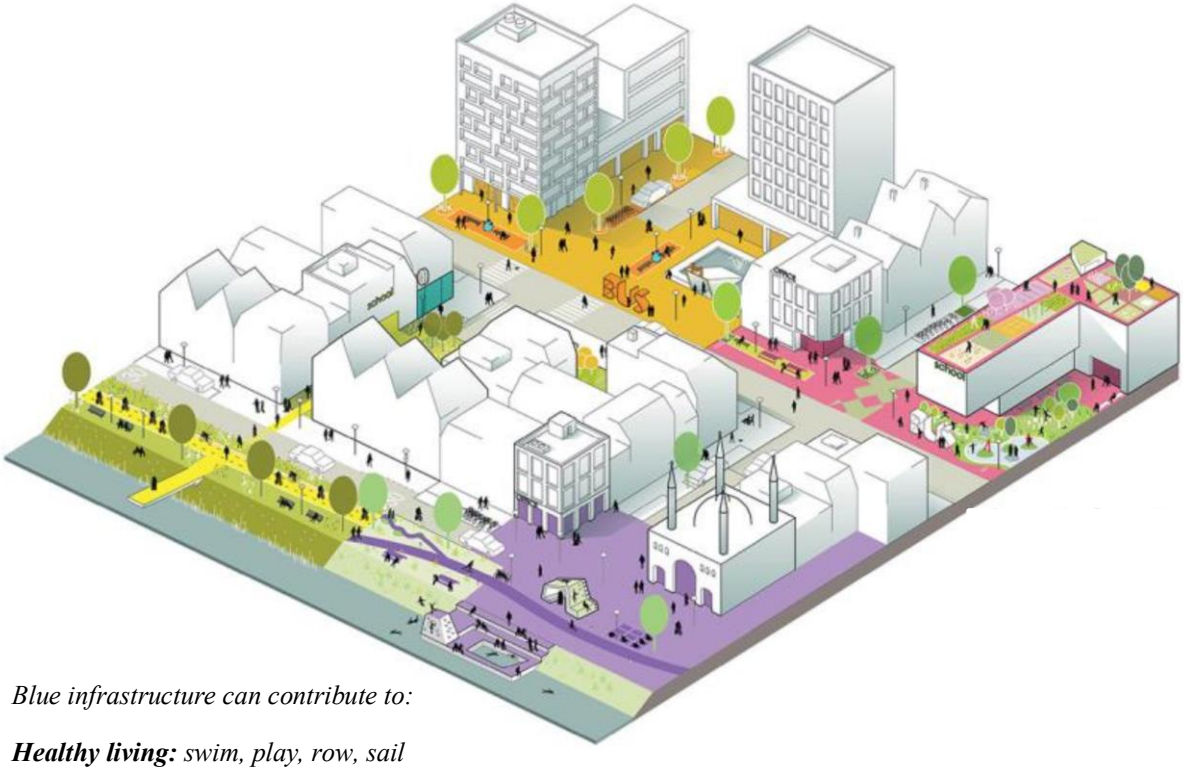
Figure 2.4:Adaptive Circular Cities concept (http://www.adaptivecircularcities.com/)

Typical aspects of a city:

- *Crowded / limited space*
- *A lot of waste produced*
- *A lot of resources imported*

Challenges relevant for Water quality and health:

Close the circles: *what use to be wasted can be a new resources*
Create (blue/green) space *to play/rest/sport, (multiple use of space); use the city for short distances / daily use, use the boundaries for regional use e.g., for a day out*
Invite to live healthy *(attractive tracks to cycle/walk/public transport/skate/row)*

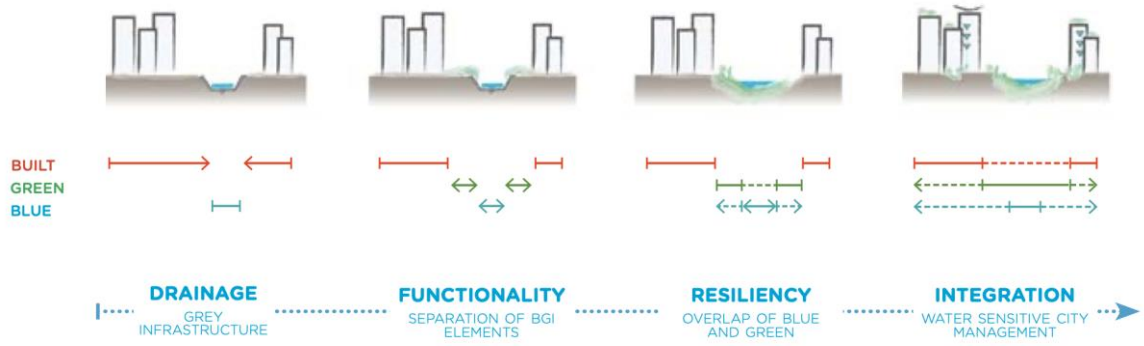


Blue infrastructure can contribute to:

Healthy living: *swim, play, row, sail*
Mental health: *social interaction, resting, leisure, restaurants, design*
Medical health: *no toxic compounds, bacteria, pathogens*

Figure 2.5: A visualization of part of a city that is designed according to principles of healthy urban living. (Gehrels, Hans & Meulen, Suzanne & Schasfoort, Femke. & Bosch, Peter & Brolsma, R.J. & Dinther, Daniëlle & Geerling, Gertjan & Goossen)

If developed to an interconnected system of BGI, existing blue elements have shown the promise of enhanced resilience in an urban environment. Like in the research from Ramboll(Ramboll, n.d.) we can see how a simple drainage system can be transformed into water



sensitive city artery.

Figure 2.6: The Process of Integration. Urban infrastructures need to be retrofitted from conventional drainage systems to more functional and resilient systems that bring together built areas, green (landscape systems) and water. (Enhancing Blue-Green Infrastructure)

2.6.Urban Landmark

Every city has landmarks, whether they are historical buildings, certain features of streets, the ambiance of places, or natural features. Without a landmark, a city will be a puzzle, and the inhabitants will feel lost and disoriented. It comes naturally to humans to bind meanings to their surroundings and to make collective memories. These collective memories serve as landmarks for people to harmonize themselves within the world around them. As Lynch (1960) puts it, although life is far from impossible in the visual chaos of the modern city, the same daily action could take a new meaning if carried out in a more vivid setting(Chapman & Lynch, 1962). There are landmarks on urban scale, so people orient themselves around them. And then there are landmarks which are in small scales where people dwell. They can be a small boutique shop just around the corner, a Ficus tree at the neighborhood center, or a pond around which a neighborhood develops.

Bing Wang and Hang argued that landmark is a vague word (Wang & Sun, 2019). Kevin Lynch's landmark is a reference point where the user does not enter and only uses it externally. Nevertheless, an Urban Landscape Space itself also includes the peripheral plot where it is located and the skyspace it occupies. Their conceptual analysis divides landmark features into three categories

1. Landmark: Any landmark with specific identification in space or spiritually significant.
2. Urban Landmark: Urban structures and buildings have particular spatial roles and give identity to the city. Like the Assembly building of Bangladesh or the Dome of Florence.
3. Urban Landmark Space: It relies on Urban Landmark with one of its parts where people can connect themselves. It is a spatial environment given with spiritual meaning and forms a psychosocial cognition under human involvement and design.

On principles of the act through the figure-ground relation of material space, cognitive process of perceptual space, symbolic symbols of the meaning of space, they formulated some design strategies.

a. The design strategy of Material Space

b. The design strategy of Perceptual Space

c. The design strategy of Meaning Space

Their suggestion to design an Urban Landmark space is to follow the principles of co-ordination, progressiveness, innovation, and ecology.

2.7.Image of the city and Water

Every city has a story to tell. Every city has a unique flavor. Citizens spending a certain span of their life in a city creates a cobweb or memories. They put pieces of themselves all over the city. Every subjective memory and every story come together and form the Image of the city. Kevin Lynch, in his book “Image of the city” described, how to interpret Image of the city or how to read cities.

Physical forms of a city include Paths, Edges, Districts, Nodes, and Landmarks. Then, there are other features like the social meaning of a place, history that contributes to a city’s image-ability. Not every element of a city within these classes gets the attribute to define the image. They need spatial quality, a specific feature, proper exposure, view-ability, and so on. Like for a landmark bridge, it has to be visible from considerable distances to affect the image. A street and a boulevard are the same by physical form and functions, but their importance is different for their ambiance.

Water feature in every city is the most valued piece of land. Land prices go up according to their proximity to the nearest waterbody. Waterbodies remove visual obstacles and make incredible scenery. Water edges in a city are always familiar places where people can look far away from city mechanics. Many of these waterbodies have myths and legends, making them unique and creating a vital ambiance to the cultural identity. People interacting with these water features and re-innervating these stories make them Urban Landmarks. With their stories, legends, and abundance in every corner of the city, these sites’ visual strength makes up the city’s image.

2.8.Urban Ecology and Wetlands

Around 50% of the world is currently living in cities, and within thirty to forty years, almost two-thirds of the world population will benefit from an urban lifestyle. So, it became more critical to employ urban ecology in every urban environment we have. Urban Ecology is an entirely new branch of science that started around the 1970s, focusing on the urban sphere's components. Cities establish themselves within the natural landscape, molding their features with the shape of the new city. Thus, the ecological balance of a city largely depends upon the remaining fragments of natural bodies. Abiotic elements are the most ubiquitous city element; all the biotic components remain in chunks, fragmented, and continuous abatement. Urban ecology focuses on these diminishing urban habitats and features to develop a symbiosis between the city and nature. Water is the source of life, and to urban ecology, this truth stands all the same. To conserve our cities' water bodies in question, we have to regard their ecological context and preserve them. The city environment and the inhabitants' health largely depend upon these natural components and their interaction. We, the dwellers, are humans, a part of the biotic component of the urban ecology.

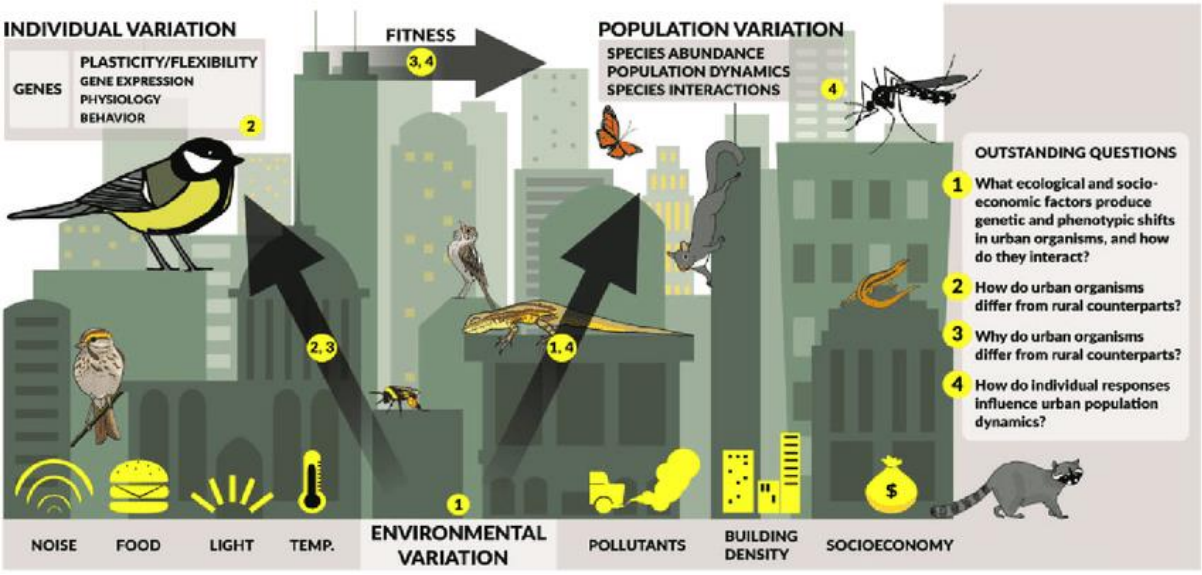


Figure 2.7: Outstanding questions for urban ecology (1–4) in the context of environmental, individual, and population variation. Some representative common animals found in cities around the globe are pictured. Environmental variation can affect individual and population-level variation. Individual variation affects individual fitness which then can lead to changes at the population-level. (A New Framework for Urban Ecology: An Integration of Proximate and Ultimate Responses to Anthropogenic Change, 2018, Integrative and Comparative Biology 58(5):915-928)

With the development of urban areas, faunas are forced to adapt to the new environment. Covering uplands with human intervention led to the destruction of natural habitats and reduction of biodiversity. While some of the organisms are adapting to the new ways but they are under continuous threat. In the research "A New Framework for Urban Ecology, 2018," the authors addressed how ecological and socio-economic factors interact and how they affect the urban species.(Ouyang et al., 2018) The above figure explains their outstanding question of city organisms and the catalysts that boost the evolution.

Author Jianguo Wu (2008), in his paper, distinguished five urban ecological approaches based on the degree of emphasis and reliance on biological ecology as well as conceptual and methodological frameworks (Wu, 2008). These approaches are based on three broad perspectives of Urban ecology; ecology in cities (the first approach), the ecology of cities as socio-

economic structures (the second approach), and ecology of cities as ecosystems (the third to fifth approach).

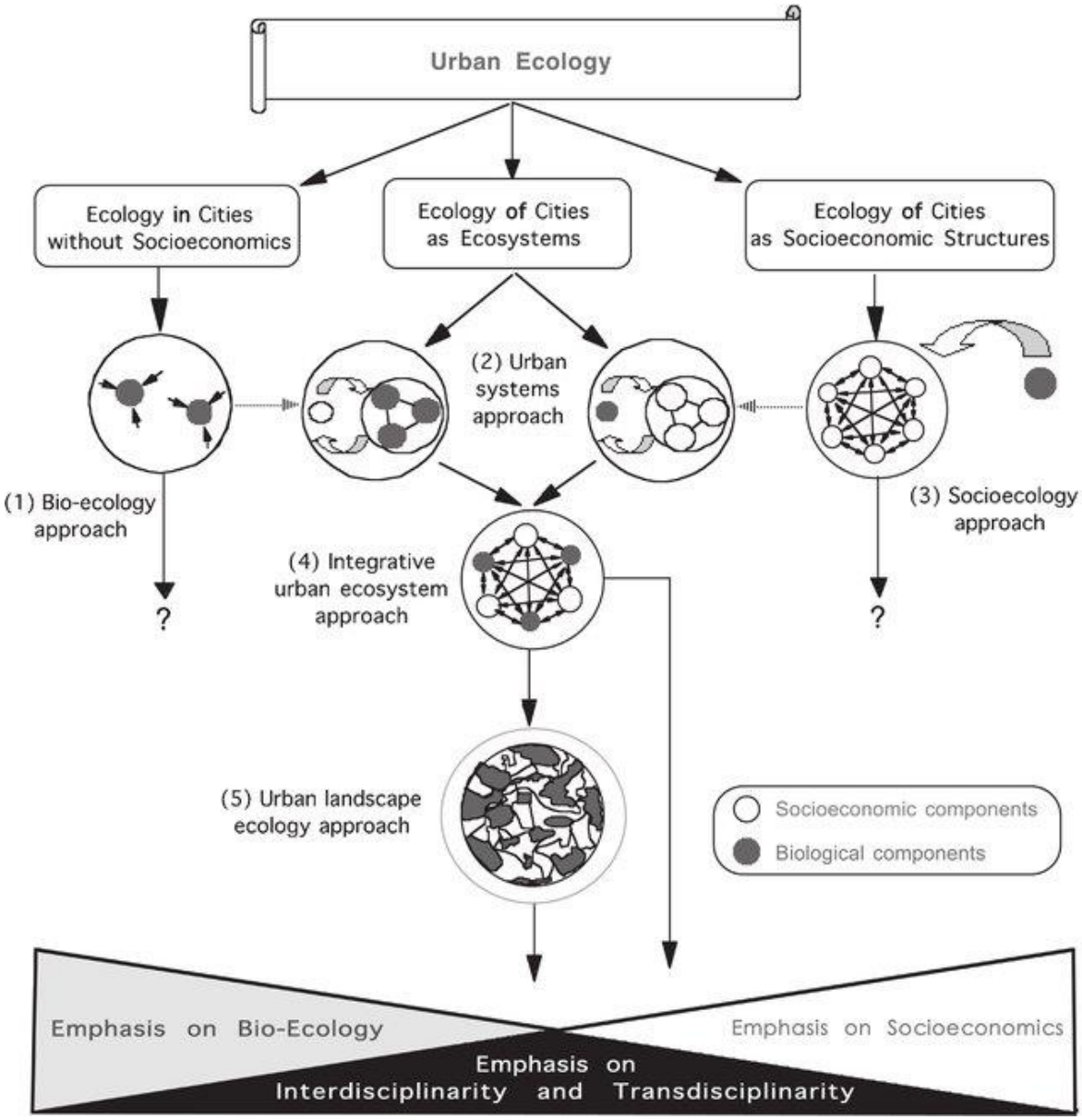


Figure 2.8: Development of different perspectives in urban ecology. (Toward a Landscape Ecology of Cities: Beyond Buildings, Trees, and Urban Forests, 2008: Ecology, Planning, and Management of Urban Forests)

2.9.Placemaking: The Power of 10+

Power of 10+ is a placemaking concept developed by a cross-disciplinary team called Project for Public Spaces. They evaluate and facilitate Placemaking at multiple city scales with this concept as a guiding principle. (McNeely, 2007)

It is a powerful tool that creates a city narrative, from a human scale to Urban. The idea is that a city should have at least ten destinations where people can have different sensorial experiences. The variety of these places will inscribe different moods so people can engage more variedly. There will be things to do within these destinations, places to explore, foods to be enjoyed, music to be heard, and many other experiences. Some of these experiences will be unique to those destinations alone.

The next point is within these destinations. There should be at least ten places to go in each of these destinations. So, people can circulate the place, creating a live vibe. There will be music, the hustle and bustle, crowded passing, children screaming, steaming food carts, and benches.
Each of these places should employ at least ten things to do. These activities can be as simple as having a bench, a drinking water dispenser, a food cart, a small flower pot to water. People of the surrounding neighborhoods will provide suggestions for these activities as they are the people who will engage the most.

These placemaking concepts will employ cities' cultures and traditions, landmarks, and history. Not only will locals benefit from healthy urban living, but tourists visiting the city will also see how to live a city can be.

Figure 2.9: Placemaking concept: Power of 10+ (https://www.pps.org/article/the-power-of-10, 17.10.20)

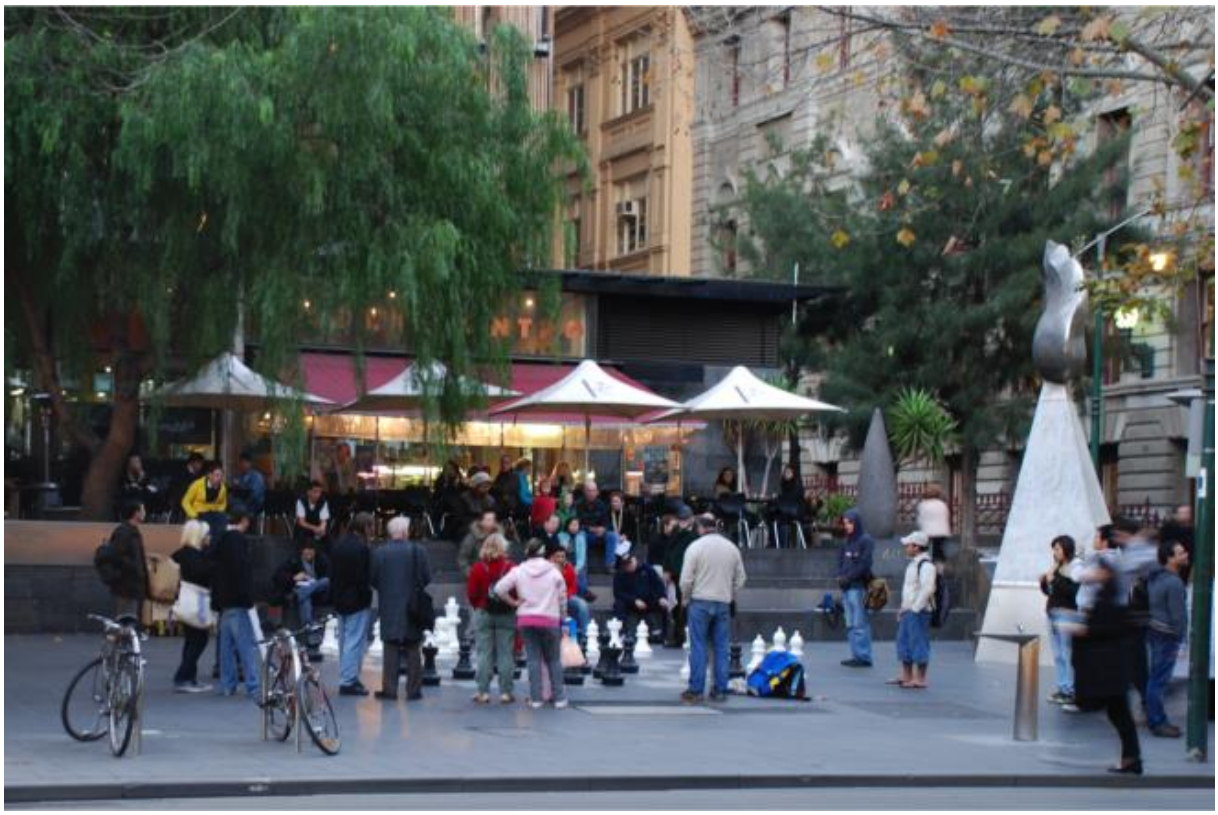


Figure 2.10: A plaza in Melbourne, Australia (https://www.pps.org/article/the-power-of-10, 17.10.20)

Here in this example from PPS's website, we see a case study from Melbourne, Australia. Within Melbourne is a place where the given photo is taken of a plaza. A restaurant serves the outdoor people adjacent to a plaza where people can enjoy food and loot over the activity. Big-sized chess for people to play and others to spectate, a water fountain for drinking, a sculpture that signifies the place's particular history. Cycle stands for the bikers, stepped seating, and extensive pedestrian so people can choose to stay, spectate or pass by. The overall atmosphere emanates such a lively aura that makes people crave to come here to experience this unique encounter.

2.10. Storm Water Management and Sustainable City

Stormwater is a blessing that comes down in the form of rain, snow, or other precipitations. Stormwater is part of the natural water cycle.

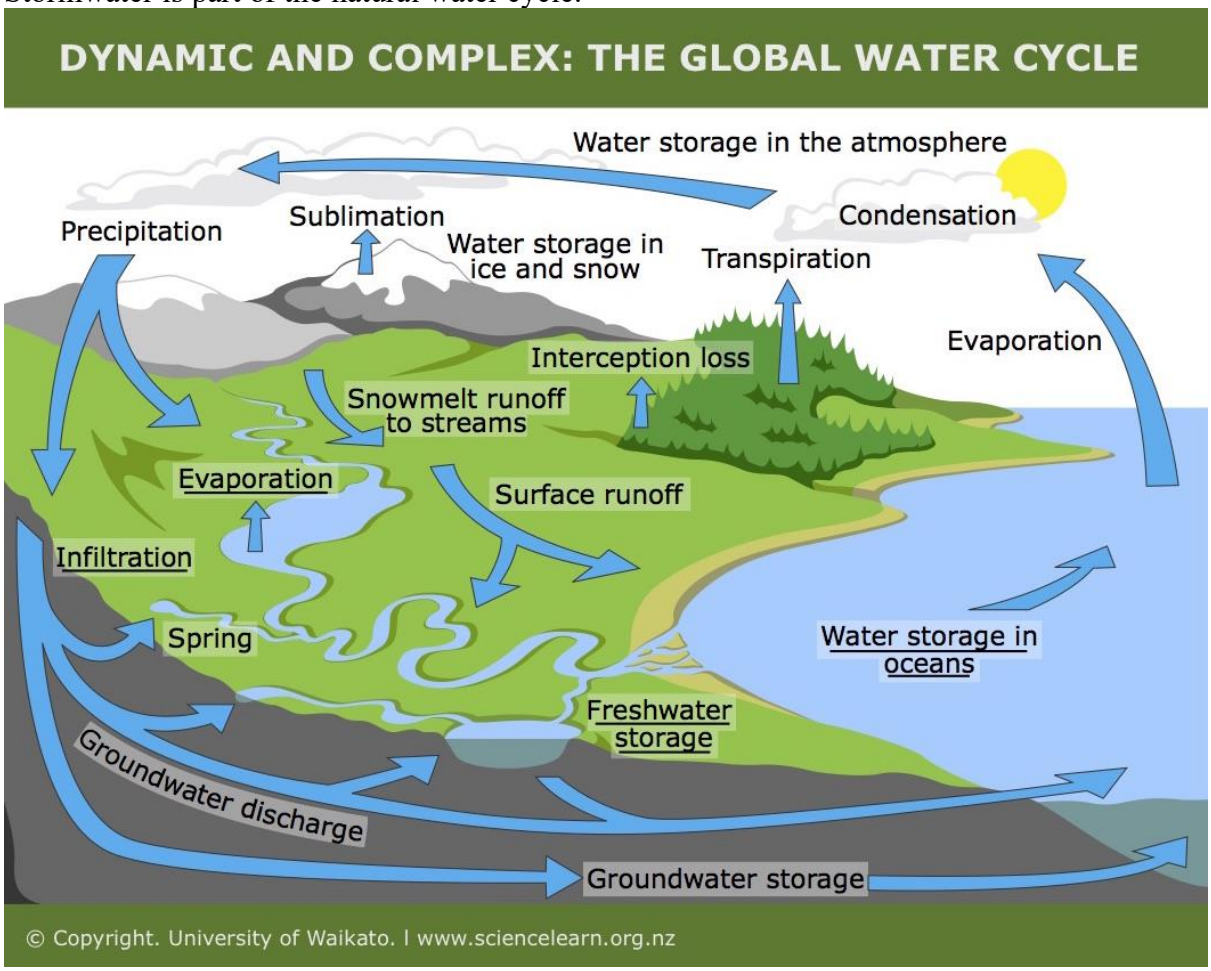


Figure 2.11: Global water cycle. (https://www.sciencelearn.org.nz/image_maps/36-dynamic-and-complex-the-global-water-cycle, 12.09.20)

In a natural setting, this water cycle follows the natural laws. Some water evaporates, maintaining the air's moisture and temperature, some perforate the ground recharging the aquifers, and some flow back to the oceans. However, when it comes to human-made Urban areas, these natural rules get disturbed. Hard surfaces cover the earth in an urban setting; water cannot perforate the earth. Moreover, there are not enough water surfaces for water to be evaporated. These problems yield other great problems. City temperature rises, and the water table in the underground aquifers decreases. The unnatural setting creates an artificial world that is not healthy for the cities' dwellers.

Preservation of the natural water cycle has been a challenge for centuries. Draining the water out from the city is not going to solve our water management problem. Thus, we have developed many innovative solutions for the management of stormwater. Stormwater management is a complex system that reduces the run-off from precipitation to the streets and pedestrians, lawns, and other usable areas and improves water quality. In a well-planned Urban design, open spaces, green areas, water surfaces were used as absorption areas the add to the permeability of water. The drainage system carries excess to designated areas and flushes city water to rivers, canals, or other streams. However, this is the old system that took the whole concept as a problem.

Sustainable Storm Water Management is the new concept where precipitation is no longer a problem for the city. It is a concept that harmonizes the natural environment and built-structure and recognizes rainwater as a resource. A Sustainable stormwater management system uses both structural and non-structural devices. Structural being rain barrels, perforable pavement, perforable asphalt, cisterns, Planters. And non-structural devices like roof gardens, water retention roofs, swales, watersheds, rain gardens, ponds, landscapes, and parts of other natural environments. These elements retain the water and release the excess water slowly. While in the meantime, water perforates the earth. This water also benefits plants and reduces ground heat absorption. In the extended complex system of water management, one part is the conveyance of water. LID or Low Impact Development is a new trend mainly developed in Canada and spreading everywhere is an improved version of the typical water management system. It is more sustainable and more efficient. Some of the most popular concepts of Sustainable Stormwater management in the light of LID are discussed below.

Bio Retention Swales: A swale is a sunken, shallow vegetated shady or non-shady earth form that conveys water. It employs a natural condition for water to infiltrate its surface. Swales reduces run-off volume and maintenance compared to underground drainage as problems can be assessed visually and solved quickly.

Figure 2.12: Swale on left, Bio Retention Swale on Right (https://www.susdrain.org/delivering-suds/using-suds/suds-components/swales-and-conveyance-channels/swales.html,12.10.20,https://catalog.extension.oregonstate.edu/em9209/html,12.10.20)

A bio-retention swale makes use of a landscape. Plants help to filter water and protect the soil. These swales also add up to the beautification of sidewalks. These kinds of swales are not too deep, so there are no safety issues. Depending on the area, a swale can also be extensive in different plant groups, stones, blocks, and other landscaping elements where people can walk into and enjoy the water.

Rain Garden: A rain garden is in some terms similar to swales. Swales convey water while rain gardens hold the water. It is usually a water pit where the surface run-off accumulates. This water pit acts as a basin for the excess run-off that evaporates and perforates slowly. Nevertheless, it is becoming increasingly popular now to transforms these water pits into rain

gardens. In a rain garden, the pit is treated for more water to perforate and grow plants. Usually, native shrubs, flowering plants, and other aquatic plants are aesthetically pleasing and filter the water.

Figure 2.13: Typical rain garden (https://www.bgozarks.org/designing-rain-gardens-with-native-plants, 12.10.20)

Successful implementation of a Rain garden can reduce the flow of rainwater into the central system. Reduce the pressure on stormwater treatment structures, filter heavy metals and pollutants from water, and enhance the community's beauty. A small rain garden is a crowded area for different species. The bio-diversity of tiny organisms can grow their habitats in these small patches of green-infrastructures.

Water Retention Green Roof: Green roof can transform a city into a green carpet that hides all the concrete jungle we have created. Green roofs naturally absorb sunlight and do not reflect it. They help the city by providing clean air and beauty. Public well-being can be improved a lot by employing green roofs. These are the primary benefits of green roofs. However, a green roof is also a water retention unit. It acts as a retention block that holds the rain-

water for a definite amount of time and slowly releases it into the system, decreasing any excess water rush. In the meantime, plants benefit from the water, and also, more water can

Figure 2.14: An extensive water retention roof garden. https://odu-green-roof.com/ultralight-extensive-green-roof,12.10.20)

evaporate.
A green roof can be both extensive or intensive. There are also other kinds of roof gardens like sedum gardens. All of these will serve as a water retention unit. Even without roof gardens, a roof can be transformed into a water retention roof with proper treatment. The central concept here is to hold as much water as a roof can provide within its border. Also, in a sustainable city, a roof garden is one of the hotspots for ecology.

Bio-retention Pond: A retention pond is a crucial part of a floodwater management system. Water run-off comes from all sources, accumulates in these ponds, and stays for a specific time before releasing. In a bio-retention pond, the run-off water gets treated naturally by plants. Planted buffer strips of grass and other vegetation filter sediments coming with the water. Sandbed reduces the velocity of heavy elements and velocity, giving a slow water transition to the core retention area. The whole Bioretention area exfiltrates the water. The larger area also contributes to the evapotranspiration process.

Figure 2.15: Walking along a Bio retention wetland (https://worldlandscapearchitect.com/weiliu-wetland-park-xianyang-china-yifang-ecoscape, 12.10.20)

Bio-retention ponds are a sustainable and ecologically rich system. Urban ecology may flourish in such natural conditions that sustain a natural cycle. Urban welfare of people will also improve with a proper landscape design that will connect people with nature.

3. Site Analysis

Cumilla city, formerly known as “The City of Banks and Tanks,” is situated in the country’s eastern part. The city is distinguished by the great size and number of more than 400 of its water storage tanks. One of the oldest cities of the subcontinent has a rich history dating back to the 4th century AD. Xuanzang described the area as low and flat (Sama-tata), humid land; east of Kamarupa. This low-flat land was called Samatata, a self-explanatory name meaning flat plain. Later Cumilla became part of the ancient empire Tripura, named after the Mythical Maharaja Tripur. From this time we have written history of the region. Cumilla holds many wonders of the past. It is famous for the archaeological heritage and relics in Mainamati, Dharmasagar Dighi, Ananda Vihara, Jagannath Temple, Ranir Kuthi, Town Hall, World war memorial, Shah Suja Mosque, Birchandra Library, Rajrajeshwari Kalibari.

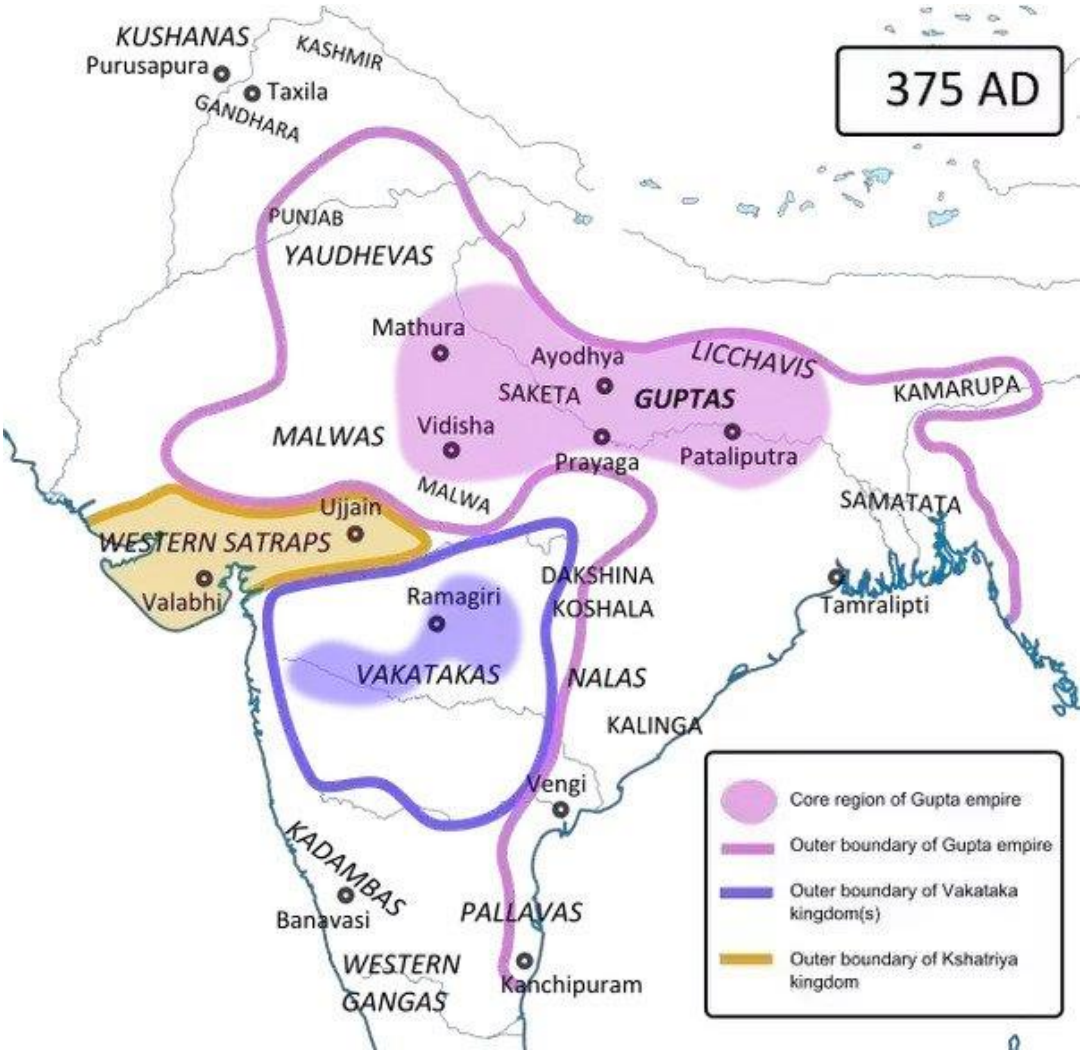


Figure 3.1: Historic Map showing Samatata in the context of ancient India

Cumilla is the third largest district in the country, and the Tropic of Cancer runs above the middle of the district through the city. So, the tropical savanna climate is more pronounced in this region.

Figure 3.2: Cumilla within the administrative boundaries of Bangladesh.

3.1.City Expansion and Demography

The geographical location made Cumilla one of the earliest places to settle and build a commercial hub. One of the oldest highways of the continent passes through the city. Now the city is situated along the most important highway of the country, the Dhaka-Chittagong Highway. Gomoti river generated from hilly regions of Tripura runs along Cumilla. Once known as the “Sorrow of Cumilla” because of flash floods each year, now embanked by Bangladesh Water Development Board saved the city.

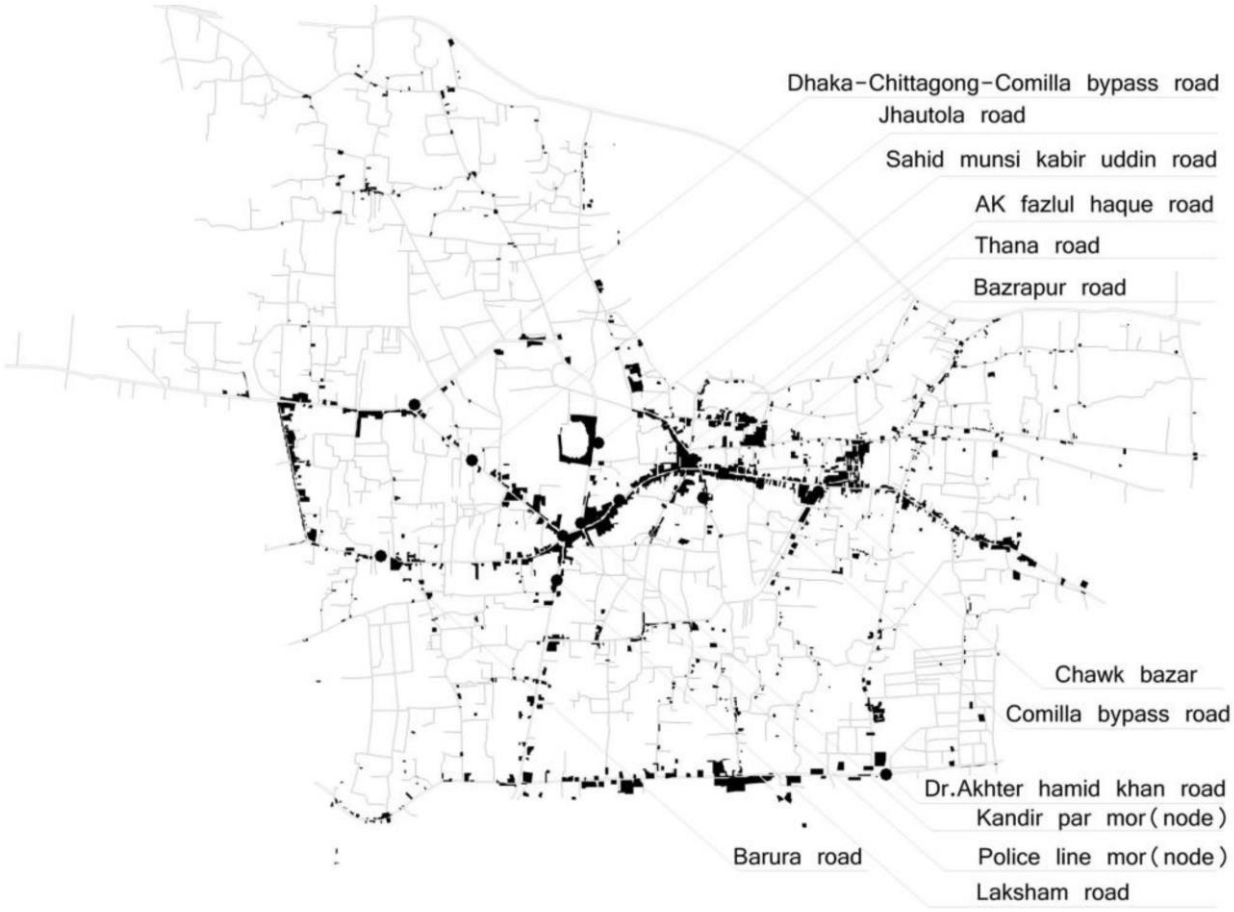


Figure 3.3: City commercial spines (Exploring Possible Extension to Commercial Development of Cumilla City, Bangladesh: A Perspective from Space Syntax Bushra Nayeem et la, 2015)

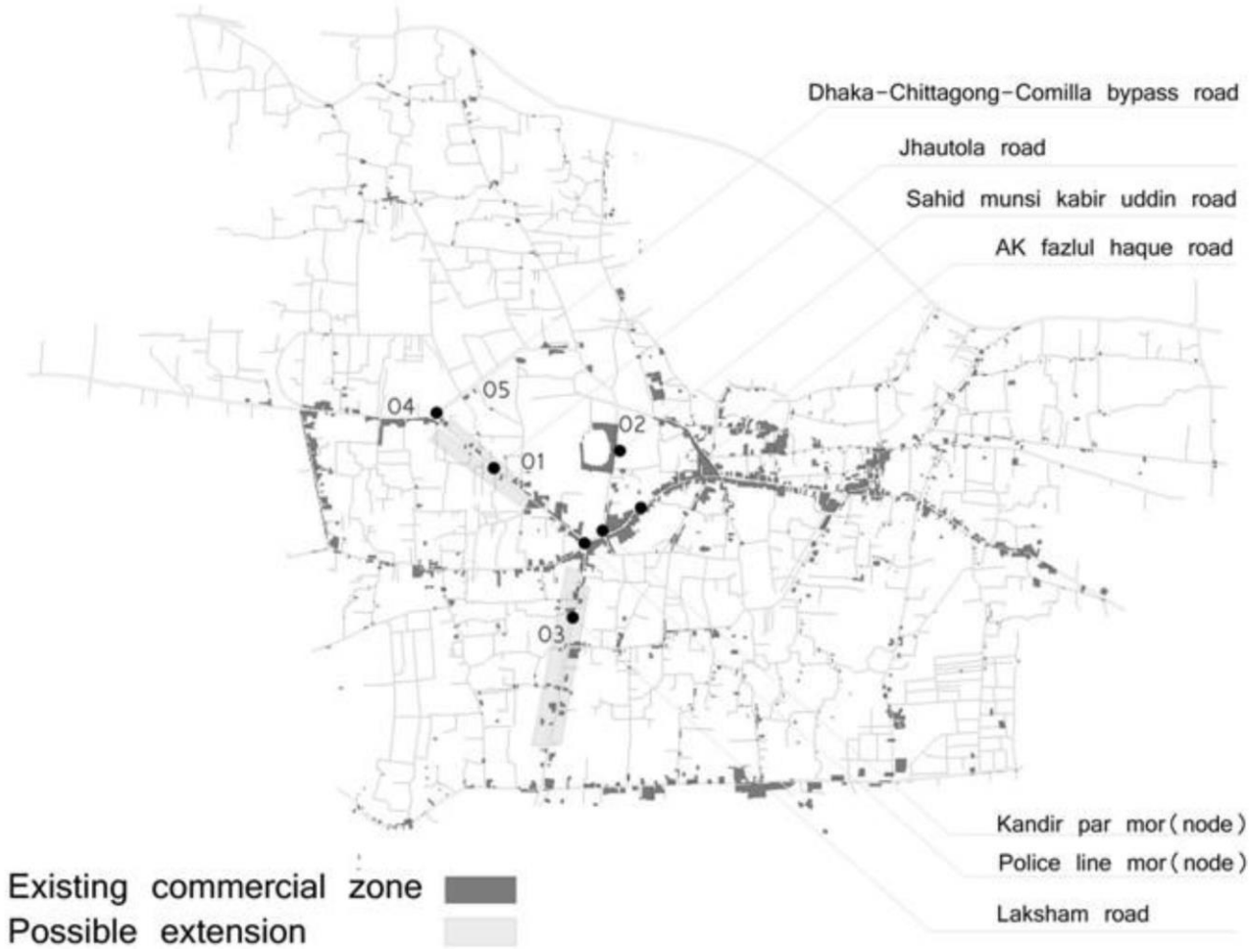


Figure 3.4: Possible Extension on City commercial spines (Exploring Possible Extension to Commercial Development of Cumilla City, Bangladesh: A Perspective from Space Syntax Bushra Nayeem et la, 2015)

The commercial core of the city is packed with densely built forms. High river banks restricted the city from growing northward, and flat geography allowed the south to grow. In their study of Bushra et la (2015) they analyzed the current land use pattern with space syntax to show the city is near-future development (Nayeem et al., n.d.). Suggested areas are inside the current city corporation border.

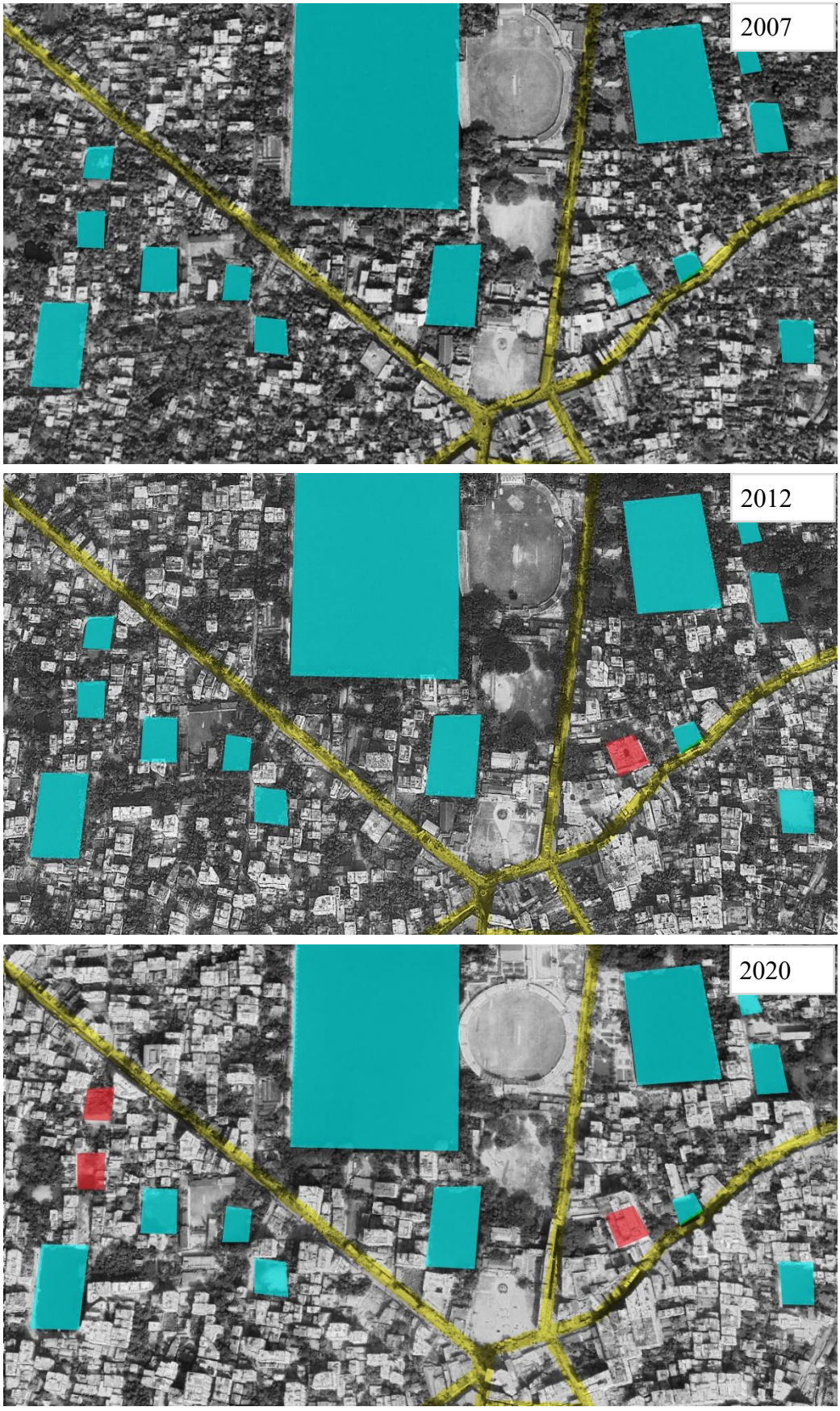


Figure 3.5: Historical Map comparison showing loss of urban wetlands (google earth).

These comparative maps' visual quality from 2007, 2012, and 2020 shows the city development process. Unplanned urbanization is consuming every inch of natural, and the future expansion areas suggested by the previous research show a very urban fabric. As a result, the future of those areas will only repeat if the current development pattern continues.

3.2.Threats to Waterbodies

Table 3.1: Number of ponds over the years (Bangladesh Bureau of Statistics, B. 2013. District Statistics 2011)

Lifelines of the city, these water bodies are in continuous threat from various factors. The filling up of ponds is one of the main reasons why numbers are diminishing. In the whole district in 2011, the number of ponds was 73532. (জেলা পরিসংখ্যান ২০১১ ল্ল *District Statistics 2011 Comilla BANGLADESH BUREAU OF STATISTICS (BBS) STATISTICS AND INFORMATICS DIVISION (SID) MINISTRY OF PLANNING GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH*, 2013) This number decreased drastically due to urbanization in the following years. The table below from A. A. Kafi and L. Ferdous's (2018) research shows the scenario.

Year	Number of Ponds	Area (km^2)
2011	73632	23876.07
2013	71523	21575.05
2015	64097	14727.15
2017	61426	11198.99

Table 3.1:Ponds Diminishing over the year (AA. Kafi and Ferdous's (2018))

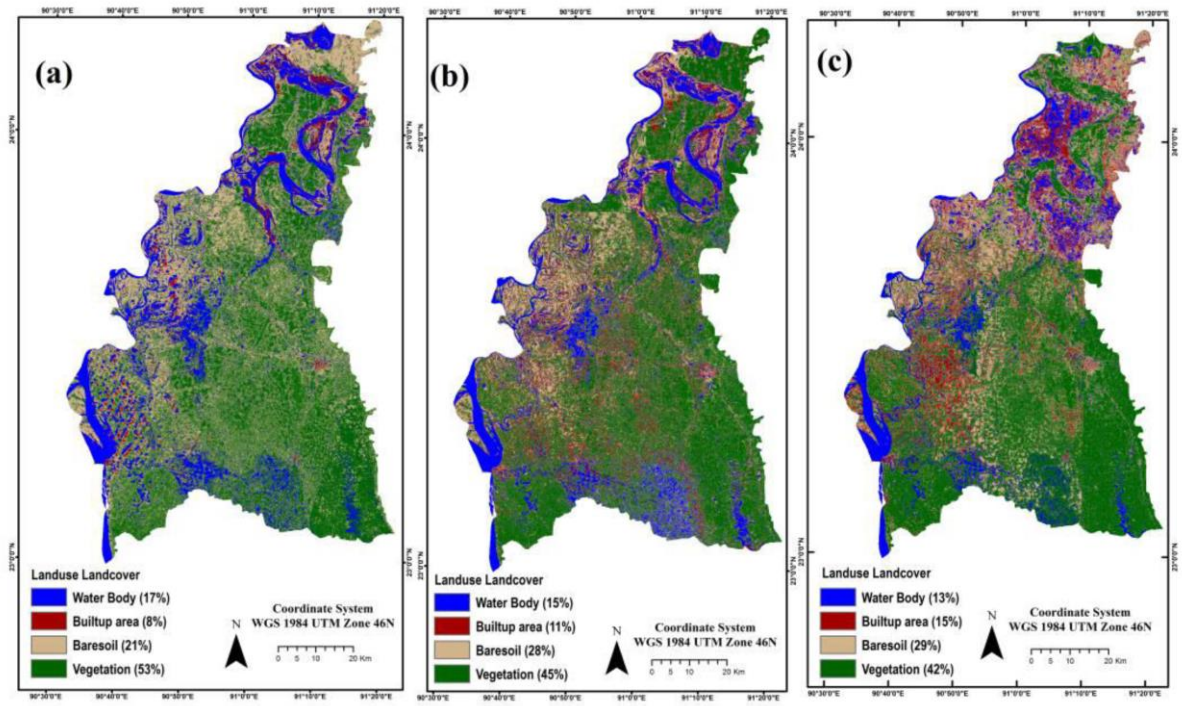


Figure 3.6: Diminishing Ponds of Cumilla District in year 2013(a), 2015(b) and 2017(c) (Kafy A-A, Ferdous L. Pond filling location identification using Landsat image 8 in Cumilla district. Paper presented at the 1st National Conference on Water Resources Engineering (NCWRE 2018), CUET, Chittagong, Bangladesh. 2018.)

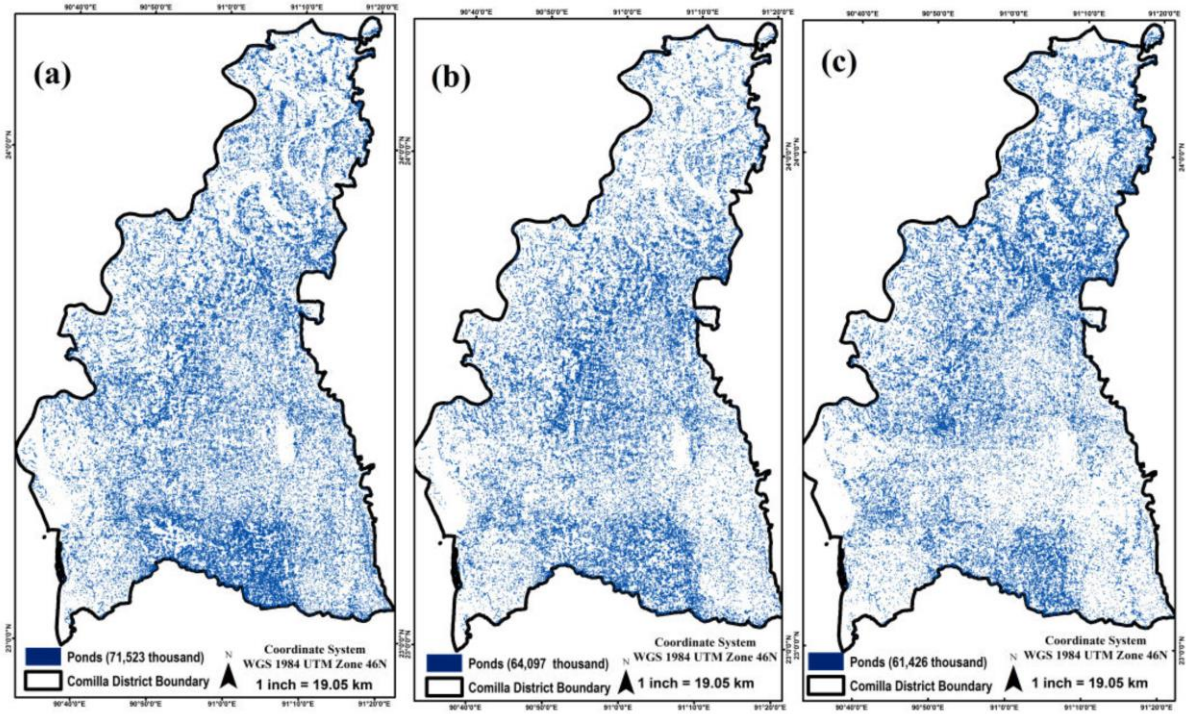


Figure 3.7: Diminishing Ponds of Cumilla District in year 2013(a), 2015(b) and 2017(c) (Kafy A-A, Ferdous L. Pond filling location identification using Landsat image 8 in Cumilla district. Paper presented at the 1st National Conference on Water Resources Engineering (NCWRE 2018), CUET, Chittagong, Bangladesh. 2018.)

Authors from this paper conducted a Geographic Information System (GIS) analysis with Landsat-8 imagery and Erdas Imagine software to analyze a supervised classification and change detection technique to identify the locations of ponds fill up every year.(Kafy, n.d.) Land cover maps and ponds in these times analyzed by the authors shows the scenario

Figure 3.8: Waste dumping at Ranirbazaar co-operative pond (https://www.prothomalo.com/bangladesh/environment/পুকুর-দিঘি-খালে-আবর্জনার-স্তূপ, 2015)

The second major threat is pollution and the dumping of waste into the ponds. Many crimes also take place in and around these ponds because of no proper public accessibility and involvement. They remain hindered, unused, and breeding ground for diseases and crimes. Proper guidelines and planning are needed to address these problems and turn these curses into the city's riches.

3.3.Study Area

Situated in the middle of the most important highway of the country (Dhaka-Chittagong Highway), the city of Cumilla is expanding rapidly. Without any proper planning, this growth gave birth to numerous gigantic problems. One of these grave problems is the urban conglomeration. The city has very small area of urban open spaces where people relax, meet, and organize other social, cultural, and other functions. Furthermore, not all

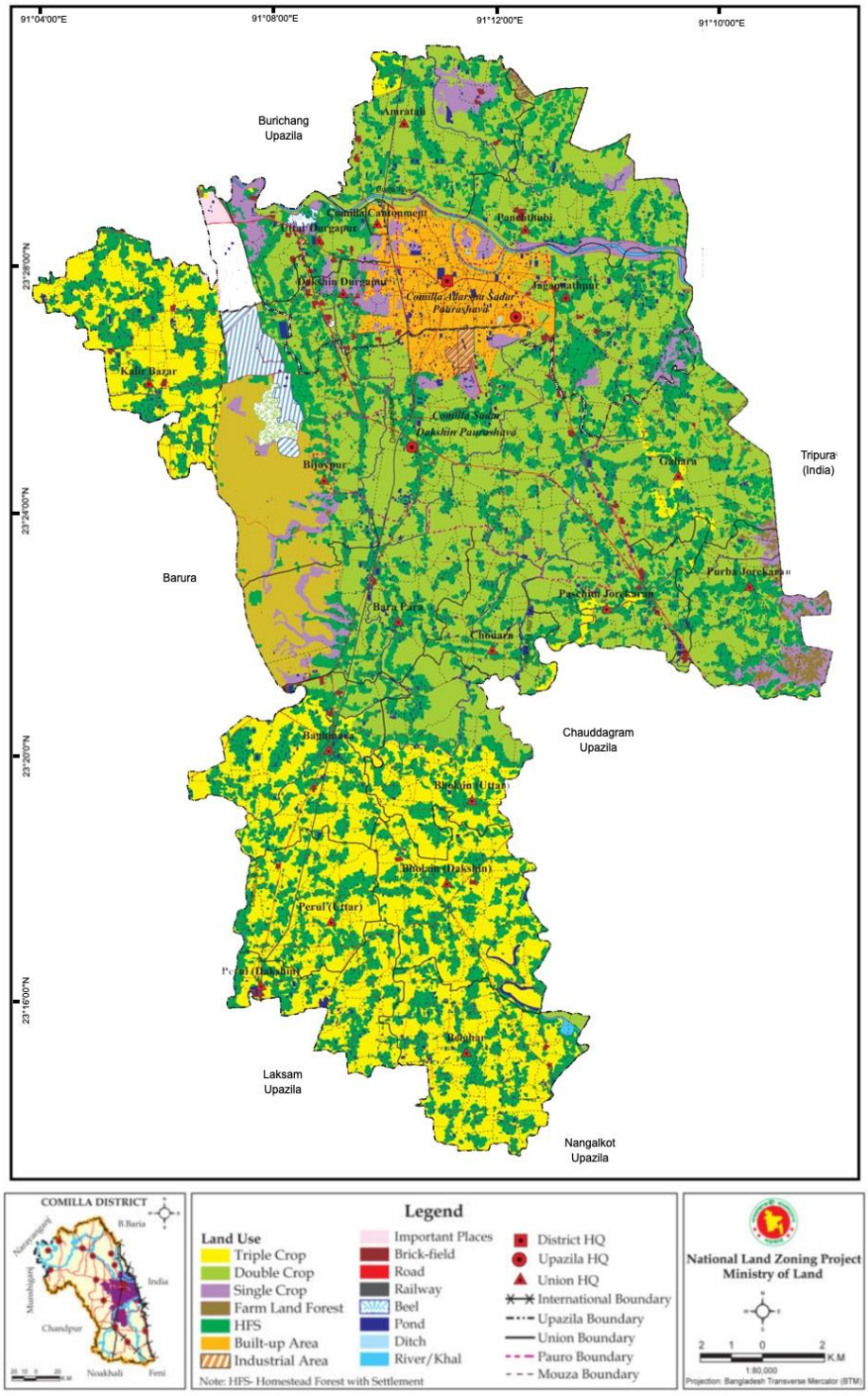


Figure 3.9: City Core within the City corporation boundary

of these places are defined as public open spaces, nor are they accessible year-round. Thus, the central city park is the only place where people usually meet friends, socialize, or other interactions. The place is always overcrowded, and on any holidays, it is unimaginable. This is a great failure as people cannot breathe even in the city's most breathable open space. Suppose proper measures can be taken with all the urban water bodies within the municipality. It will increase the city's blue infrastructure's aforementioned environmental services and serve as urban open spaces bringing life and colors to the city and its communities. Ponds are one of the most unusual features of this region of the country. Simultaneously, almost all of Cumilla district's ponds are now at a threat to extinction because of many human-made and environmental reasons. However, this threat is more significant in the city as it is an artificial threat created through unplanned urbanization. The city's climate, health, and image largely depend upon these ponds and reduce their number to threaten the city's life and future.

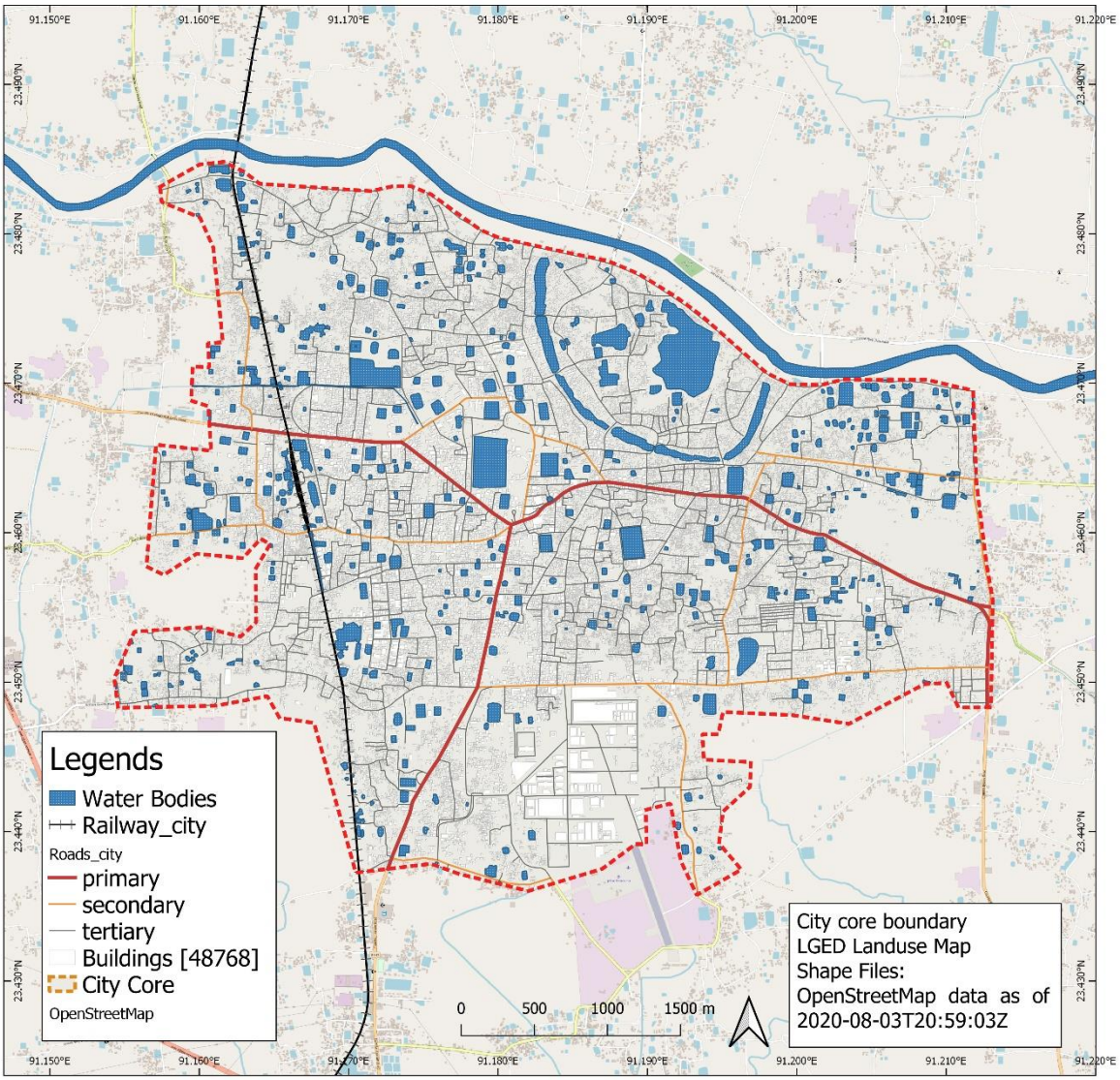


Figure 3.10: Project Area: City core

Cumilla City Corporation was formed in 2011 as a municipal administration. Cumilla town is the district's administrative center, and the city corporation oversees the

administration and development of Cumilla city. The city corporation covers over 53.04 square kilometers, where 5 million people live as permanent residents. Consisting of 27 wards city corporation extends from Cumilla Sadar to Cumilla Sadar Dakkhin.

3.4.Blue Infrastructure within the city

A city is built with all the new needs and modern interventions with the continuous flow of time. While it expands, it encumbers its surroundings and includes all the elements that once had been active on various functions. Blue infrastructure is one of these elements that once were a physical manifestation of nature, but now they serve the city and its macro-climate with environmental services. However, to serve with their full potential, it is essential to maintain their health and regeneration. Here we can see the encumber of the blue-infrastructure by the city of Cumilla from its surrounding. While not conserved, these potential elements cannot serve their most whole and dissolve into monotonous concrete with time.

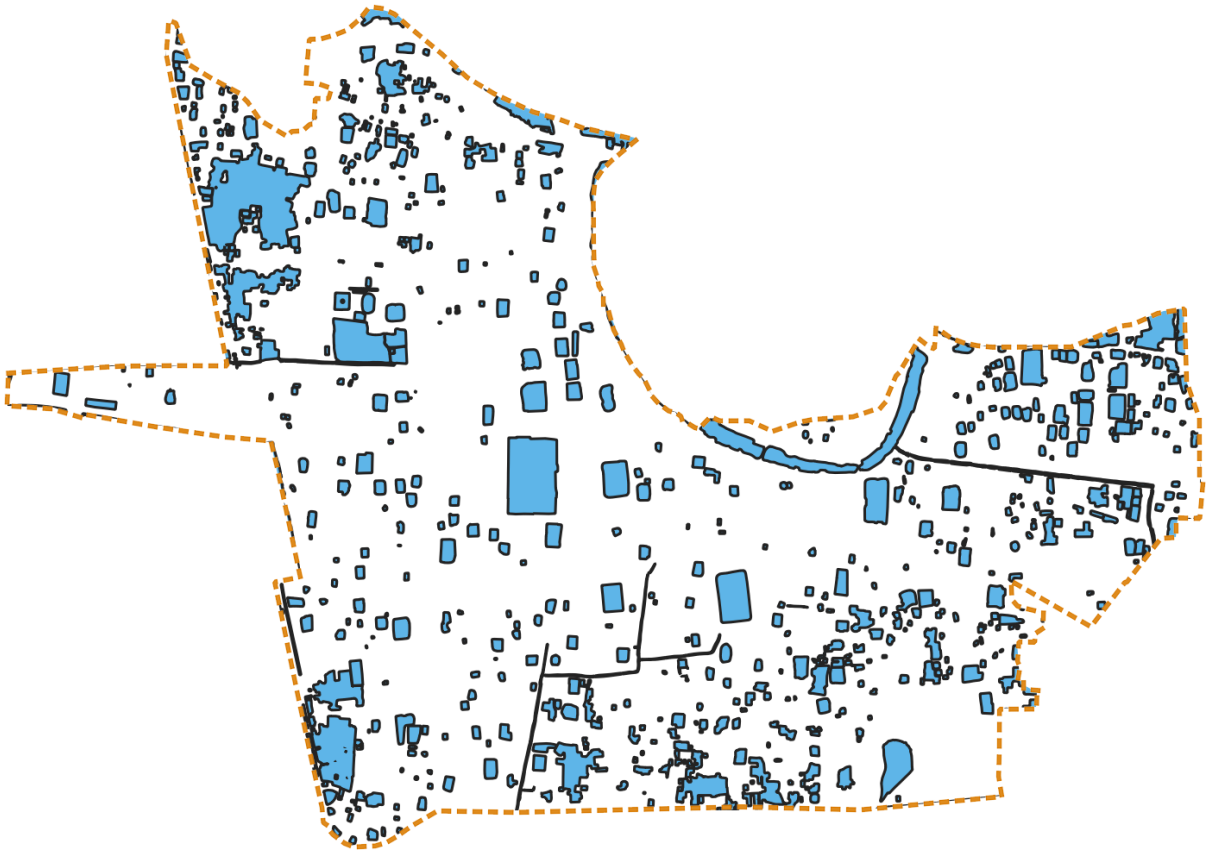


Figure 3.11:Blue Infrastructure of the Core City

City Blue infrastructure consists of Pukur, Dighi, water pits, an oxbow lake, and canals. Pukur and Dighi, as discussed, are the most extraordinary element of them all. They are human-made, and almost all of them have history inscribed. There are stories, myths surrounding these water bodies that form the cultural landscape. Many of these ponds are part of the greater history of Cumilla and have been here for a long time. Because of this, as time went by, some of these became landmarks. Street names and various parts of the city do not correspond with their name, but people always use these hotspots as landmarks when navigating or describing the way around. This name-calling might

survive for some more decades, but these ponds are already hindered. Even there are places known by certain ponds which are not present anymore.

Within the densely built city the Blue Infrastructure is still the most significant part of the city. From all these elements, ponds are the most ubiquitous ones. From GIS analysis, we can see a total area of 17000sq. meters is integrated within the city boundary, which is 8.21% of the total land. There is a possibility to connect all these elements by means of green corridors and other green networks. This is also very important to build a strong connection with the city Green Infrastructure for them to provide ecological services more efficiently.

The main problem with the conservation of these ponds is they are not under any specific national protection and do not have proper guidelines. People do not directly benefit from these ponds, so they fill them up to build buildings.

As human civilization progresses, history is all we have as our primary source of inspiration, our identity. Knowing the history and preserving them gives meaning to our existence, and these ponds are part of it. To know our roots and connect ourselves to our roots, we must acknowledge ponds as historical elements and save them by employing conservation, preservation, design, and assigning new functions and other necessary means.

3.5.Green Infrastructuer

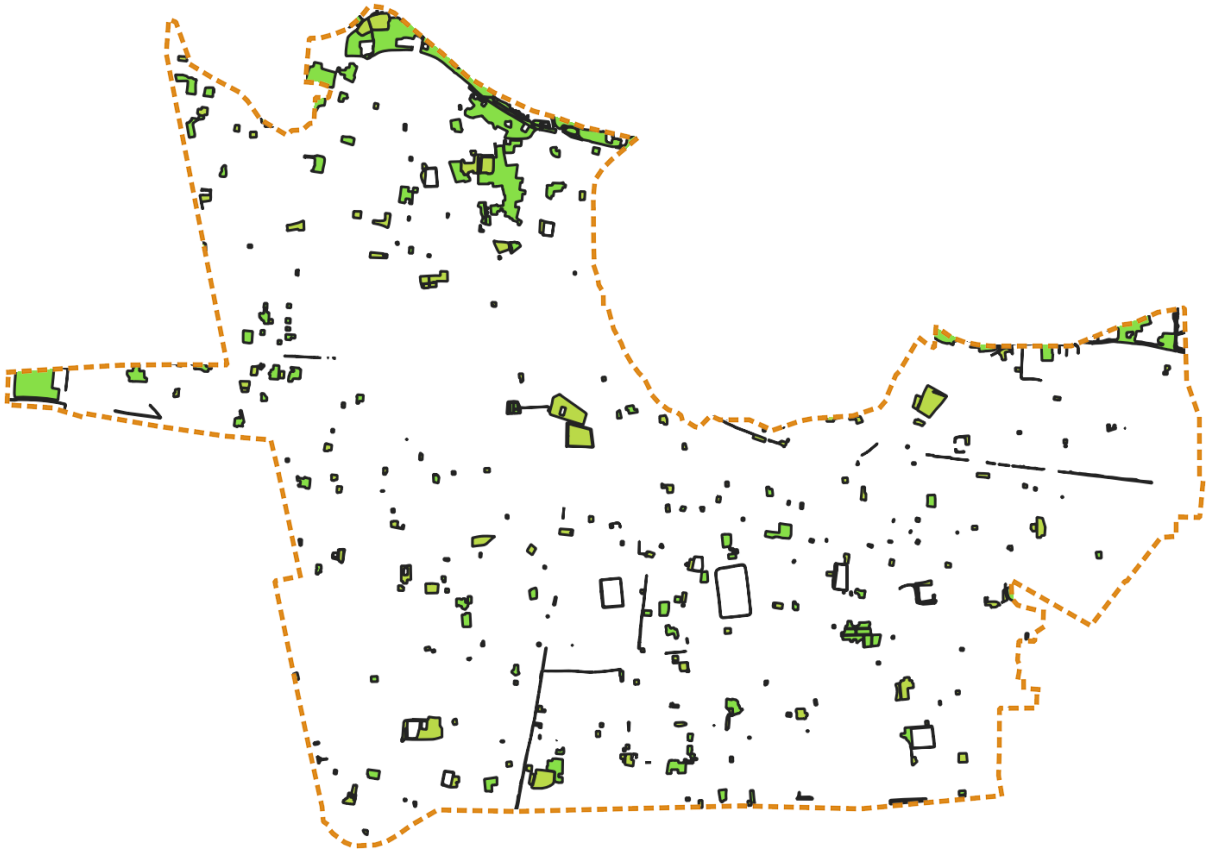


Figure 3.12:Green Infrastructure of Core City

Green Infrastructure is at very bad condition. Grey infrastructre took over every land there is. Now only bits and patches of green is left inside the city. Next problem is the documentation of the elements. There are still possibilities to increase green surfaces to add to the green infrastructure. In an ideal city condition these elements will function more efficiently together with green roofs, green walls, tree avenues and the blue infrastrure if planned sensibly.

3.6.Flooding and Climate Change

Bangladesh has a subtropical savanna climate with an annual rainfall of 5800 mm(World bank group, 2020). Thousands of rivers and their estuaries carry the water to the sea, but Bangladesh faces flooding each year. Cumilla city lies on cancer, has an average elevation of 70m (*Comilla - Wikipedia*, n.d.), and mostly flat. Flooding is a significant problem in this part of the country as well due to the Meghna delta. So, it seems normal that the municipality of Cumilla will also have a flooding problem. This is mainly because of the absence of a proper rainwater management system. The city sewage and rainwater drainage are not separate. Water retention zones are vaguely defined. A lot of the rainwater thus comes pouring into these ponds unfiltered and polluting the pond-water. It will help reserve some of these existing waterbodies as stormwater retention zone for a proper stormwater management system. Coastal countries like Bangladesh falls under the significant threat of sea-level rise as climate change is imminent. Bangladesh will lose 15 percent of its land by 2050 if the sea level rise to 50cm(EJF, 2018). Cumilla is situated in the eastern part of the country and not so far away from the shore.

Flooding was also a common problem of Cumilla due to heavy rainfall and flash flood from the river Gomoti. However, after the embankment on both sides, the city is now safe from the yearly flash flood. Even the recent development of flooding shows that this region remains unaffected. Now the only problem that remains is the stormwater within the city. The proper rainwater management system is absent. This leads to water clogging in the city drains and causes waterlogging. Unfiltered and direct rainwater flows to the ponds and lakes, polluting the water and harming biodiversity.

The urban heat island effect is also perceivable now more than ever. As more and more challenging surfaces are being erected city is getting more and more heated. Evaporation of urban wetlands reduces this effect very ineffectively as most of these water bodies are covered with waste, algae, and other plant substances, which reduces the evaporation process. The city is also losing its greens and thus no shade to the ground to reduce heat gain.

In these contexts, it seems the solutions to flooding and climate change lie within the city. A well-maintained solution for stormwater management, a proper guideline for Blue-Green-Infrastructure, sustainable building code, LID, and sponge city concept can transform the city into a climate-resilient future city.

3.7.Ponds

Pukur is a water body that is smaller than a lake. There are bigger Pukurs which is called Dighi. It is one of the essential parts of the Bangladeshi homestead. From time immemorial, pukurs are dug by people. It had been seen as an extension of our household. Like the living area, the kitchen, the verandah, pukur is also a functional space for the dwellers. It was common practice for women to soak house dishes and utensils in the water and wash them the next day in older times. It was so popular that when people referred to how big a settlement is, they counted how many Pukurs there are in that settlement.

In our monsoon climate, water is abundant. Rivers and their tributaries have covered the whole land like a fishnet. Water scarcity was not a problem for irrigation or any other use until the dry season came. In these challenging times, a pukur becomes an oasis. Many water bodies were not part of the homestead but were distributed among the fields where farmers work. Trees surrounding the water create shades for the people working under the scorching sun.

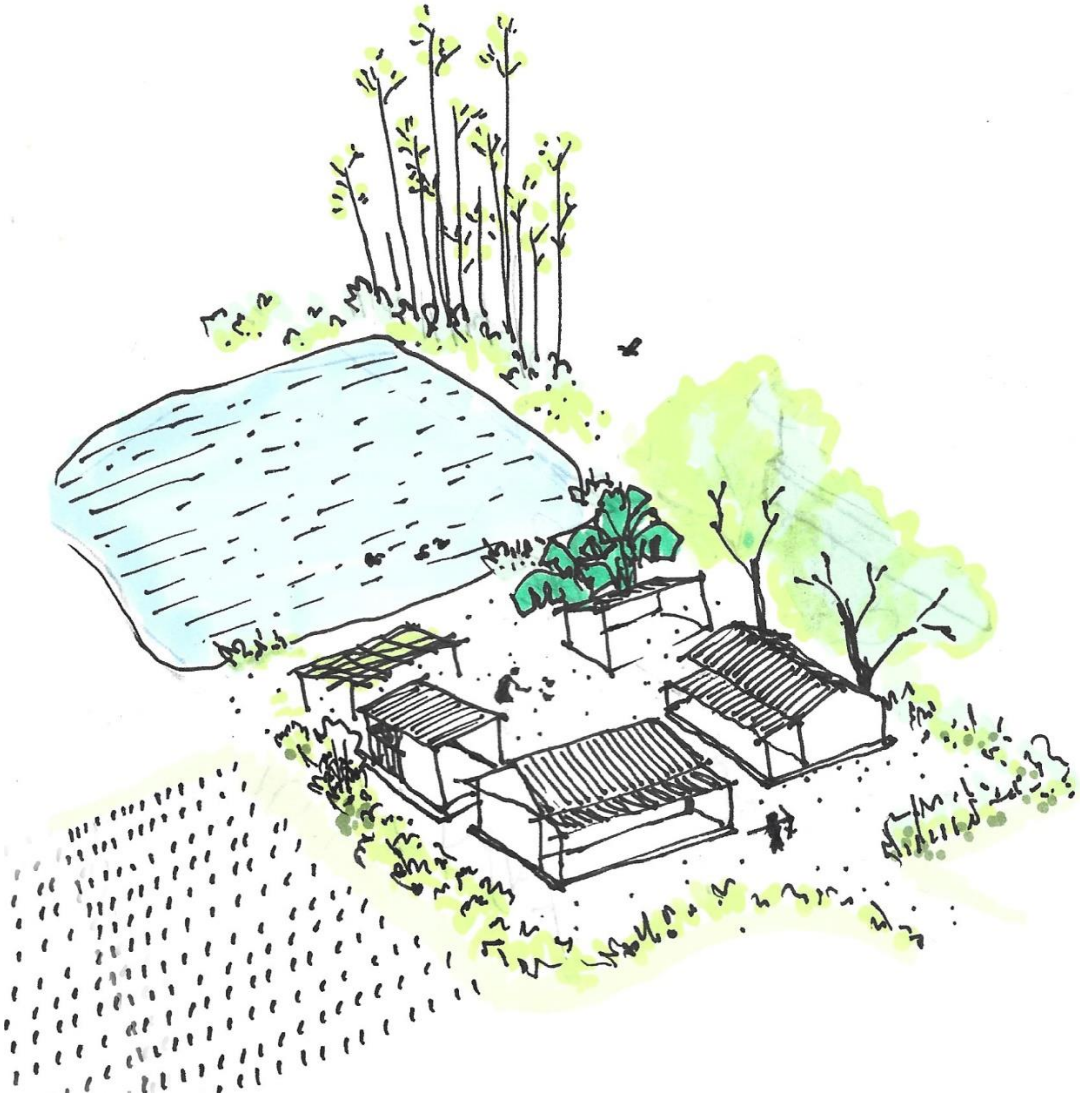


Figure 3.13:A common house type of Bangladesh with Pond as an intricate element of the household

Ponds of Cumilla are all historical ponds. From the history of Cumilla, we know this place was home to many substantial historical, cultural conglomerations. Many of these ponds were made from earlier city flourishing times to ease the people's water scarcity. The unique history of these ponds has little to no documentation or is hard to find. However, almost all of them have histories and myths surrounding them, which can be heard from the local people. Pukur or Dighi; ponds in this area have a common typology. A high band surrounds every pond to restrict rainwater.

Furthermore, there are one or more Ghats which is a structure to go into the pond. People used these ghats for daily chores of life like washing, bathing, fishing, etc. Sitting by the pond and socializing is as old as the history of ponds.

Many Pukurs and Dighis (Bigger Pukur) were dug by the then rulers for the people. Many types of Pukurs existed for various purposes. Pukur along paths of settlements for the travelers, Pukur at the front of the home with seatings, pukur in fields for working people,

Pukur for women, Pukur for washing, Pukur as a recreational asset for the high class, and so on.

Apart from its physical inclusion, it has an immense cultural value. Digging up a Pukur itself was a big event. It is believed that after a Pukur or Dighi is dug, the queen of that area has to bathe there for the coronation. It was a widely celebrated tradition to collect water from seven Pukur for the bride's bathing ceremony in every marriage ceremony. Not all Pukur were used for collecting drinking water. Usually, there were designated Pukur for that purpose. In the morning, women of many households get together to go and collect water for the day. There are not many religious practices that do not start from water.

Folk stories are filled with incidents surrounding these water bodies. So many tales and songs originated from here. Nothing stays forever. So are these stories. They are lackluster now in our Urban living. These land spirits are shredded into pieces and scattered around in these water bodies filling up now, sending these spirits to the grave.

Every pond had various functions, and depending upon their functions, they were maintained differently. However, today these needs are forgotten, and so are the structures of these ponds. Any typical water pond follows the natural ecosystem that contributes to the surrounding natural setting's habitats.

To conserve these ponds is to conserve their ecosystem and their physical form. In the city, when we talk about the blue-infrastructure, maybe it is not required for each pond to be used as fishing ponds, but we can define a common criterion like the depth so sunlight can reach its bottom to sustain the biotic elements. Furthermore, clean the surface from any harmful coverings that restrict this sunlight. We have seen some ponds recognize a public open space as people use these as meeting points and other social gatherings from the survey.

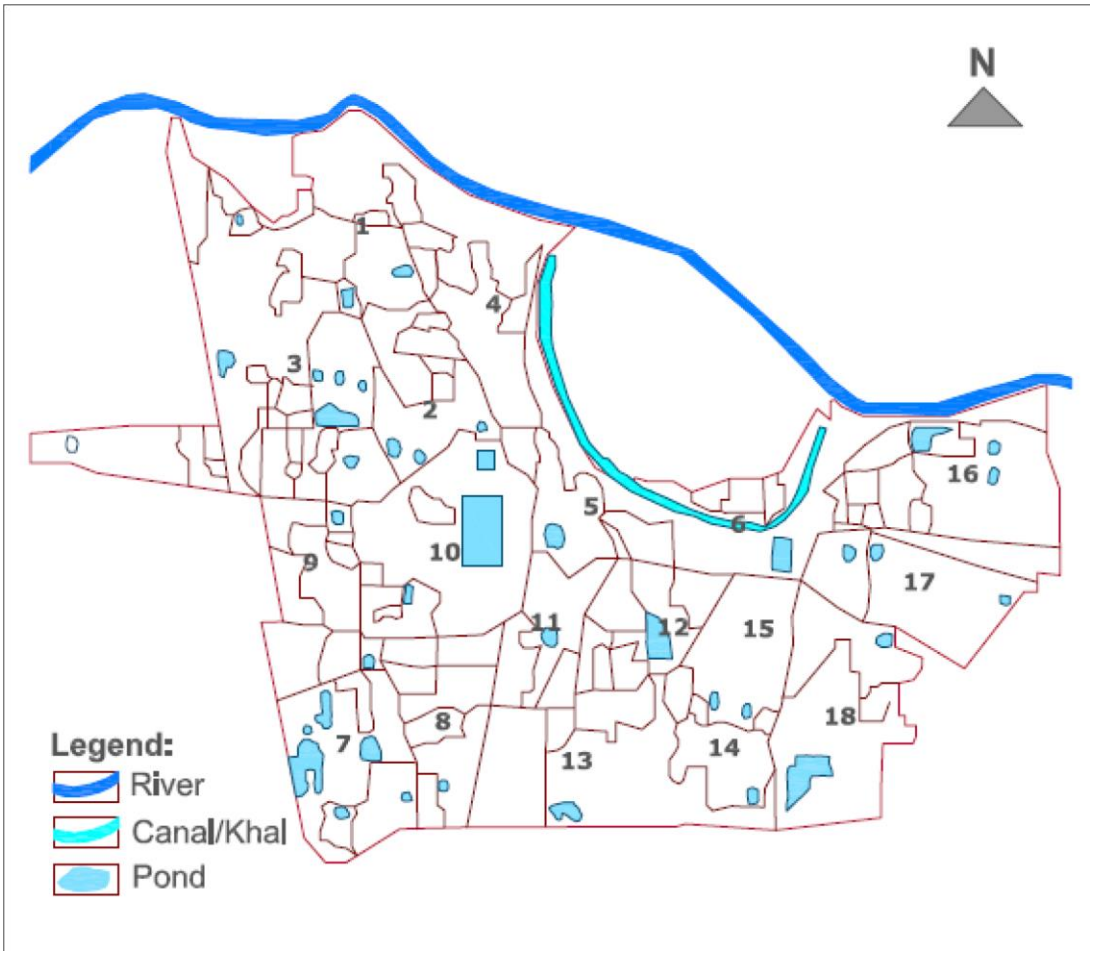


Figure 3.14: CoCC map of important water bodies within comilla core city (March 2014 JAPAN INTERNATIONAL COOPERATION AGENCY PADECO Co., Ltd., 2014)

Comilla City Corporation recognizes eight main ponds marked as essential and usually maintained (*March 2014 JAPAN INTERNATIONAL COOPERATION AGENCY PADECO Co., Ltd.*, 2014). This will help me develop a design solution around these ponds to create public open spaces.

3.8.Pond Banks

As Zamindars dug ponds, landlords and Rajas always tend to have other vital elements by their banks. Many historical structures standstill now by almost each of these ponds. Then there are ponds dug for religious purposes. So, mosques, temples are also found by their sides.

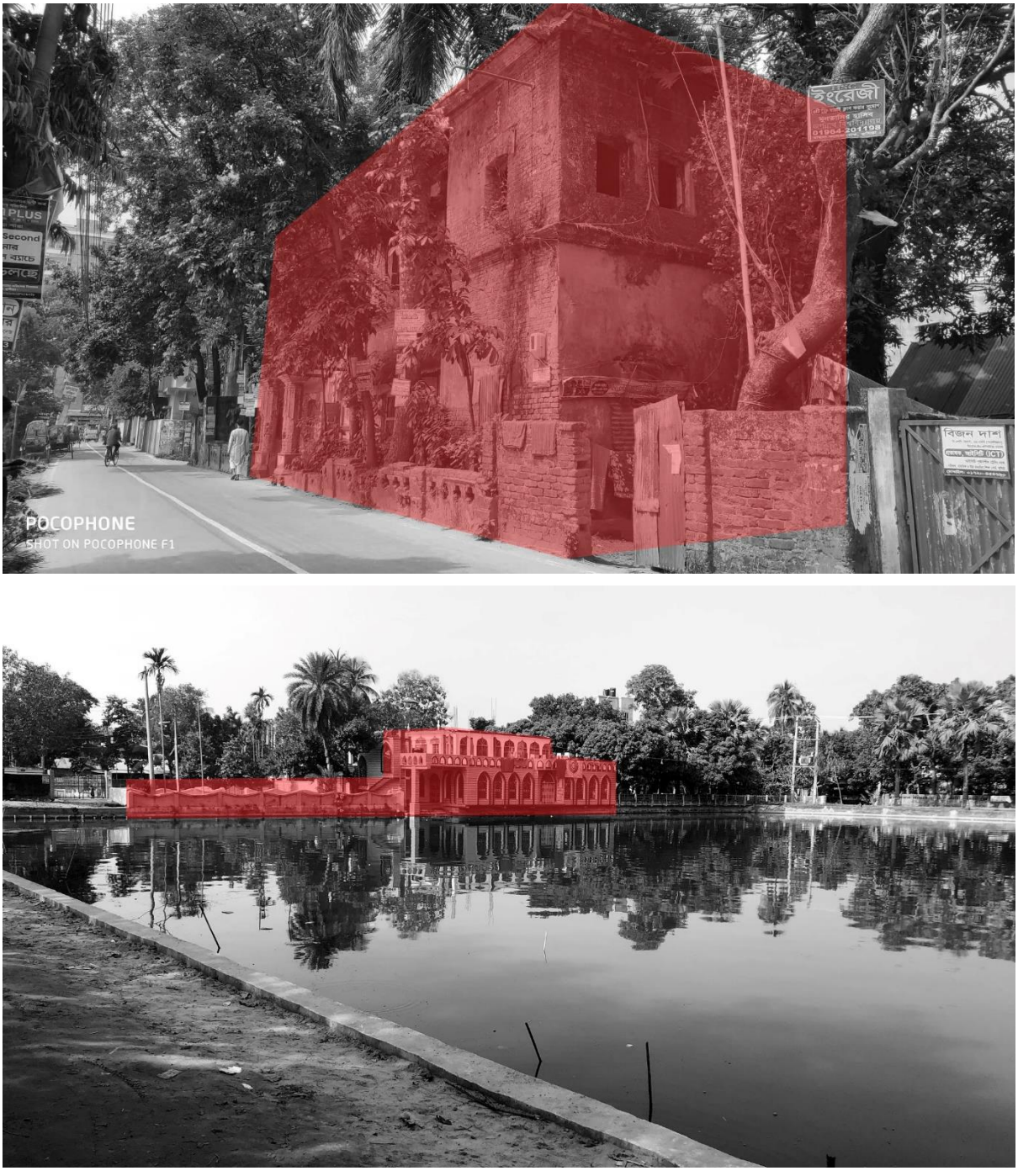


Figure 3.15: Historic and Religious Establishment by the Pond: (photos: Mamunur Mamun

Now ponds are surrounded by urban fabric, leaving no space for the ponds to develop further. Many of the adjacent dwellings are built at the edge of these ponds restricting

continuous connection around them. Historical and Religious structures exist, but most of them cut ties with these ponds by the name of urbanization.

Figure 3.16: Educational and Residential establishments by the pond (Photos: Mamunur Mamun)

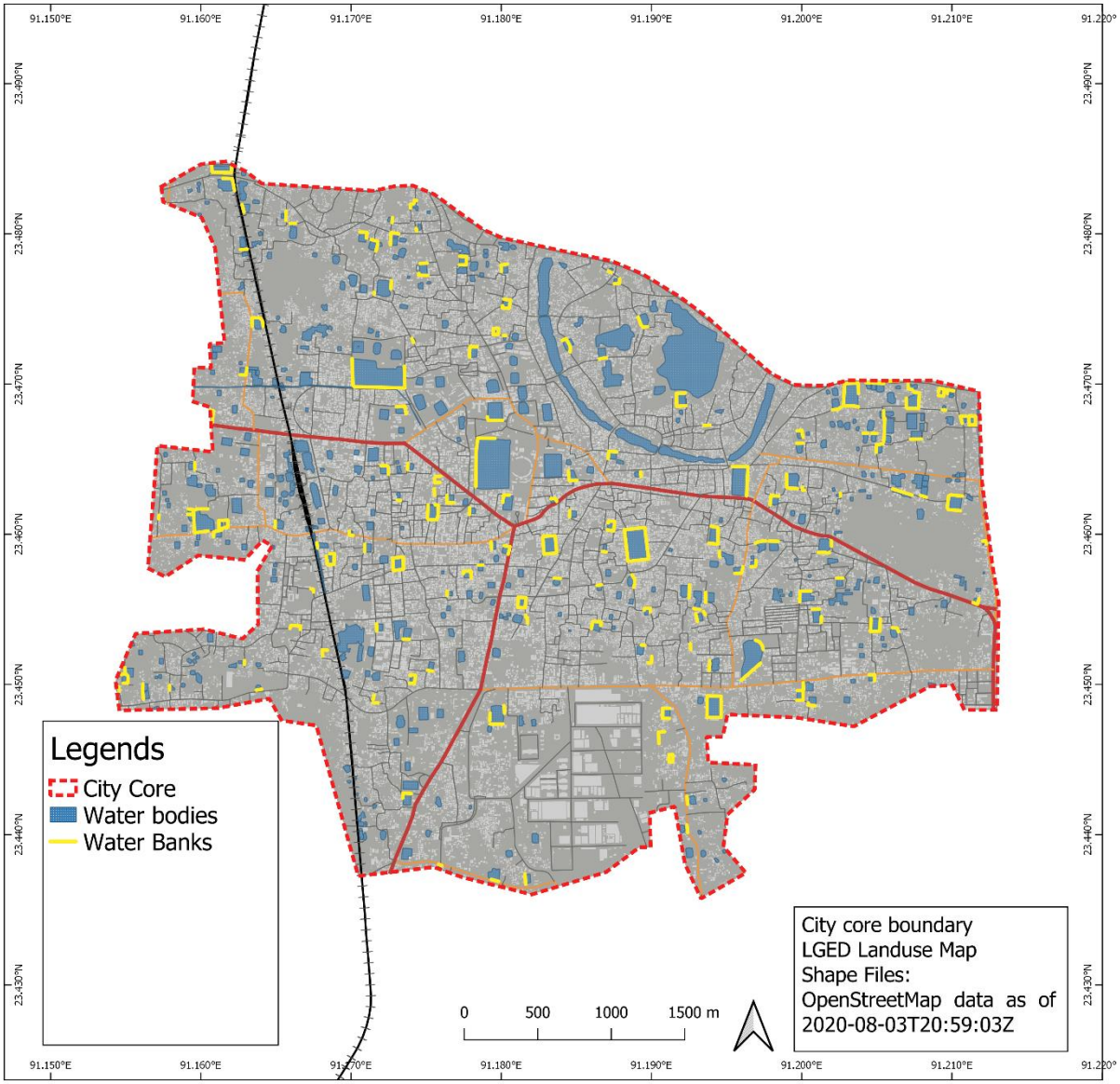


Figure 3.17:Banks of various water bodies and their shapes

Not all the ponds are accessible through all sides. Only a few of the ponds have connected banks. Some have broken connection which can be reestablished. Nevertheless, the rest of the ponds have one or two faces shared with the street.

Also, the street width varies depending on the pond and its location. Some pond banks have buffer areas from the street, while some have none. Some banks have proper pedestrians built along.

Figure 3.18:Boundary walls separating man from nature. (Photo: Mamunur Mamun)

These walls are built along property lines cutting off connection to nature. This is not only unpleasant for the owner, but also it creates a suffocating landscape.

Figure 3.19:Buffer between street and pedestrian (Photo: Mamunur Mamun)

This portion of buffer area is present in almost all central pond banks between the pedestrian and the street. The pedestrian in this photo is relatively newly built as this is

one of the significant ponds inside the city. Other ponds usually do not have proper pedestrians.

Figure 3.20: Green Buffer. (Photo: Mamunur Mamun)

This type of plantings can be seen all over the city, which lacks any design guidelines and public accessible functions. They also require high maintenance, so the city could not implement these guidelines for all the ponds.

Figure 3.9:Tree Buffer. (Photo: Mamunur Mamun)

These buffer areas hold great potentials to restrict stormwater from entering ponds and develop functional urban open spaces around the ponds.

3.9.Ponds as Open Spaces

For us, human 300m is a suitable walking distance. Moreover, in a healthy urban environment, open spaces should be integrated so that people can pass their time within this walking limit. There will be unique hotspots in the city with multiple activities to serve the whole city, but each neighborhood should have its piece of land where they can relax and call it their own.

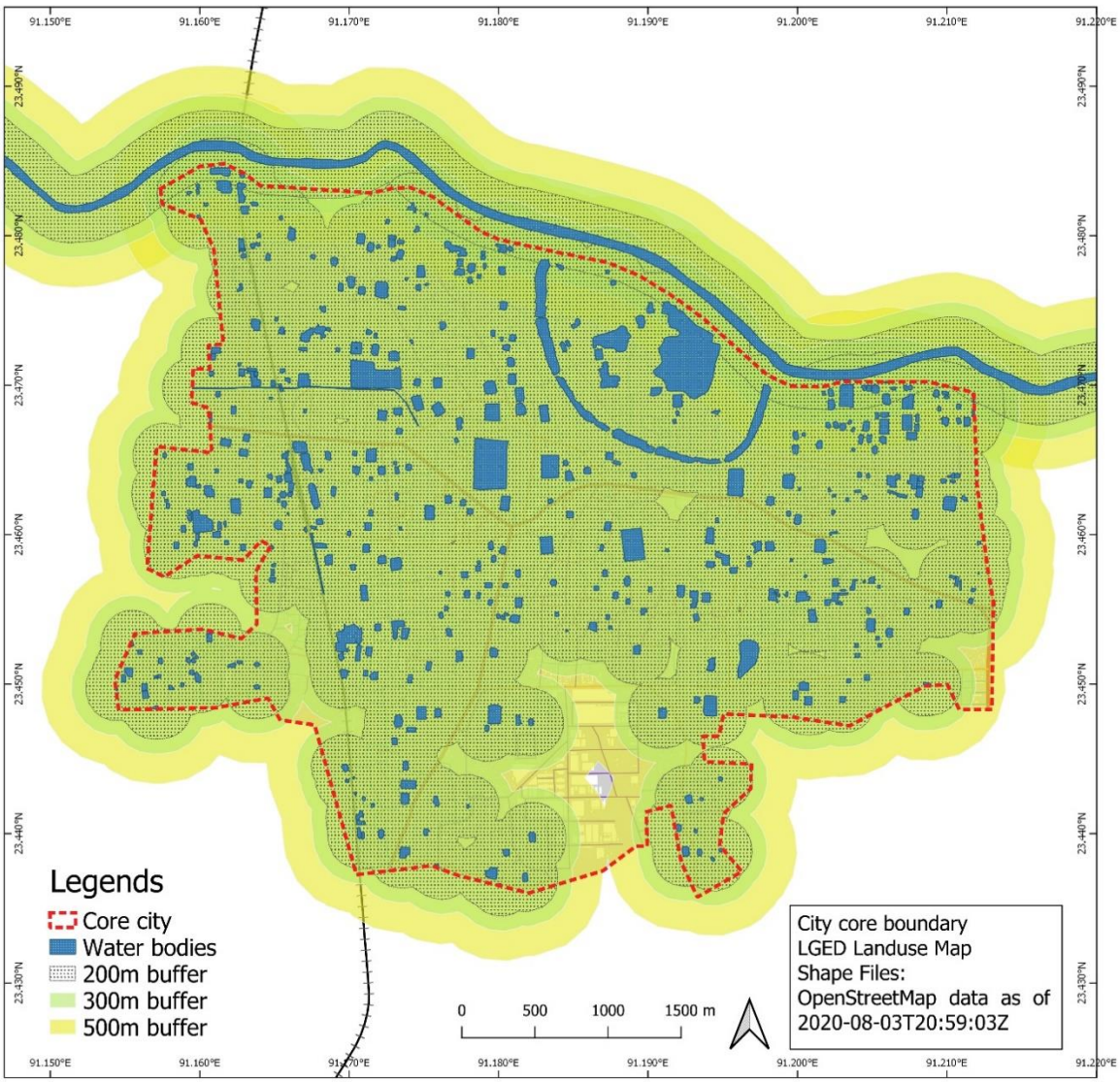


Figure 3.21:Buffer zones to show how all the waterbodies can create a breathing city

Current open spaces with this parameter show that they are very inadequate.

Taking this parameter of 300m, I took a buffer in my GIS analysis to see how well these ponds can function. Here it shows employing a simple guideline for each of these ponds

can serve as an urban open space. Moreover, these urban open spaces will be full of water which is part of life.

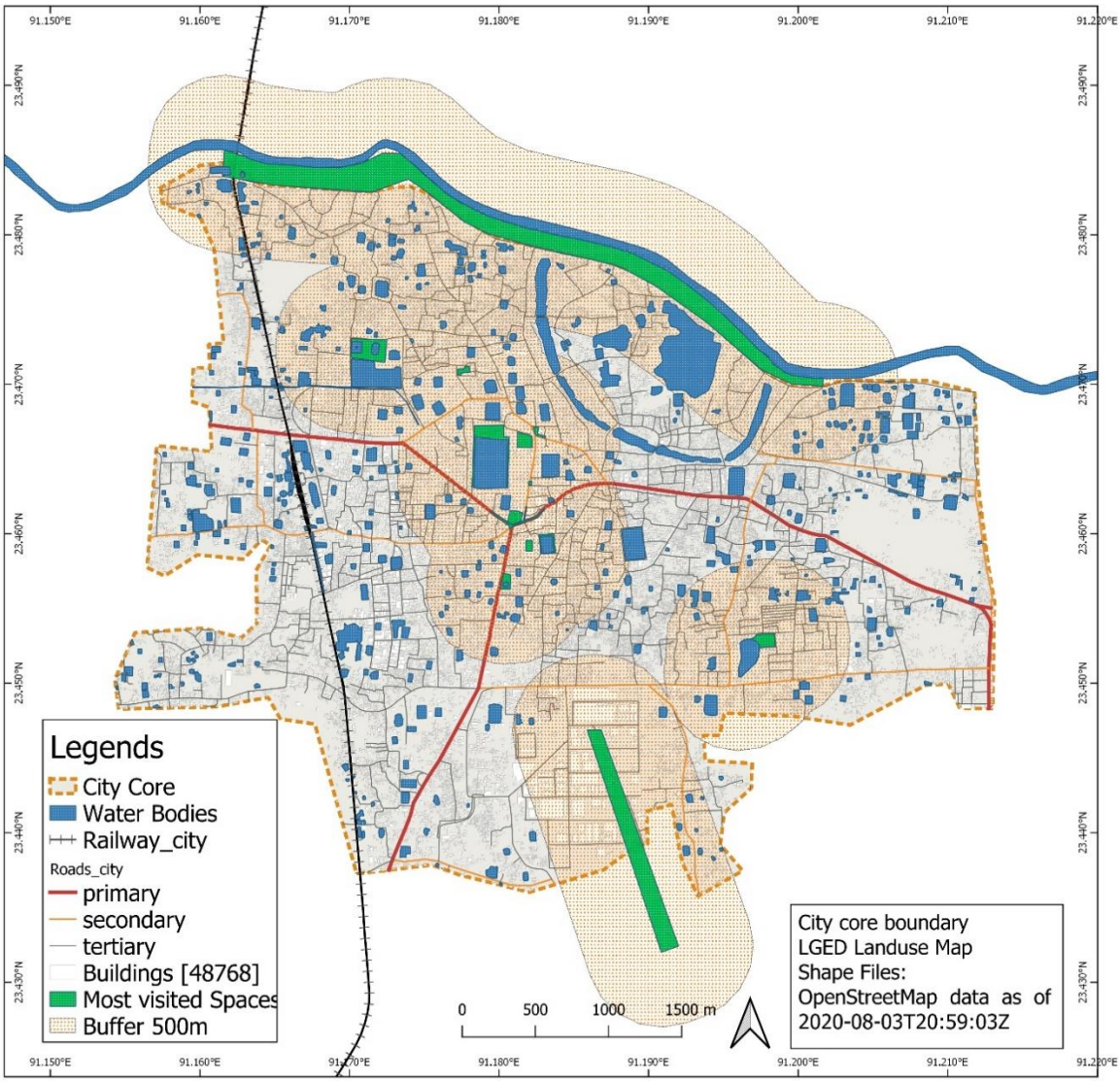


Figure 3.22: Inadequacy of the current frequently used public open spaces

3.10. Case Study 1: Qunli Stormwater Wetland Park, China

Project Name: Qunli Stormwater Wetland Park
Project Architects: Turenscape
Project Location：China Qunli New District, Haerbin City, Heilongjiang Province, China
Project Concept: Sponge City
Project Scale：30 hectares
Design Time：June 2009-2011
Project Source: https://www.turenscape.com/en/project/detail/435.html, 23.10.20

Figure 3.23:Qunli stormwater wetland park. (https://www.turenscape.com/en/project/detail/435.html, 23.10.20)

The sponge city concept is a new Urban design concept which is gaining popularity among landscape designers, urban designers, and architects in recent years. Chinese government got

so fond of this concept that 16 pilot cities are chosen to implement this excellent water management strategy (https://www.worldfuturecouncil.org/sponge-cities-what-is-it-all-about, 23.10.20). It will not only give sustainable cities of future but natural heaven for the dwellers. Turenscape is a Multidisciplinary consultancy firm conducting designs that bring Nature, Man, and Spirit into One. Qunli Stormwater Wetland Park is one of the most successful works Turenscape has implemented at the outskirt of the Qunli New Town.
The New Town of Qunli is 2733 was planned at the beginning of 2006 at the outskirt of Haerbin city of North China. Thirty-two million square meters of land will be urbanized at this former natural wetland. The permeability of the city will be reduced dramatically by this great endeavor. As a result, the former wetland is now at a threat. Turenscape faced a great need for a new strategy to transform these dying wetlands and provide multiple ecosystem services for the city's new dwellers. This challenge made it possible to implement the "Sponge City" concept. A sponge city is not impermeable to water like contemporary cities, but it absorbs the water like a sponge, holds it, filters it, recharges urban aquifers, and release excess water. In the meantime, it is providing healthy well-being for the people and replenishing the ecosystem.

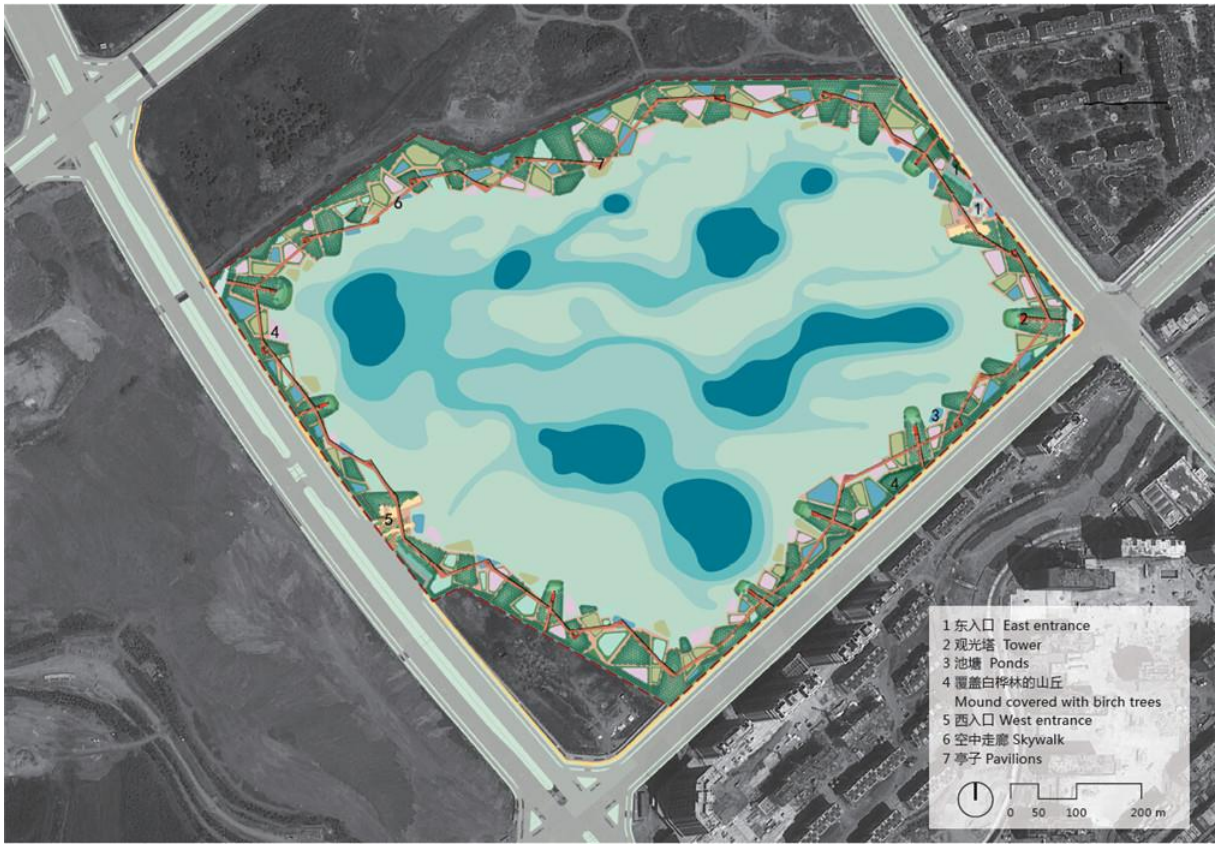


Figure 3.24:Necklace shaped landscape surrounding the core area (https://www.turenscape.com/en/project/detail/435.html, 23.10.20)

Design Strategy: First decision was not to touch the core area. An undisturbed core wetland is left for natural functions. The surrounding area is transformed into a necklace of ponds and mounds utilizing cut and fill. This way, the periphery becomes an active infiltration buffer for the stormwater, which is treated naturally before getting into the core area.
This ring of ponds and mounds creates a smooth transition from nature to city. This welcoming landscape invites people to come close to nature without disturbing the core ecosystem.

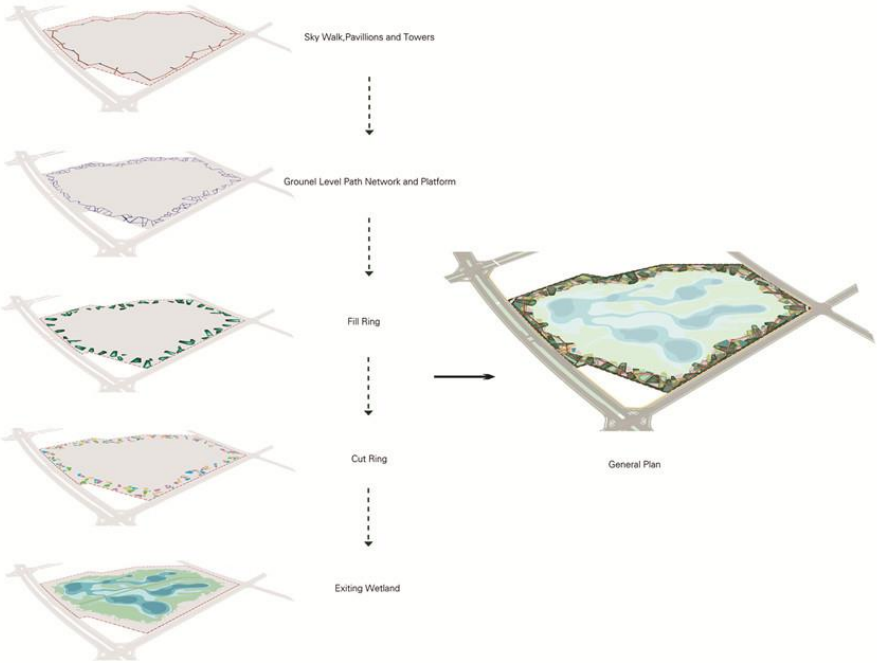


Figure 3.25:Multi layers of Landscape elements (https://www.turenscape.com/en/project/detail/435.html, 23.10.20)

The ring can be seen as these layers. Cut rings are a network of shallow ponds that retain water and slowly disperse into the core area. Then the filling layer creates an undulation effect on the landscape. The overall landscape creates a natural up and down within a small scale.

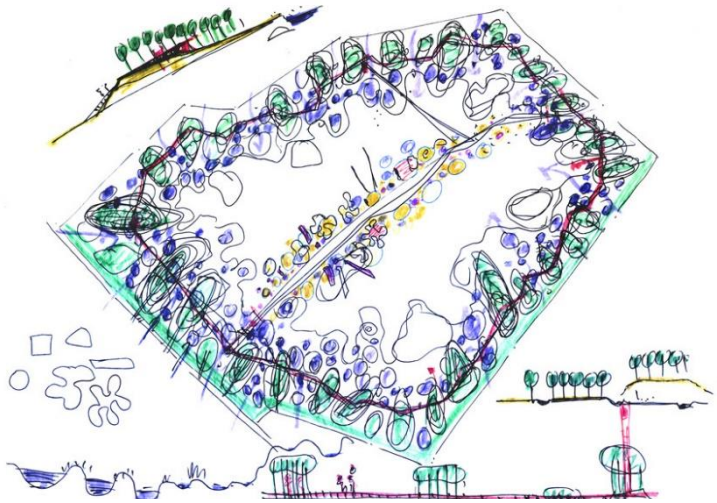


Figure 3.26: Cut and fill concept. (https://www.turenscape.com/en/project/detail/435.html, 23.10.20)

Then, a ground network of paths and activity zones was added. Towers, skywalks, and pavilions are added to create viewpoints and landmarks within the landscape.

Here we can see the core area left out and the surrounding ring area. The ring consists of different levels of earth modifications; Different levels enable different experiences and functions. Pathways go through these elements creating surprising spaces and activities.

Figure 3.27:Ground and elevated pathways create a multilevel experience. (https://www.turenscape.com/en/project/detail/435.html, 23.10.20)

Skywalks with decks are implemented for smooth walks throughout the whole area. People can experience forests, marshes, and little hills when walking through the pavements that go throughout the landscape. Seating areas by the ponds allow people to interact with water and green. On the other hand, a network of skywalks connects fast routes to and from pavilions, towers, and other locations. This also gives a multi-level experience that activates the space with a lively atmosphere.

Figure 3.29:Pavilions, watchtower and viewing decks. (https://www.turenscape.com/en/project/detail/435.html, 23.10.20)

Watchtowers create over the canopy views and are the landmarks; they orient people and the site. Pavilions with various functions and programs support the landscape and users.

Figure 3.30: Betula forest (https://www.turenscape.com/en/project/detail/435.html, 23.10.20)

Native Silver Birch (Betula) trees are planted in grooves of different heights that create small forests which people can experience through paths going through them.

Ponds are planted in various depths with native wetland grasses that activate the natural evolution process. Flowering plants both in monoculture and mix-culture are planted that convey different sensations to the users.

Figure 3.31: Seating by the ponds (https://www.turenscape.com/en/project/detail/435.html, 23.10.20)

Year 2011 one year after the stormwater park was built

Year 2014, 4 years after the wetland park was built; residential development was catlized by the stormwater park

Figure 3.32:Evolution of landscape (https://www.turenscape.com/en/project/detail/435.html, 23.10.20)

In the end, a dying wetland is transformed into an efficient source of ecosystem services. The city's flooding risk will not be a problem, and the city's dwellers can come and reconnect with nature at a reliable distance. This water urbanism approach has granted this project the National Urban Wetland Park title.

This case study shows an excellent example to deal with wetlands adjacent to the city. An ecologically rich blue infrastructure surrounded by cityscape can still function and provide ecosystem services. People from the city can quickly come, play, meet and contemplate here within walking distance and still do not harm nature. This vast waterbody is also the solution to the rainwater problem, which is invited here. A beautiful example of synchronization of nature and human that environmental, sustainable, and aesthetically pleasing.

3.11. Case Study 2: Domino Park, USA

Project Name: Domino Park
Project Architects: James Corner Field Operations
Project Location: Brooklyn, USA
Project Concept
Project Scale: 6 Acres
Project Year: 2018
Source: https://www.dominopark.com, 28.10.20

Figure 3.33:Domino Park, Brooklyn (https://www.dominopark.com, 28.10.20)

At the New York's most iconic industrial waterfront, the Domino sugar factory area is transformed into a park that recognizes the resiliency and diversity of the different generations of workers living in that neighborhood. 30 large-scale salvaged relics and 21 original columns from the former Sugar Warehouse are integrated to the landscape that re-enacts the history through "Artifact Walk" experience.

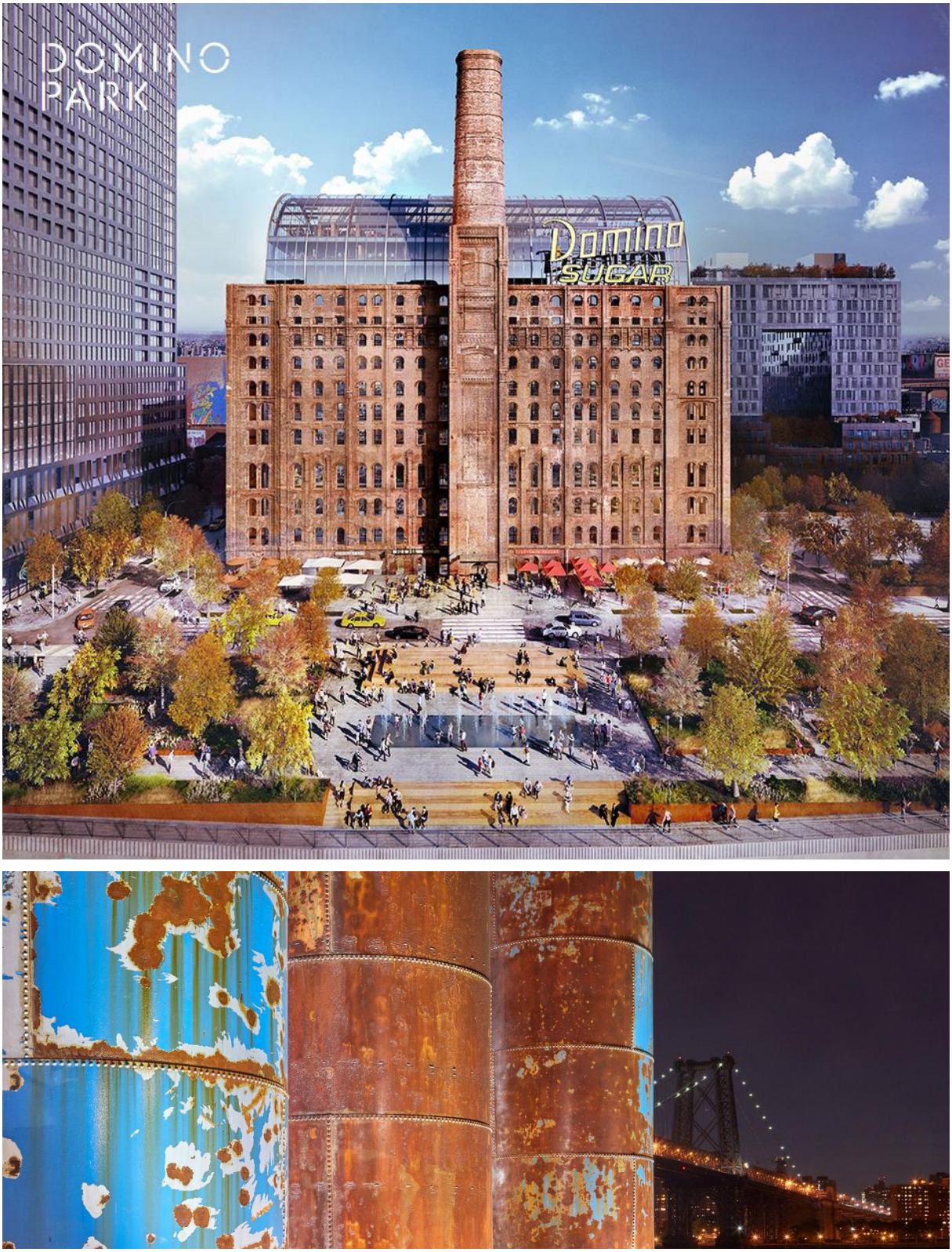


Figure 3.34:Historical Sugar Factory of Domino (https://www.dominopark.com, 28.10.20)

The iconic brick building with the smokestack is preserved at the center of the park. Over 150 years, this factory served the world under different names and owners. However, this intricate brick façade marks the spiritual heart of the Domino Park development area. Also, the building is reshaped to incorporate modern needs for the neighborhood's workspace. Other artifacts of old age are shown below that are preserved to contain the essence of history.

Figure 3.35:Industrial artifacts revived in the new landscape (https://www.dominopark.com, 28.10.20)

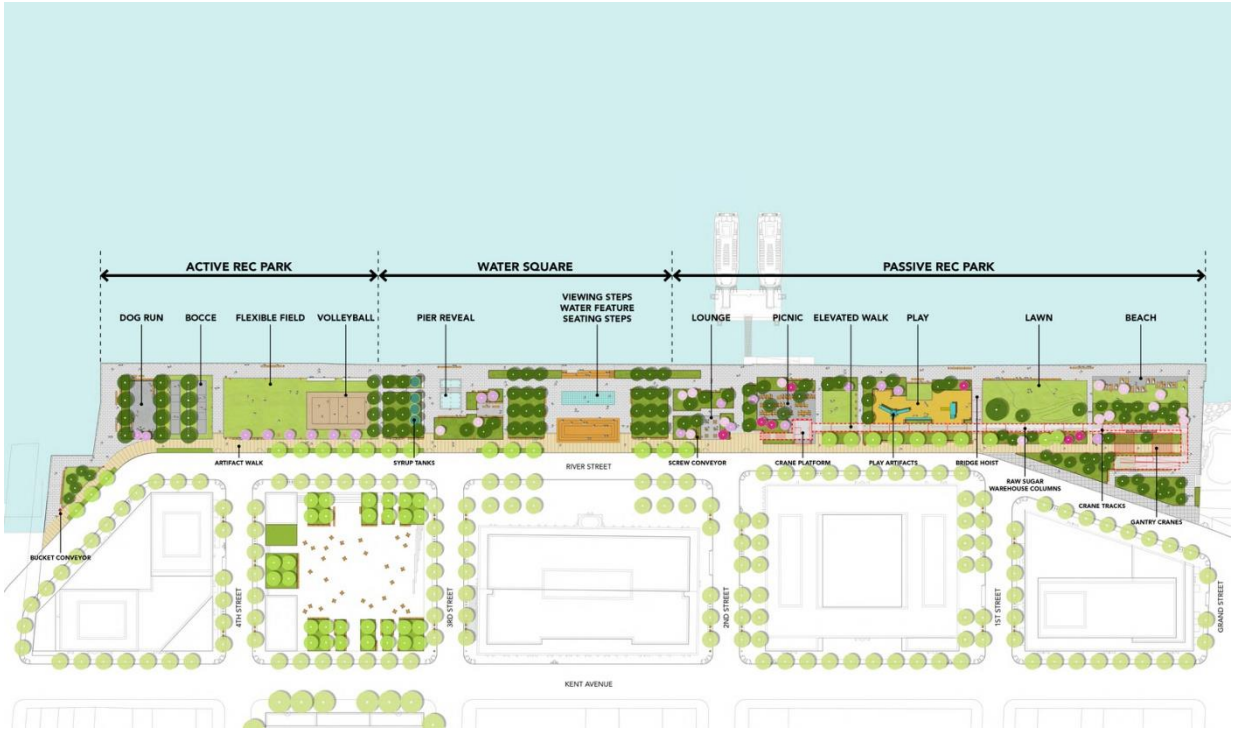


Figure 3.36:Domino park Plan (https://www.archdaily.com/914548/domino-park-james-corner-field-operations/5ca8cfea284dd1149400003d-domino-park-james-corner-field-operations-plan,28.10.20)

The 6-acres public park runs along the waterfront in a rectilinear fashion. The site is divided into three sections connected by two parallel pathways.

- Active Recreational Park
- Water Square
- Passive Recreational Park

Within each section, various activities are varied in terms of the user group, intensity, and playfulness. River street is connected to the city street, bringing the waterfront to the public realm to reduce the site's privateness and make it more open and accessible to the city.

Active Recreational Park:

Figure 3.37: Active Recreation Area. (https://www.dominopark.com, 28.10.20)

This part consists of the most vigorous activity of the park. A mixture of age group people enjoys different zones here. Dog run, Bocce, Flexible area, Volleyball ground are the main functions here.

Water Square:

Figure 3.38:Water Squar(https://www.dominopark.com, 28.10.20)

Coming through the artifact walk, the first thing after the active zone is the vast syrup tanks. Adjacent to it is the pier reveal area. There is a large area with waterwork and viewing steps at the central part of the park.

Passive Recreational Park:

Figure 3.39:Passive Recreational Area. (https://www.dominopark.com, 28.10.20)

This portion consists of slow activities like a picnic area, a lounge, a large Meadow area, a beach area, a playground for kids, elevated walkway.

This project is an excellent example of transforming a historical/industrial site into a dynamic live landscape that serves the specific neighborhood and the people of the city—taking consideration of the waterfront and stacking up a variety of functions within the 6-acres limit. Also, the response to a prolonged site and how to connect the whole area is a great example. Preservation of historic elements adds extra meaning employing storytelling through “Artifacts walk.”

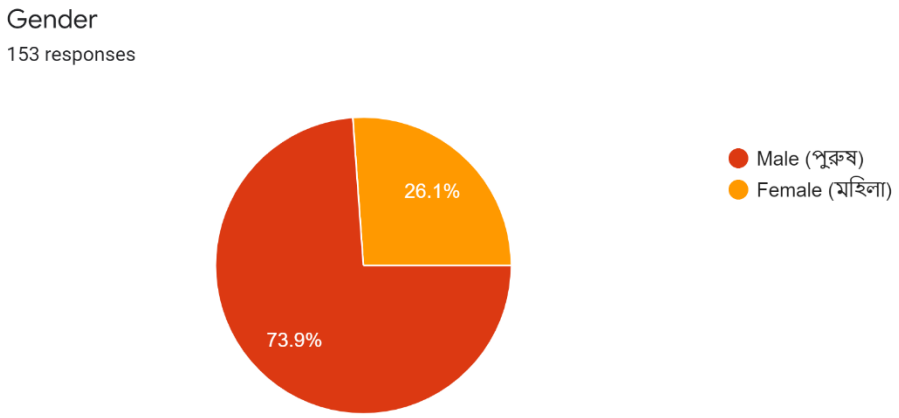
4. Survey Analysis

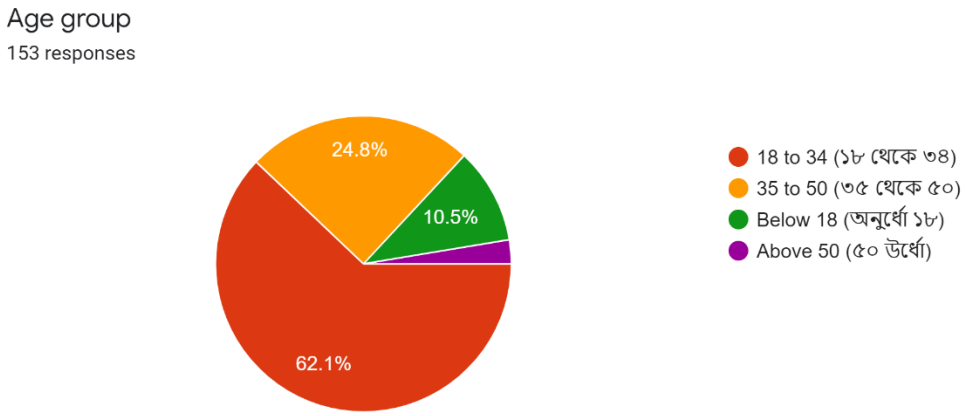
I have conducted an online-based questionnaire survey. With social media's help, a google form was circulated, and data was collected over two months. The survey questionnaire had four parts. The first part consists of primary data of person occupation, age group, gender. Then, the second part is about the water bodies of the city and the nearest waterbody. Secondly, the third part is about the nearest open space and the spaces that they go to most. The last part is their expectation from the city water bodies and the future city.
This survey's primary purpose is to identify people's feelings towards these water features, conditions, and how they feel about them. Also, to know the current condition of the open spaces. How they are inadequate and how they do not differ so much in terms of choice.

The results of the questionnaire survey are shown below.

4.1.User Group

The questionnaire was circulated through social media and emails to people residing in Cumilla city. Most of the users were students. Others consist of Architects, bankers, service holders, and all sorts of the profession.



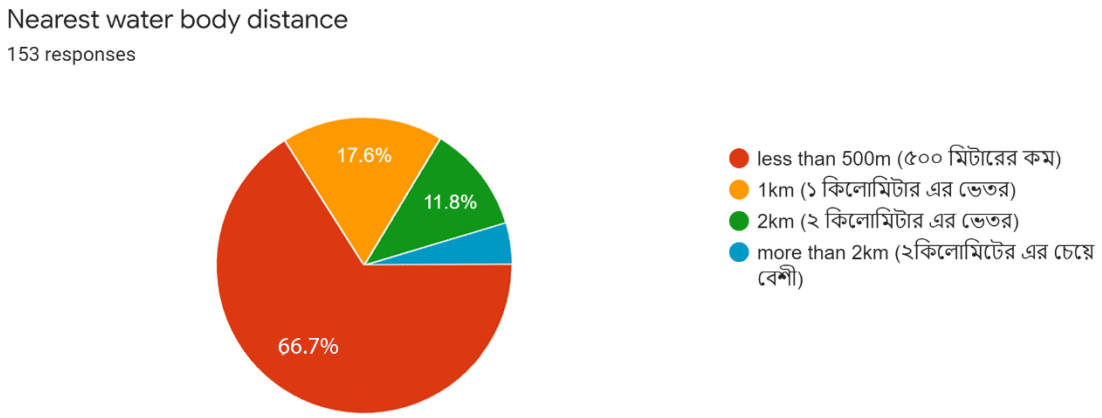


One-third of the participators were male, while the female participation was also very high. The age group consists mainly around 18 to 34. The next portion consists of people from 35

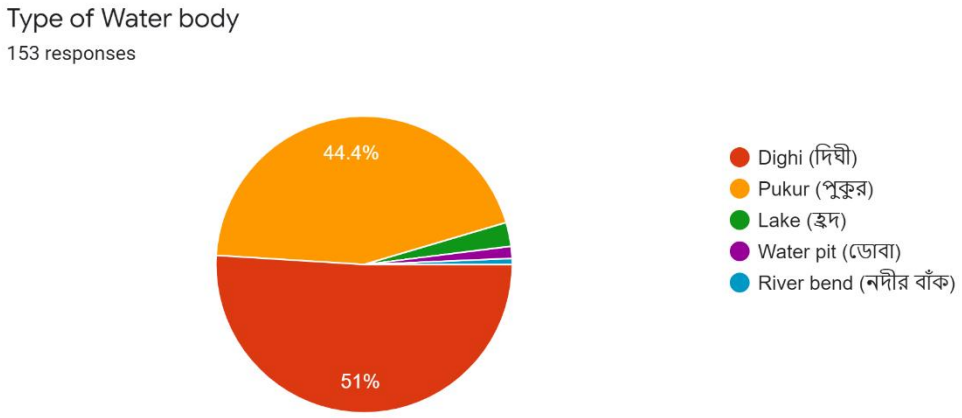
to 50. Both from higher and lower age categories also participated. Gender-based participation was essential to know how it affects their experience of the spaces and how safe they feel.

4.2. Questions on Water Bodies

Data were collected for the nearest water body and the relation between the water and the people, how the feature is used, and other city water bodies' condition. Many names came along that people noted as their nearest water bodies. They are listed below.
Dharmasagor Par, Taal Pukur, Fire Service Pukur, Nanua Dighi, Lau Dighi, Chotora Pukur, Ranir Dighi, Racecourse Pukur, Dhormopur Poschim Chowmohoni Pukur, Uzir Dighi, Moulobhipara Pukur, Gosnagar Pukur, Gulshan Lake, Ram Krishna Mission Pukur, Bagichagaon Pukur, Kaliajuri Boro Pukur, Jonglibibi Mosque Pukur, Durgapur Dighi, Kaptan Bazaar Pukur, Uttor Pukur, Cumilla Education Board Pukur, Munsef Bari Pukur, Bepari Pukur, Baitul Jannat Mosque Pukur, Durgapur Pukur, Choudhury Pukur, Karkon Rajar Dighi, Oaresh Bhuiya Pukur, Amir Dighi, Katabhil Koborsthan Pukur, Godhir Pukur, Bhuia Pukur, KTC Lake, Surgaon Dighi, Aam Dighi, Army Quarter Dighi, Shodor Hospital Pukur, Chowkbazaar Pukur, Jali Pukur, Badsha Miah Pukur, Kuchaitoli Pukur, Palpara Dighi, Sonali Bank Pukur, Jhawtola Pukur, Thana Pukur, Mogbari Pukur, Court Pukur, Dhoropur Dighi, Housing Colony Pukur, Nishnupur Pukur and many other Water bodies with no names.

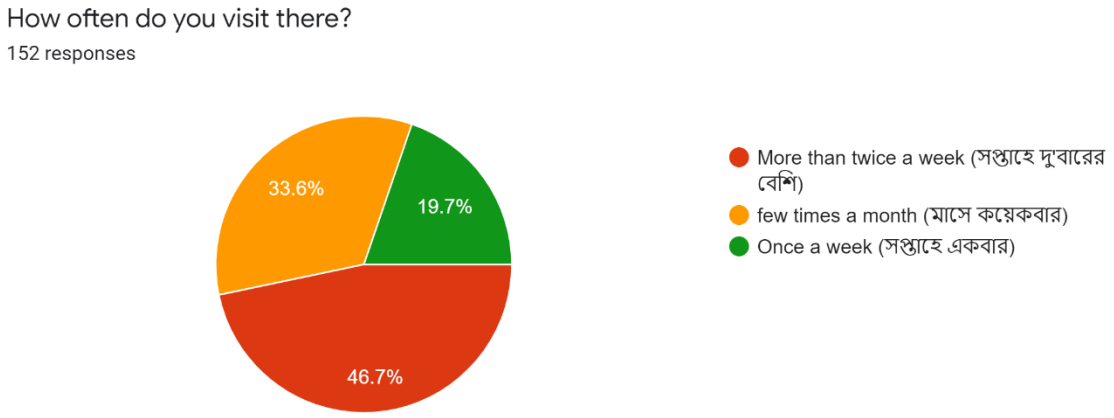


This is to be noted that most water bodies are less than 500 meters where people live.

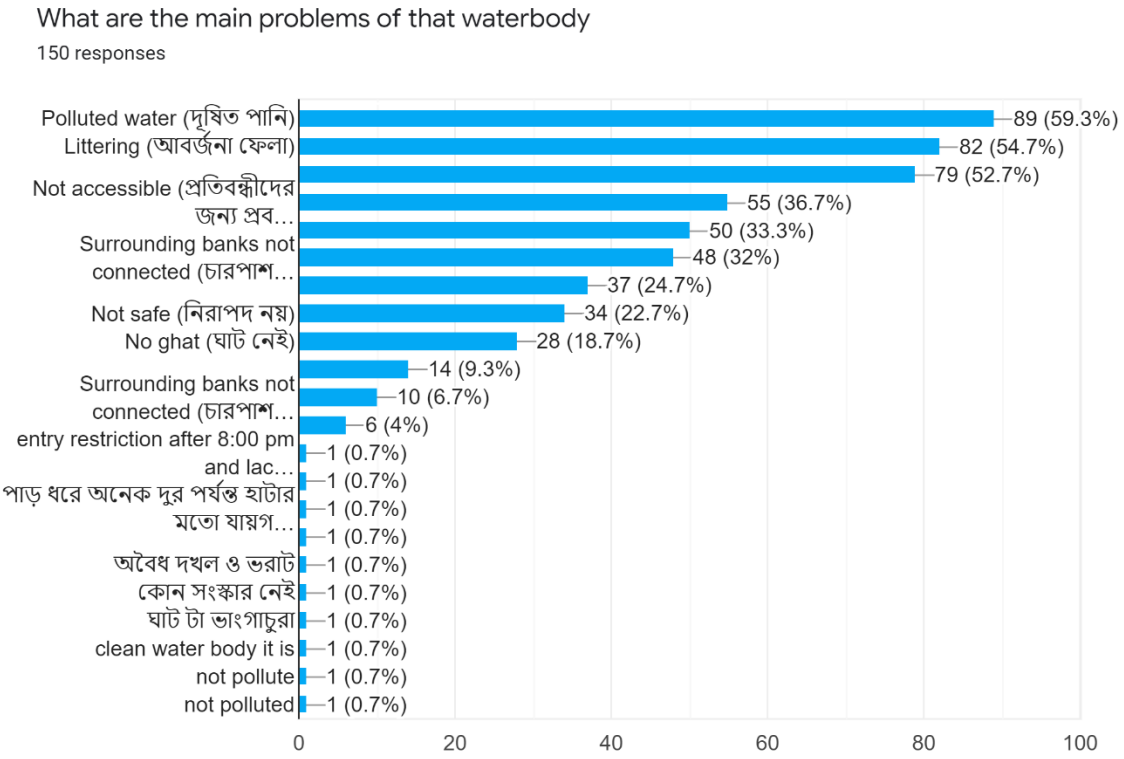


Almost all the water bodies of the city are Dighis and Pukurs. Other bodies consist of River

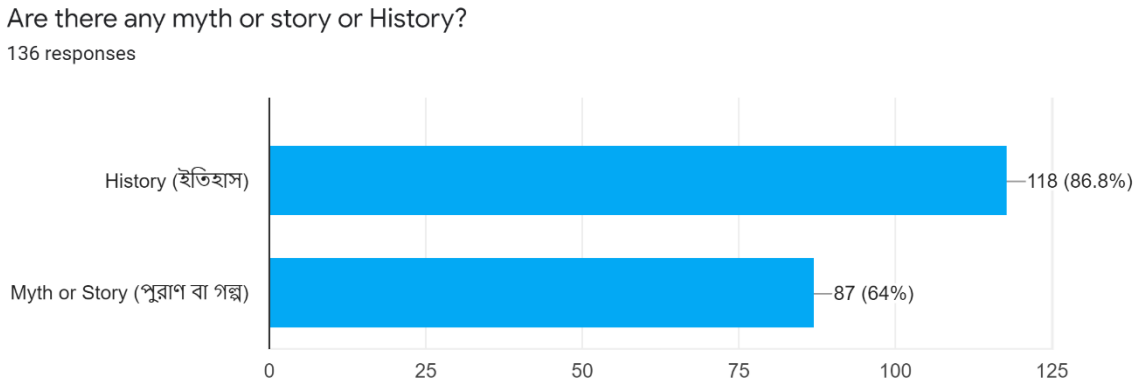
bends and small water pits. Lake noted here refers to Dharma Shagor, which is also a Dighi.



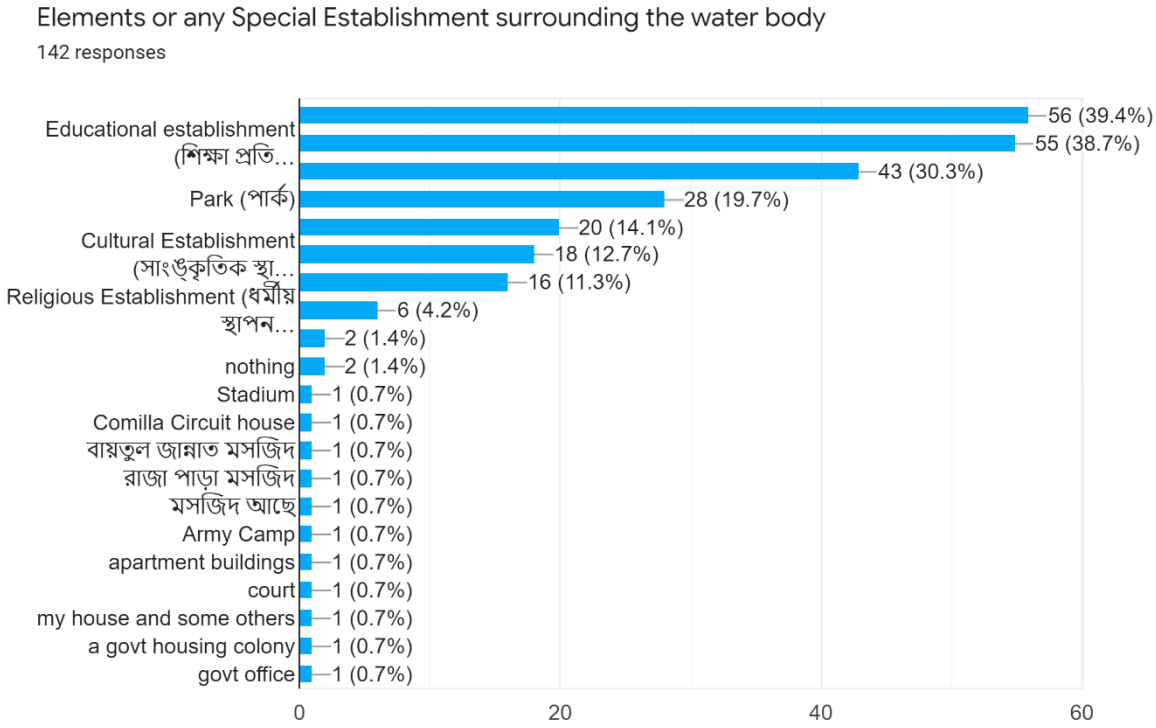
This shows the appeal of these elements to people. Because of lacings in proper facilities and environment, current stay time is short, and also most of these visits occur during people day to day life wayfaring. There are some common problems pointed out by people like the following chart.

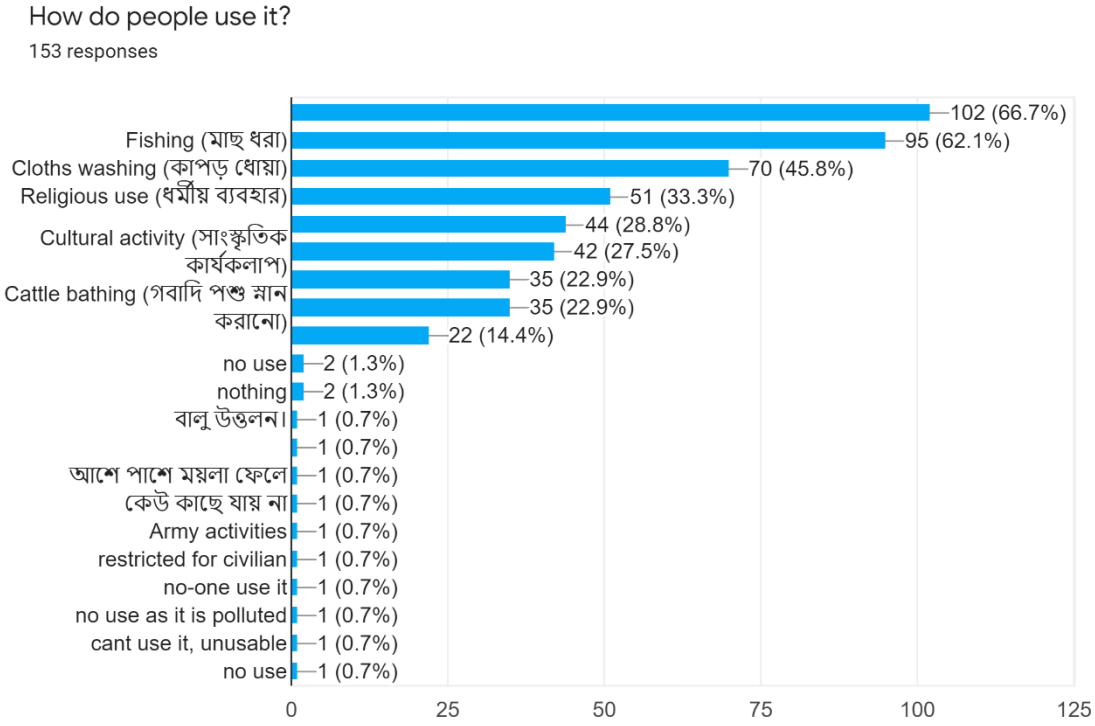


most familiar of all problems seems to be the pollution of water. Next comes littering and then having no access for disabled people. Only a few ponds have their banks connected which is a big problem for urban dwellers. Other problems like not having enough lights, note enough Ghats (stepped connection to the water), not having proper maintenance, not enough facilities to stay at the place.



Origin of each pond are historic. Moreover, since they are present for ages now, people developed some of the most beautiful myths surrounding the ponds. Each of these myths and stories is unique and worth preserving.




How do people use it?
153 responses
Fishing (মাছ ধরা)
Cloths washing (কাপড় ধোয়া)
Religious use (ধর্মীয় ব্যবহার)
Cultural activity (সাংস্কৃতিক কার্যকলাপ)
Cattle bathing (গবাদি পশু স্নান করানো)
no use
nothing
বালু উত্তলন।
আশে পাশে ময়লা ফেলে
কেউ কাছে যায় না
Army activities
restricted for civilian
no-one use it
no use as it is polluted
cant use it, unusable
no use
102 (66.7%)
95 (62.1%)
70 (45.8%)
51 (33.3%)
44 (28.8%)
42 (27.5%)
35 (22.9%)
35 (22.9%)
22 (14.4%)
2 (1.3%)
2 (1.3%)
1 (0.7%)
1 (0.7%)
1 (0.7%)
1 (0.7%)
1 (0.7%)
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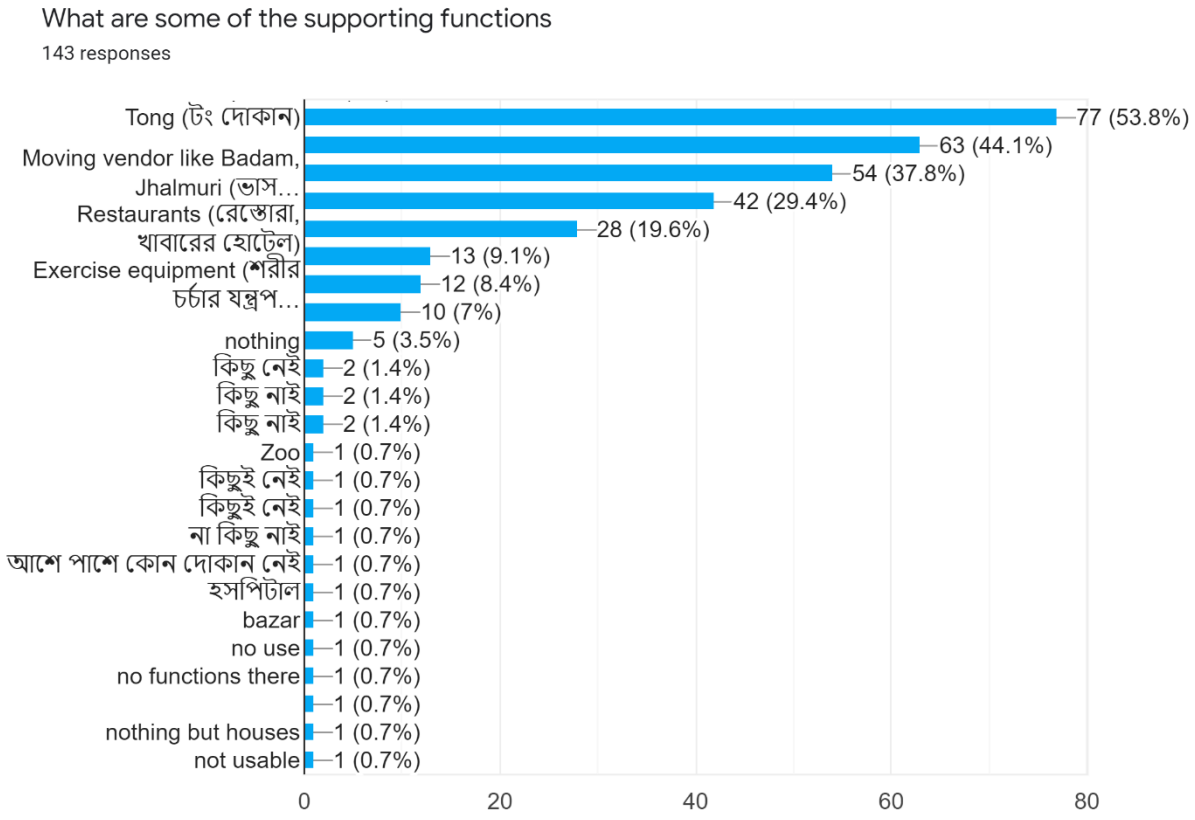
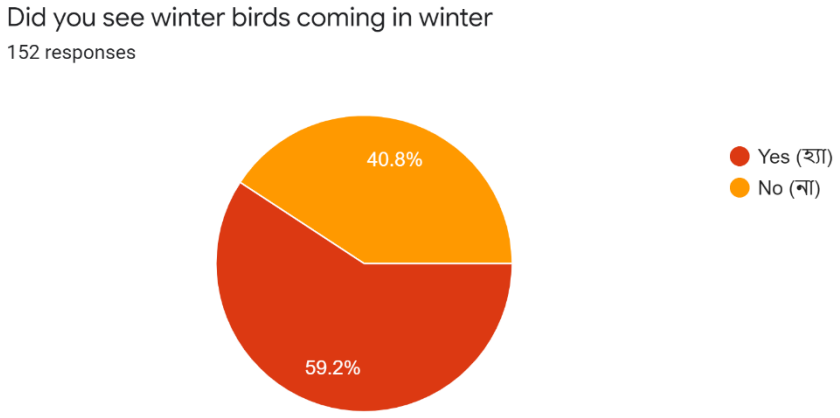
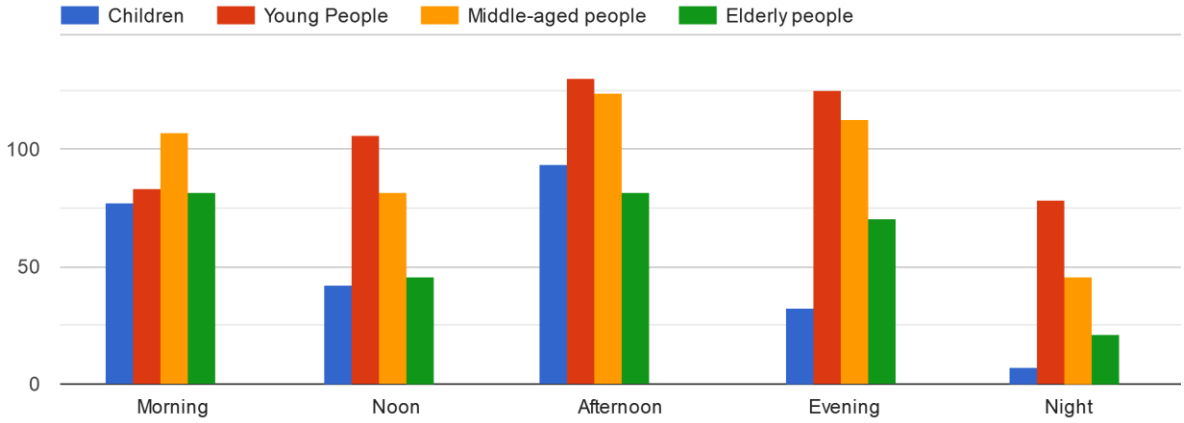
1 (0.7%)
0
25
50
75
100
125



This is an extensive survey that shows how many establishments surround the ponds and how much they vary. It shows none of these functions are properly situated, and many people also noted this as having nothing on the banks for people to enjoy.

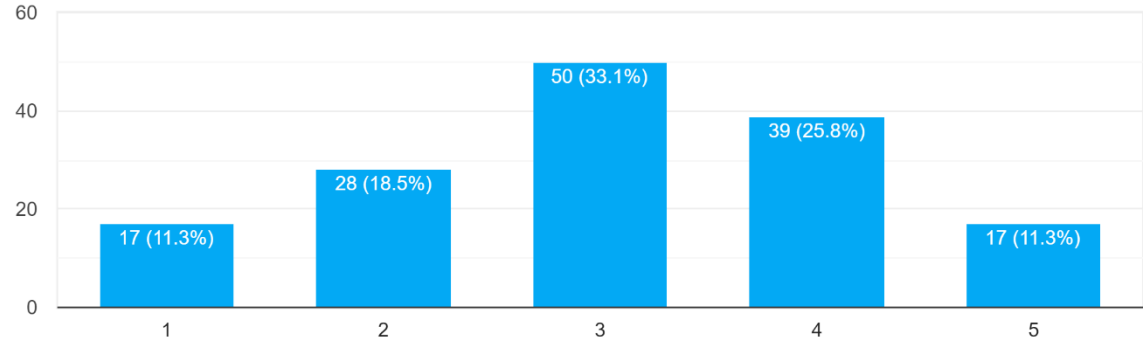


User group and the time of activity that you observed



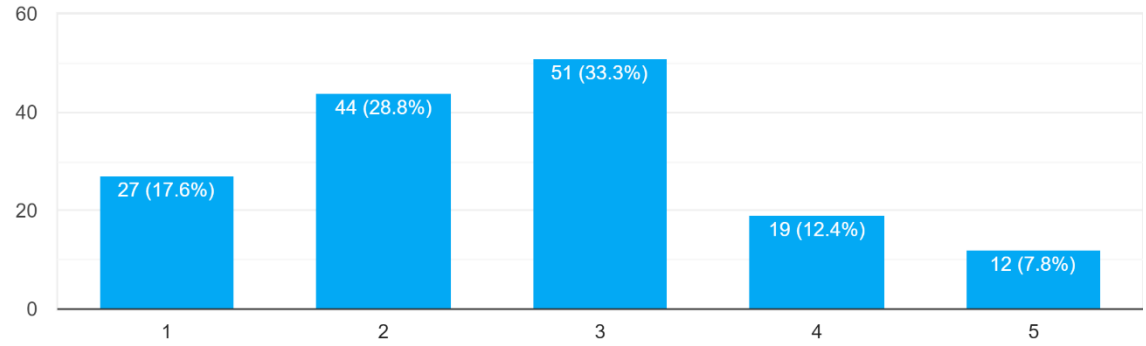
Visual quality

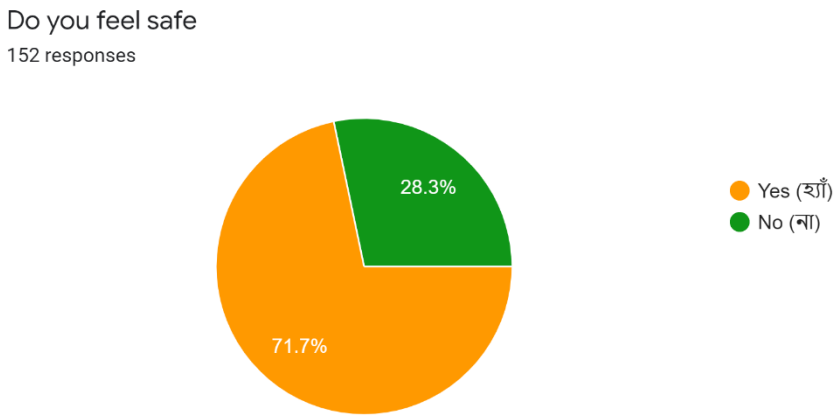
151 responses



Quality of the place

153 responses

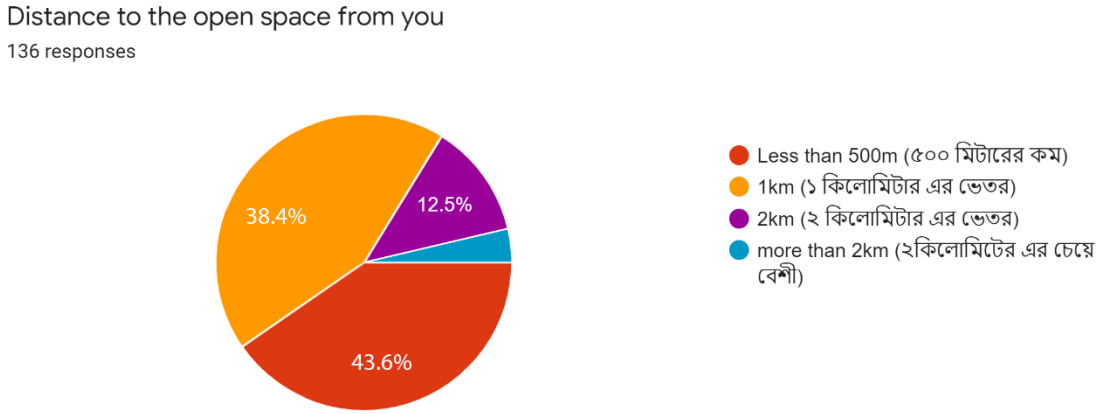




About three fourth of the sites are marked as safe. But among the 28.3 percent who feel unsafe are also mostly women. I took suggestions with an open question: Some words about safety.
Lack of lighting seems to be the first issue with security as many suggested that sites are not safe for women after dark. Disconnected banks are another problem as they reduced public circulation producing hostile corners. Banks close to religious establishments were marked as safe at all times. Peoples fear of ghost also suggest lack of lighting and having not many activities around the water bodies.

4.3. Questions on Open Spaces

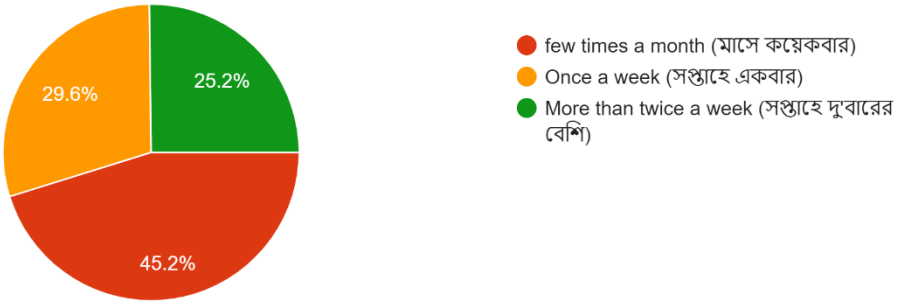
This part of the survey determines people's preference for open spaces, how they use them, and their proximity. Open spaces that people named as they consider close to them are listed below.



Unlike the water bodies, Open spaces closer than 500 m are not so many compared to the similar pie of water bodies. Open spaces that are within 1 Kilometre compromise about the same portion as the former slice.

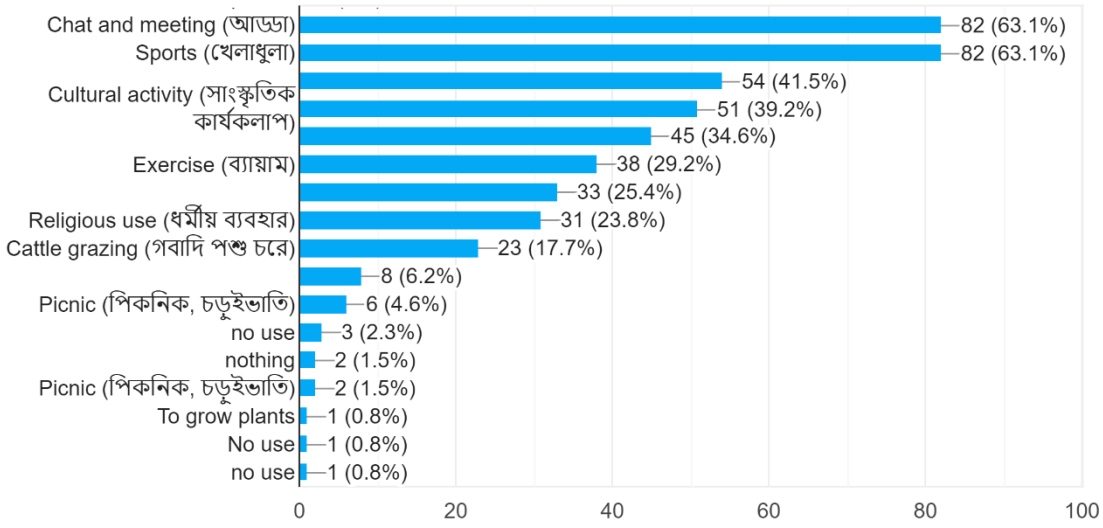
How often do you visit there

135 responses

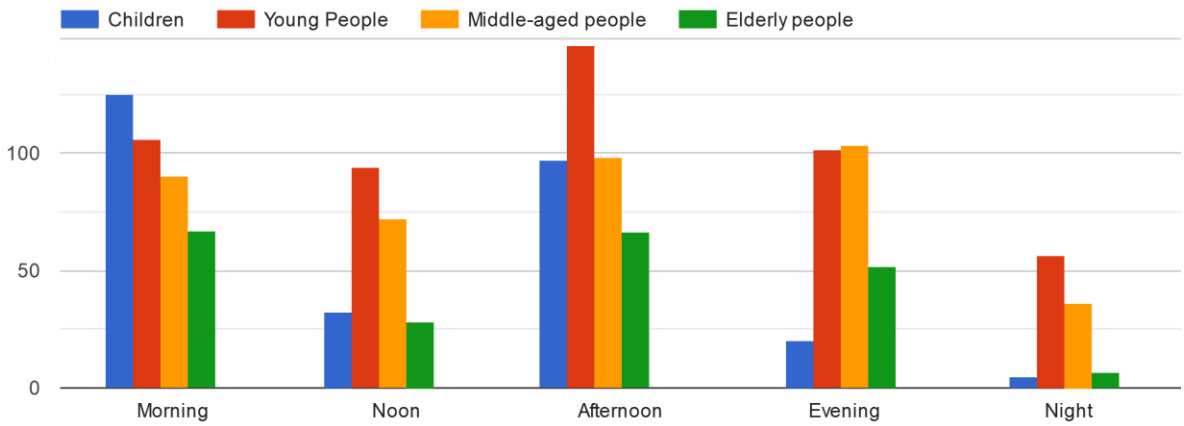


How do people use it?

130 responses

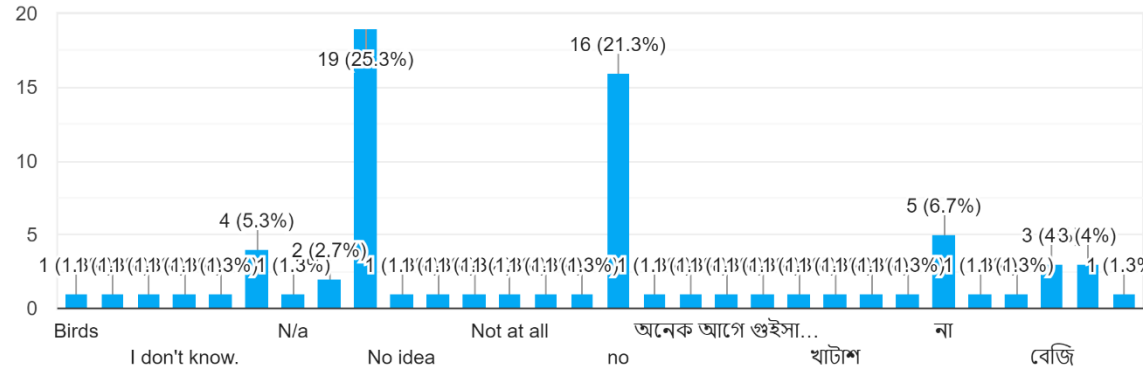


User group and the time of activity that you observed



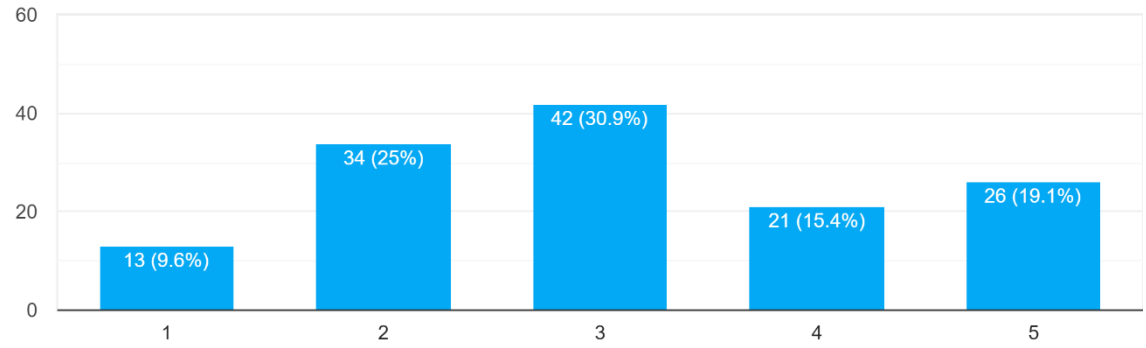
Any fauna you saw before now vanished or declined

75 responses



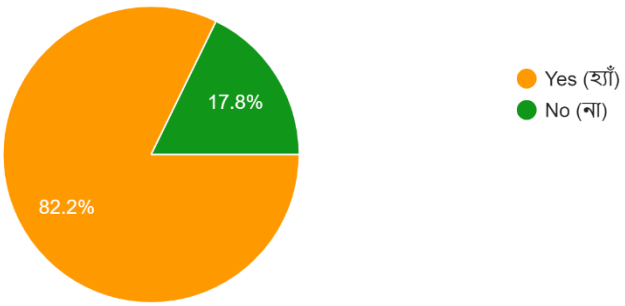
Quality of the place

136 responses



Do you feel safe there

135 responses



Open spaces are limited. So, these are always crowded. This creates a sense of safety for everyone. Even though it is always chaotic, but people from all sorts of life still enjoy these places.

4.4. Vision for Cumilla City

I asked four open-ended questions in this part—the first to list and rank their most visited places. A qualitative list is as below.

1. Dhormoshagor Paar
2. Townhall
3. City Centre
4. Ranir Dighi
5. Eid Gah
6. Nanua Dighi
7. Botanical Park
8. Riverside

The first four are the most visited among others, and we can see the first and the fourth one are water bodies. We can conclude that there is a grave lack of open spaces, so they are always so crowded.

The second question was about how people experience using these spaces. Answers are close as there is not too much variety in these spaces. These responses are also listed in rank, as users noted.

1. Hangout
2. Street food
3. Tee
4. Socializing
5. Family outing
6. Walking
7. Sightseeing
8. Cultural program
9. Playing
10. Shopping
11. Fresh Vegetable

What kind of activity do you want from the city? This is the third question. Responses are listed below.

1. Option to experience the history of the city
2. Walkability
3. More places to go within the city
4. More cultural spaces and educational installments
5. More Trees and shade to spend time under
6. Cycling tracks
7. Exhibitions and live cultural programs
8. Playgrounds and sporting facility
9. Family-friendly spaces
10. Open fields of multipurpose
11. Boating
12. Swimming
13. Kiting
14. Calm places for yoga and contemplation

The last question is about the city. What are their thoughts about the future of the city?

1. Green and sustainable city
2. No flooding in the rainy season
3. Proper drainage
4. Less traffic
5. Walkable city
6. Proper Urban Planning
7. Natural conservation
8. Historic Conservation
9. Culture should be visible in the development of the city
10. Safe city
11. City for women
12. Futuristic city

4.5. Conclusion

There are hundreds of Pukurs, Dighis, and other water features in the city. These all have their own stories and are worth conserving. From the second part of the survey, we see people want to get engaged more with the water next to their lives. Current visits to these are not engaging enough because these are not equipped with anything at all. Organic growths surrounding the banks are the only things that hold people, but they are also scattered with no proper relation. Pollution from surface run-off, littering, and other problems made the spots unusable. Despite all the negative influences, people still have feelings for these Urban Waterbodies.

Open spaces in the city are limited and are exhausted with overpopulation. Most popular sports in the city are clustered around the city core, and only one or two are at the outskirt of the city. These open spaces cannot and will not be able to contain all the needs a healthy city should provide. Their proximity is also not in a favorable location. Other neighborhoods or community spaces are not used popularly due to their lack of luster. Currently, these open spaces are losing their environmental values and are less efficient in providing ecosystem services.

Regarding these situations, city water bodies hold tremendous potentials to become open spaces that can provide the whole population with healthy urban life and the ecosystem. A green and sustainable city holds its key in these intertwined waterbodies.

Giving proper guidelines to conserve the water, providing proper design to transform them into great Urban open spaces, and upholding cities' cultural values with the sustainable development of rainwater management can transform today's haphazard city into a city of the future.

5. Discussion

From site analysis we can conclude that the scope for developing a sustainable solution is very limited in terms of land. But the potentials to transform these little pieces of gems that will not olny creat active open spaces but also protect the water and ecology.
Survey showed peoples fondness of water. Almost every one knows a water feature that is in walking distance to them. But security issues for women, crimes after dark, pollution and lack of facilities discourages people to experience these wonders. As a result people are feeling disconnected with urban water bodies and thus they are getting filled up.
Because of pollution in the water and not having enough green surrounding city bio-diversity is at a critical condition. Working from water is a good start. But it requires more integrative design strategies within the city planning to sustain a viable ecology. Green roofs, green walls and many other directives have to be included in city action plan for the proper result. Water bodies should be clean from water runoff, littering and appropriation of land. Ample lights should be provided. Wherever possible the surrounding banks should be connected. There should be active zones around the important public ponds with ample functions. Programs should include activity for all ages.

Based on these suggestions my design solution is formulated. I have developed a design toolkit that should preinterpret any context within the city to employ successful open spaces. Community suggestions and participation is must to implement the design tools that I have formulated. In the next chapter I will describe my solution in brief.

6. Proposed Design Solution

6.1.Blue thread

A blue thread is running through the fabric, sewing blue gems firmly to the wasteland. A lifeline that brings life and scatters the aura around. This was my vision when designing the ponds. A single archetype can follow through all the wetlands by touching them, looping them, going through them, and merging in other parts of the city like sewing a fabric.

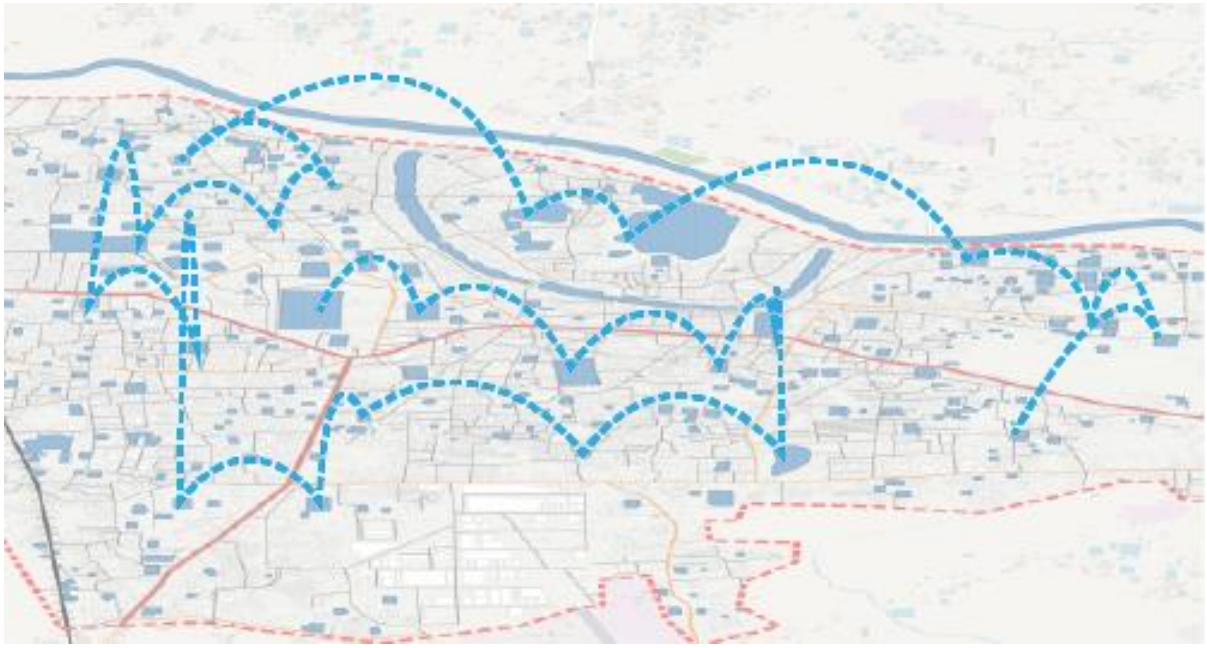


Figure 6.1: Blue thread sewing the city

City elements dispersed around these wetlands are brought together by the active functions produced from the thread. This will enable the historical, religious, educational establishment to find a public façade that invites people while also exhibiting.

Figure 6.2: Blue thread sewing bits of life

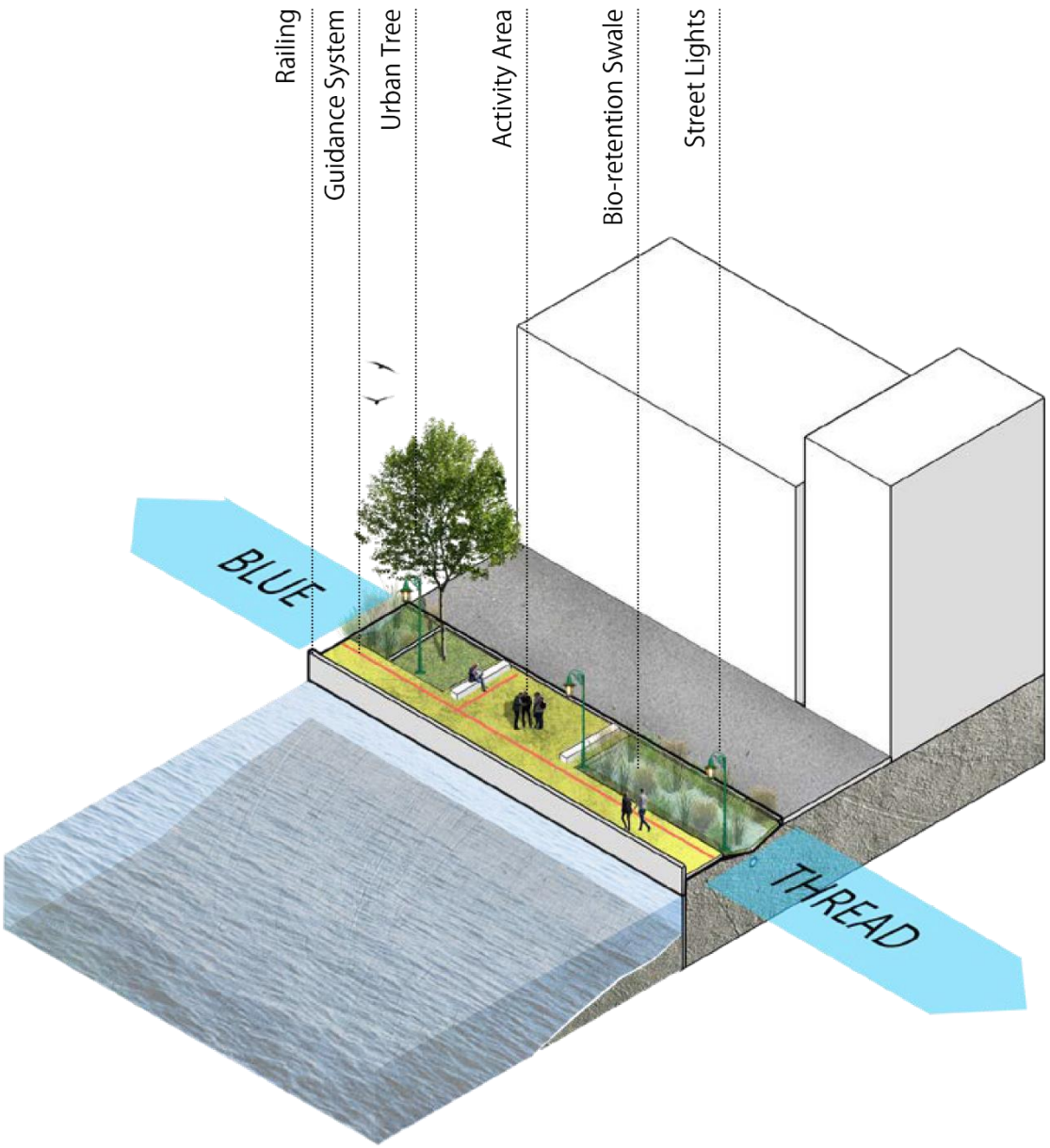


Figure 6.3:Blue Thread and its elements

A bio-retention swale runs parallel to a pedestrian line equipped with a tactile paving line. Water run-off from streets and surrounding buildings can drain into these swales. The retention area will filter the water with aquatic plants that are hardy in both wet and dry conditions. Depending on the street size, the bio-retention strip will vary in size. I designed a default size of 3 meters for the bio-retention strip from GIS road analysis. Pedestrian size is kept 2 meters. If the site is too narrow, then only the pedestrian will run along the bank. This is the blue thread that will run through the wetlands, banks, and streets where possible. There will be streetlamps running along the bank to ensure a safe environment for the people. Drinking water fountain will be provided around each pond. A notic board for the community will accompany.

Depending on the pond and surrounding context, various programs, activities, and functions are placed in the thread. Based on this concept, the thread is then extended to streets where possible. This will create a common language for the city while preserving its essence, like weaving different patterns in different places.

6.2.Ponds Categories

Pond bank analysis showed that not all the ponds had connected banks. This also suggests that not all sides are publicly accessible. Private property owners share many of these pond banks. From the survey, some common names appeared many times that people enjoy spending time in. These are

- Dharmashagor
- Nanua Dighi
- Ranir Dighi
- Taal Pukur
- Lau Dighi
- Amir Dighi
- Nanua Dighi
- Kaliyajuri Boro Pukur
- Moulovipara Pukur

CoCC(Cumilla City Corporation) recognizes eight major ponds mentioned earlier as important for maintenance and beautification; some are common to the upper list. Here are the eight ponds are shown in the earlier map.

- Ranir Dighi
- Mandir Dighi
- Nanuar Dighi
- Fauzdari Dighi
- Modina Dighi
- Dargabari Dighi
- Darma Sagar
- Thakurpara

But not all these ponds are accessible to public and hence cannot be developed into public open spaces. Based on the survey, site analysis and GIS analysis I've categorized city waterbodies in three distinct categories.

1. Public Ponds
2. Community Ponds
3. Ecologycally important pond

Besides these ponds there are also ponds that are not shared with public realm. Ponds within administrative boundaries, ponds within private properties, ponds within city prison area. These ponds play more significant part in urban ecology as they are well preserved and less disturbed. But to preserve them, city corporation should develop some policies that will convince owners to preserve and maintain these restricted ponds with certain guidelines.

6.3.Design Toolkit

Considering city context, pond banks and surrouding establishments, I've desiged some design toolkits. These are function oriented sections of the blue thread termed ‚Stitch'.

Each of the Stitches are unique functions that will serve both nature an dwellers.

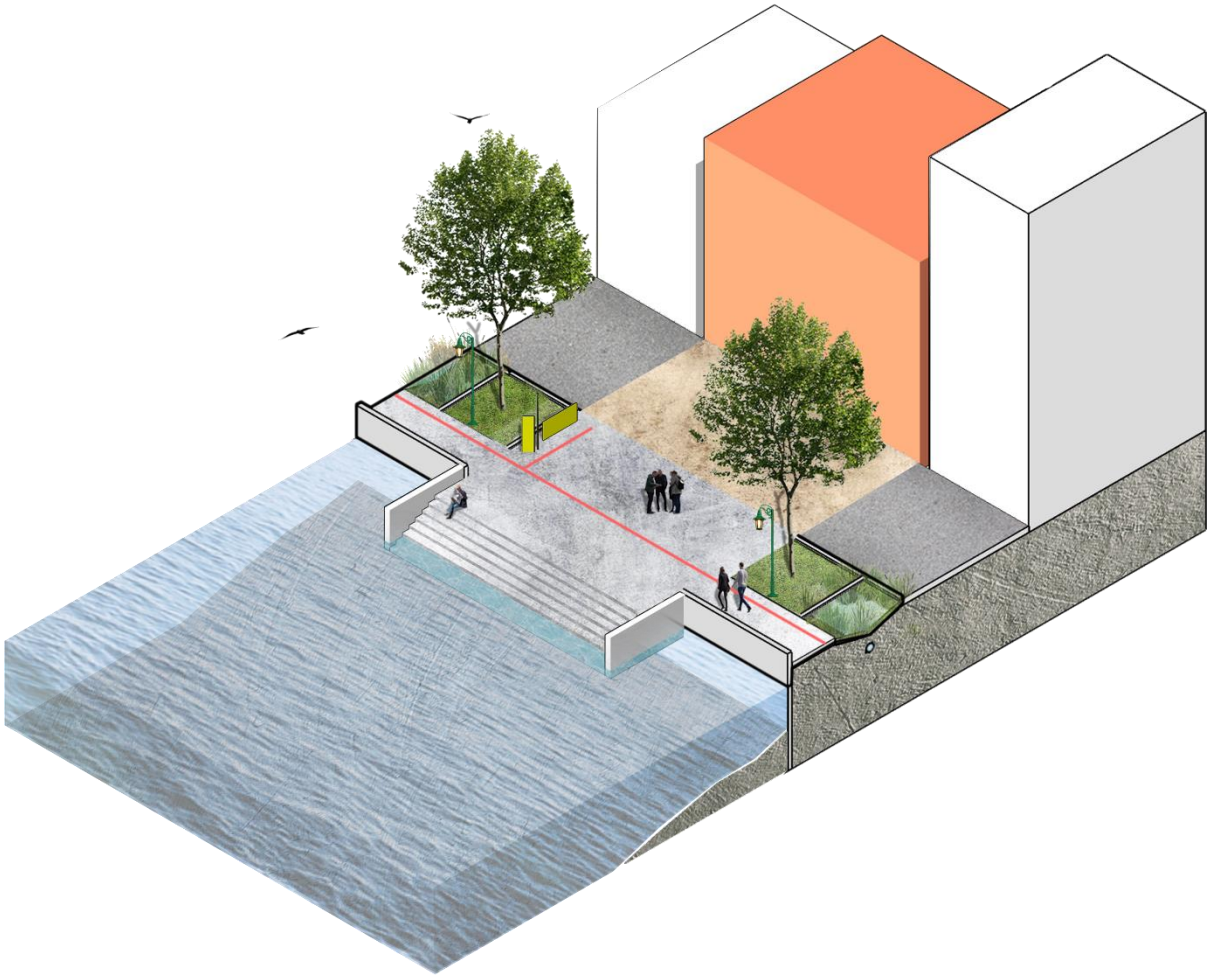


Figure 6.4: Historical Façade. No 1

Historical façade area will provide an opening to the historical establishment. There will be information boards and souvenier corners. The part in the street together with the active zone can be used as exhibitions space occationally and can hold historical and cultural events.

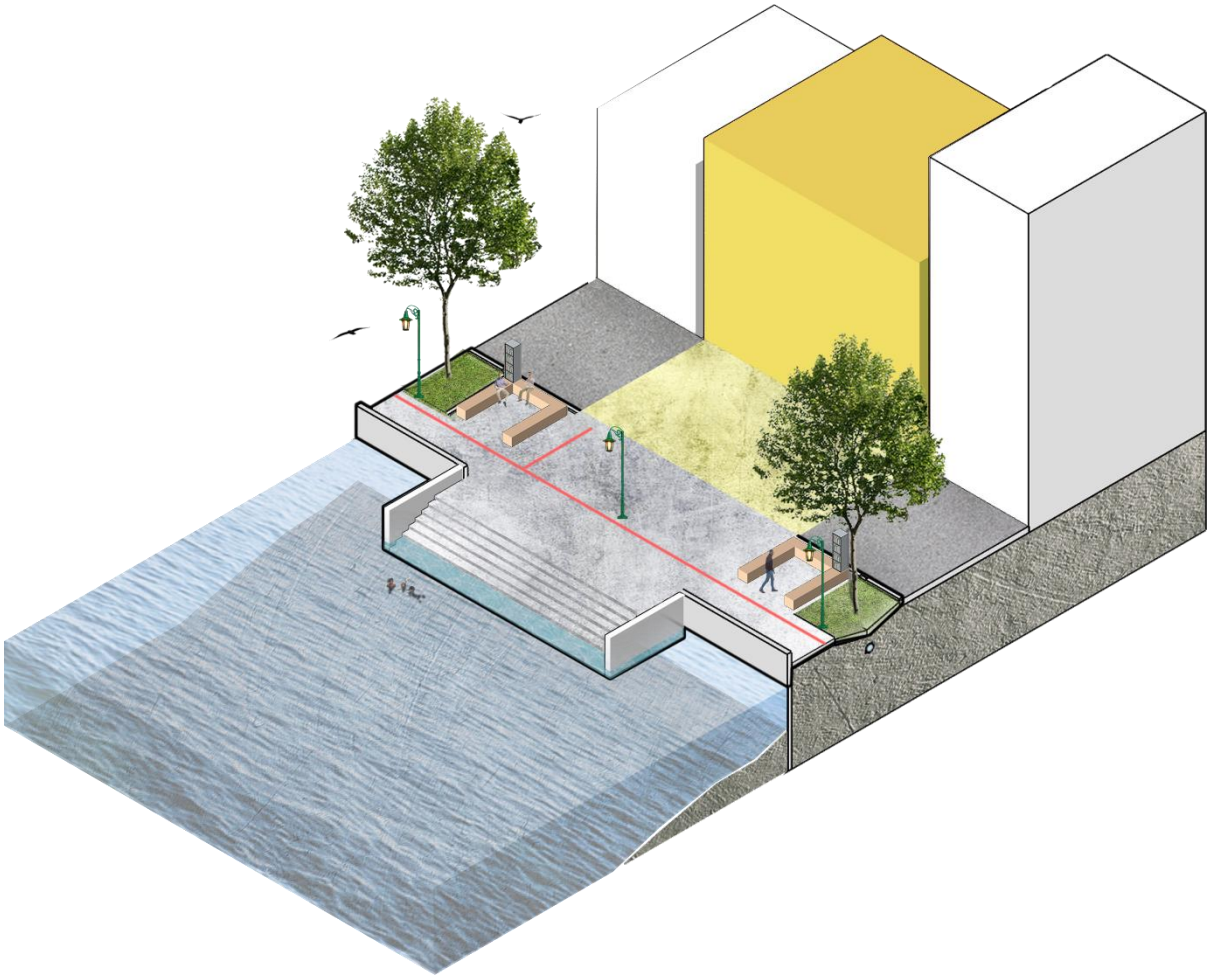


Figure 6.5: Mosque and Madrasa Façade. No.2

An extended Praying area for Jumma and reading space for religious discussion and reading. Bookshelves and a Ghat in included

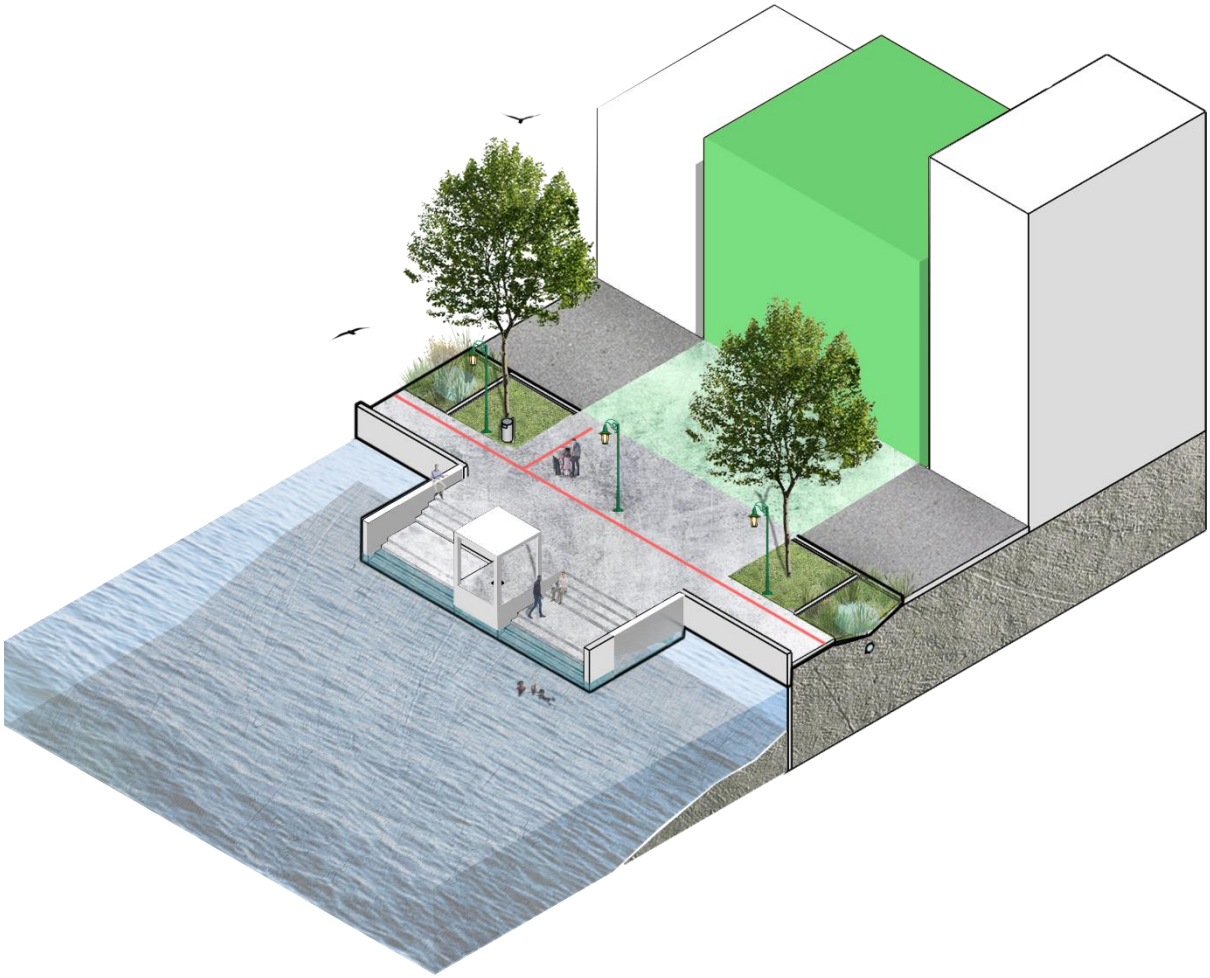


Figure 6.6:Temple Façade. No.3

Extended area for religious celebration. A dedicated alter area in front of the water and ghat is provided.

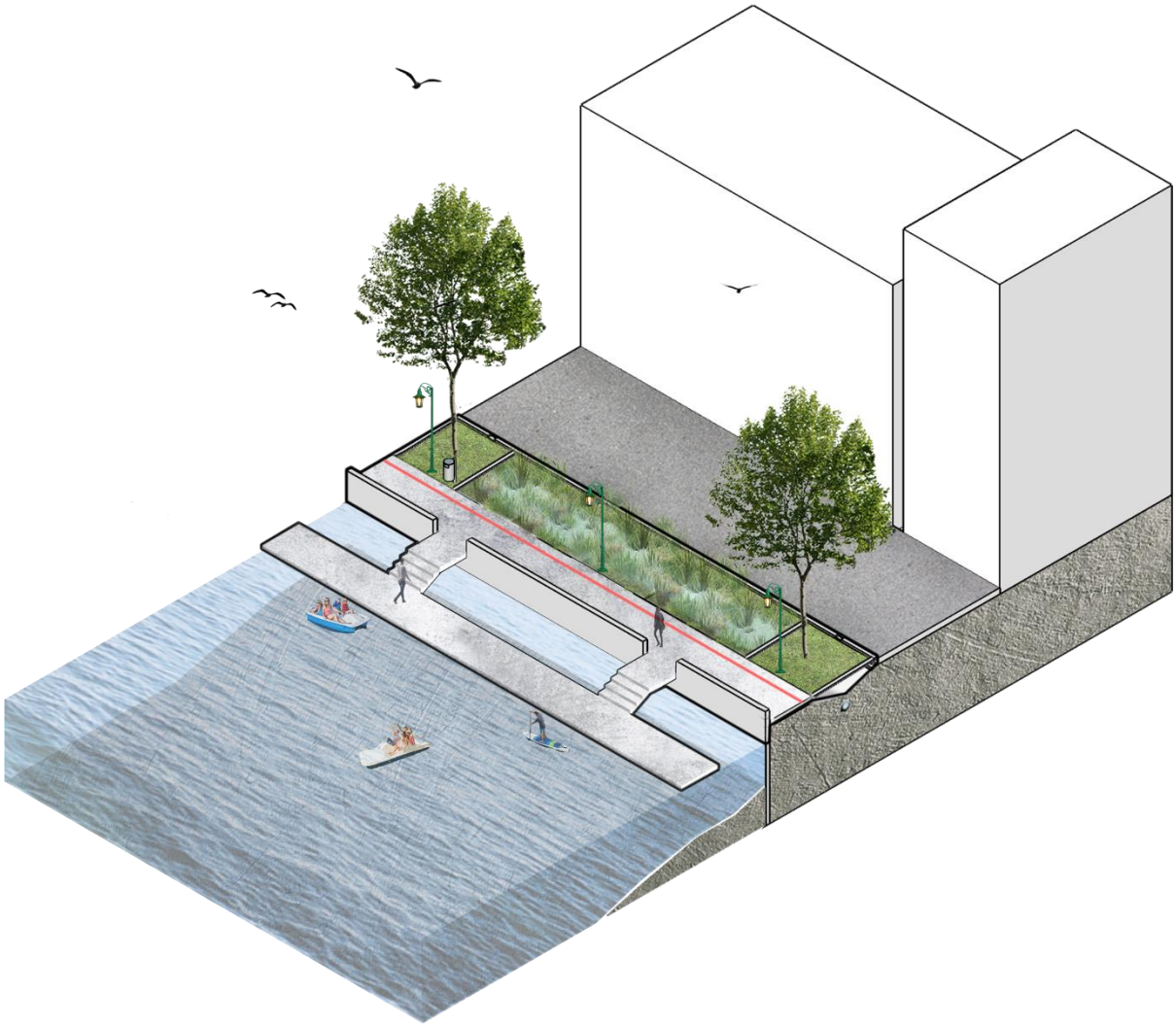


Figure 6.7:Central Promenade. No.4

Central promenade is a public plaza with multipurpose activities, sculptures, seatings, installations,art, live music and performances.

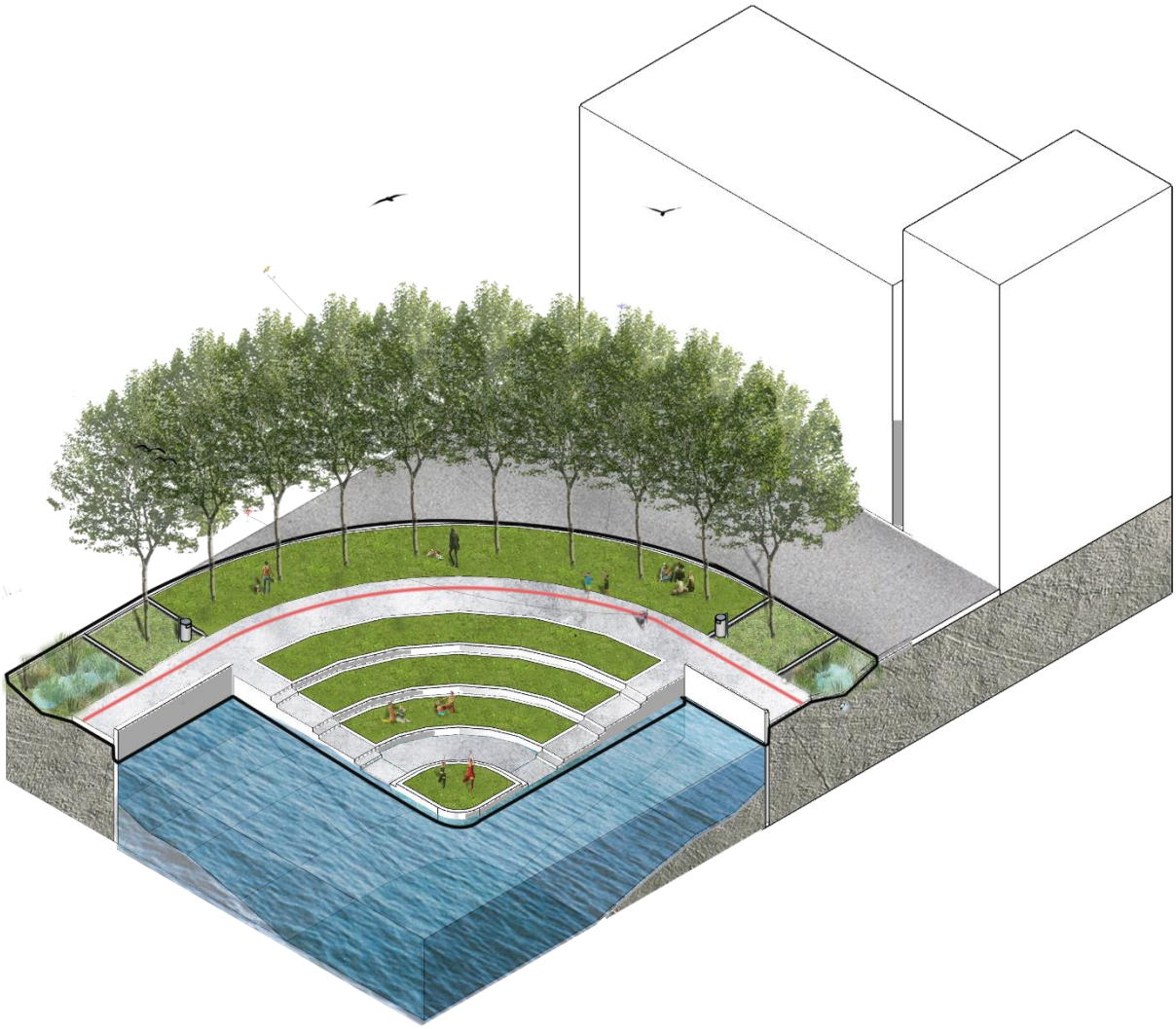


Figure 6.8:Cultural Active Area. No. 5

This is also a multifunctional space that have a structure for cultural activities, events and get togethers. This place will be used for morning yoga and other contemplative activities.

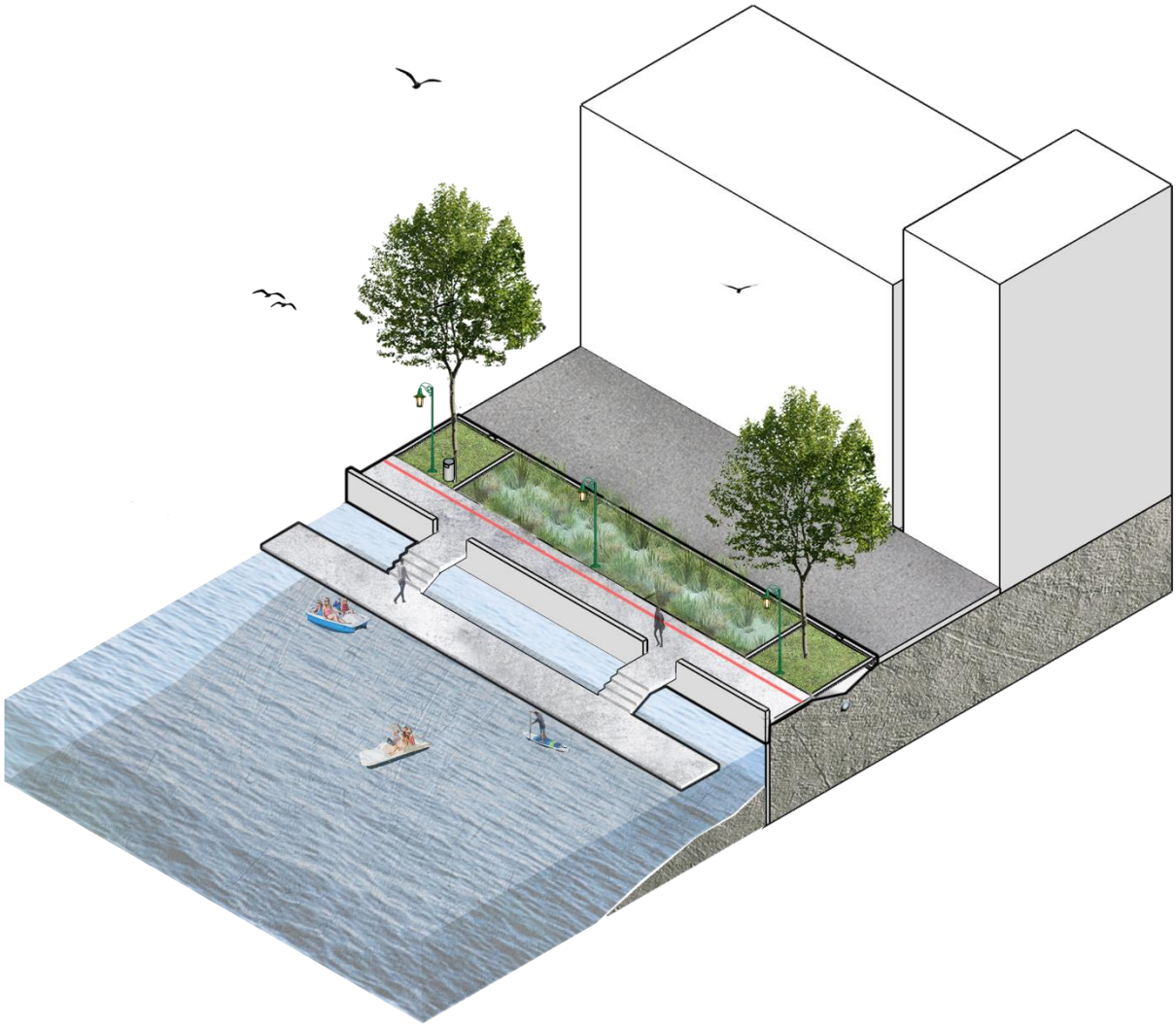


Figure 6.9:Boating Deck. No.6

A small boat deck that will provide small paddling boats and kayaking boats. Floating restaurents can also dock here.

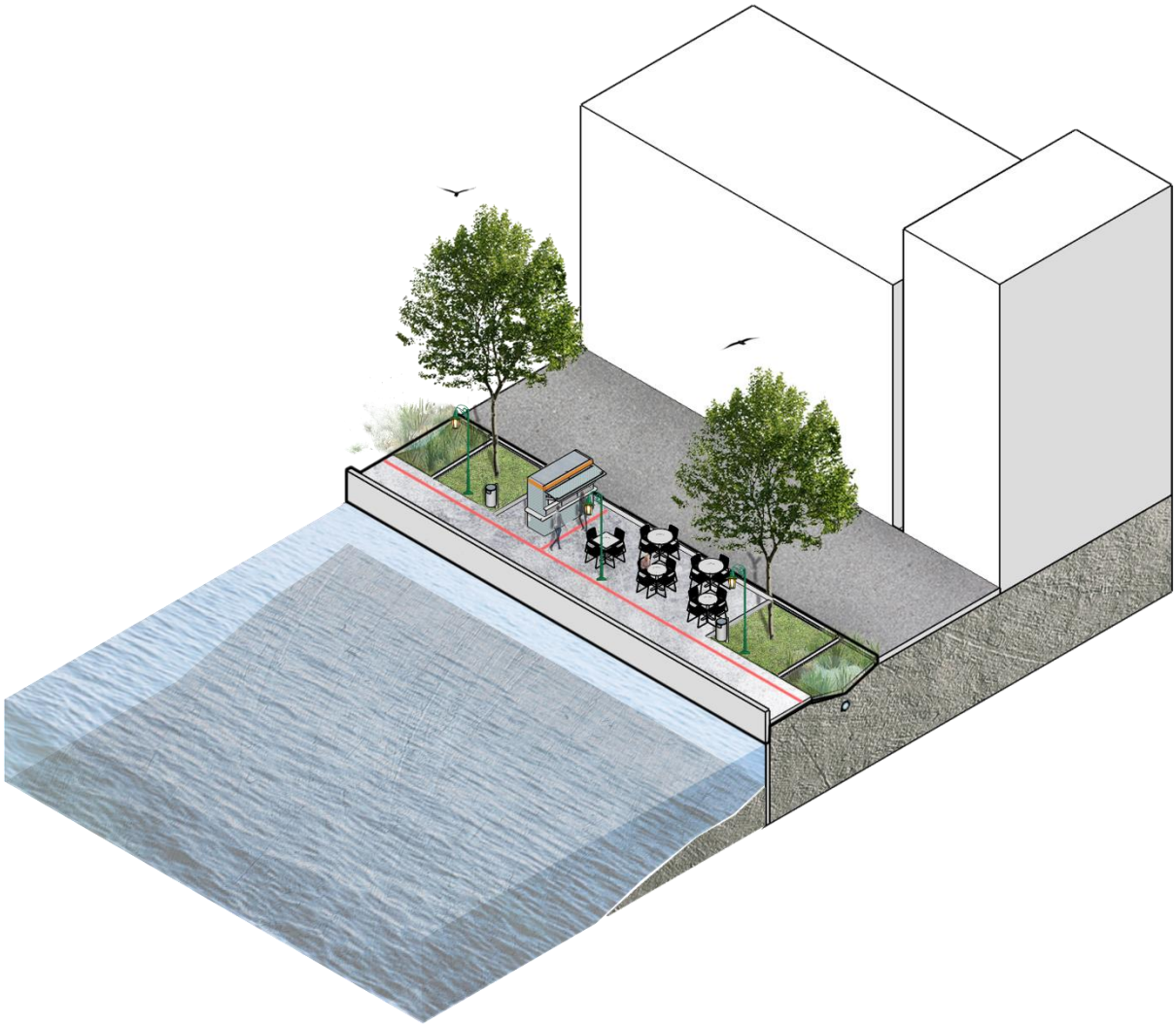


Figure 6.10: Food court. No.7

Depending of the site this area can have stalled foodcourt or only seating where food are brought from nearby food corners

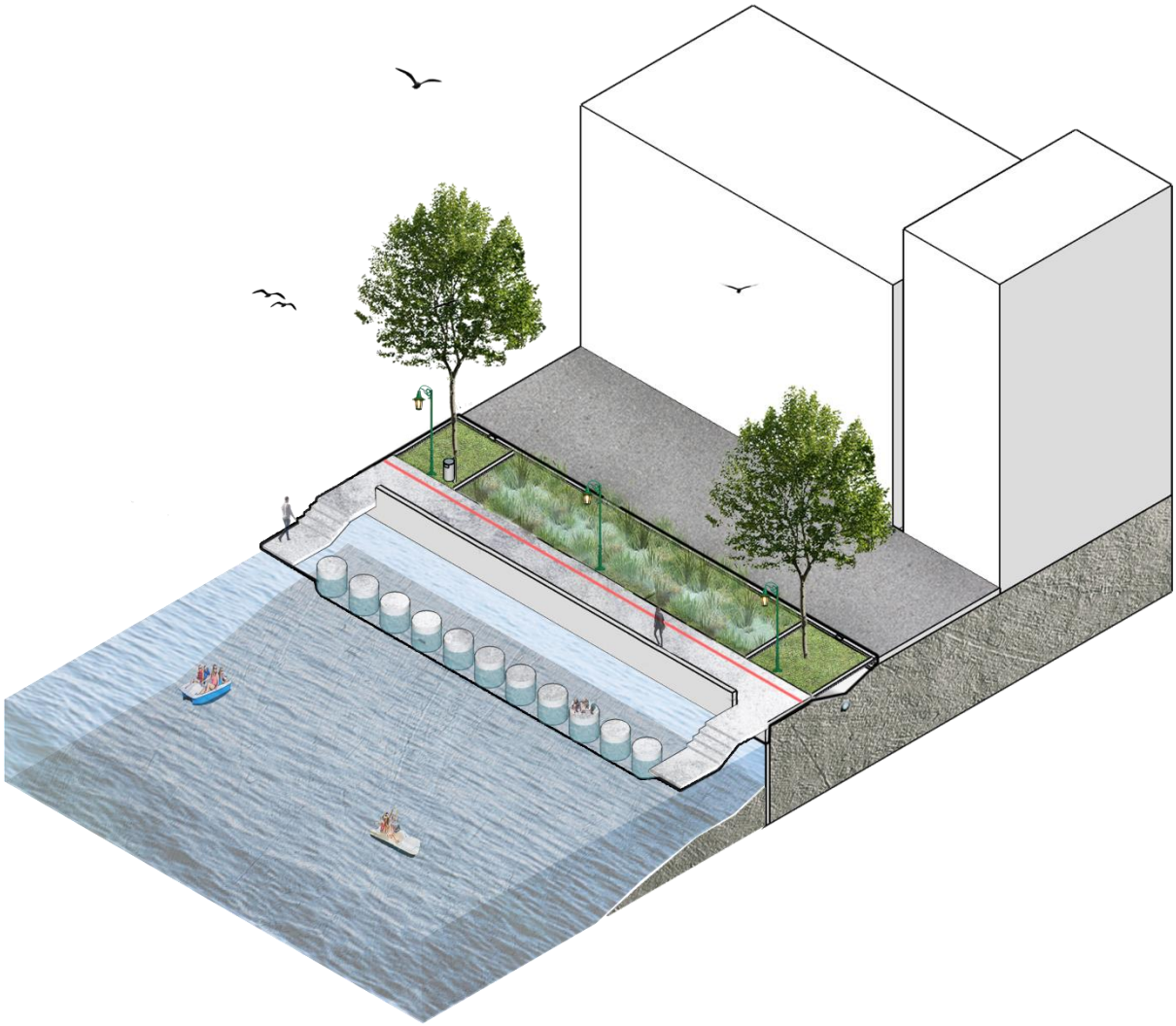


Figure 6.11:Experience Water. No.8

A small area with shallow water will provide people and experience to go close to water

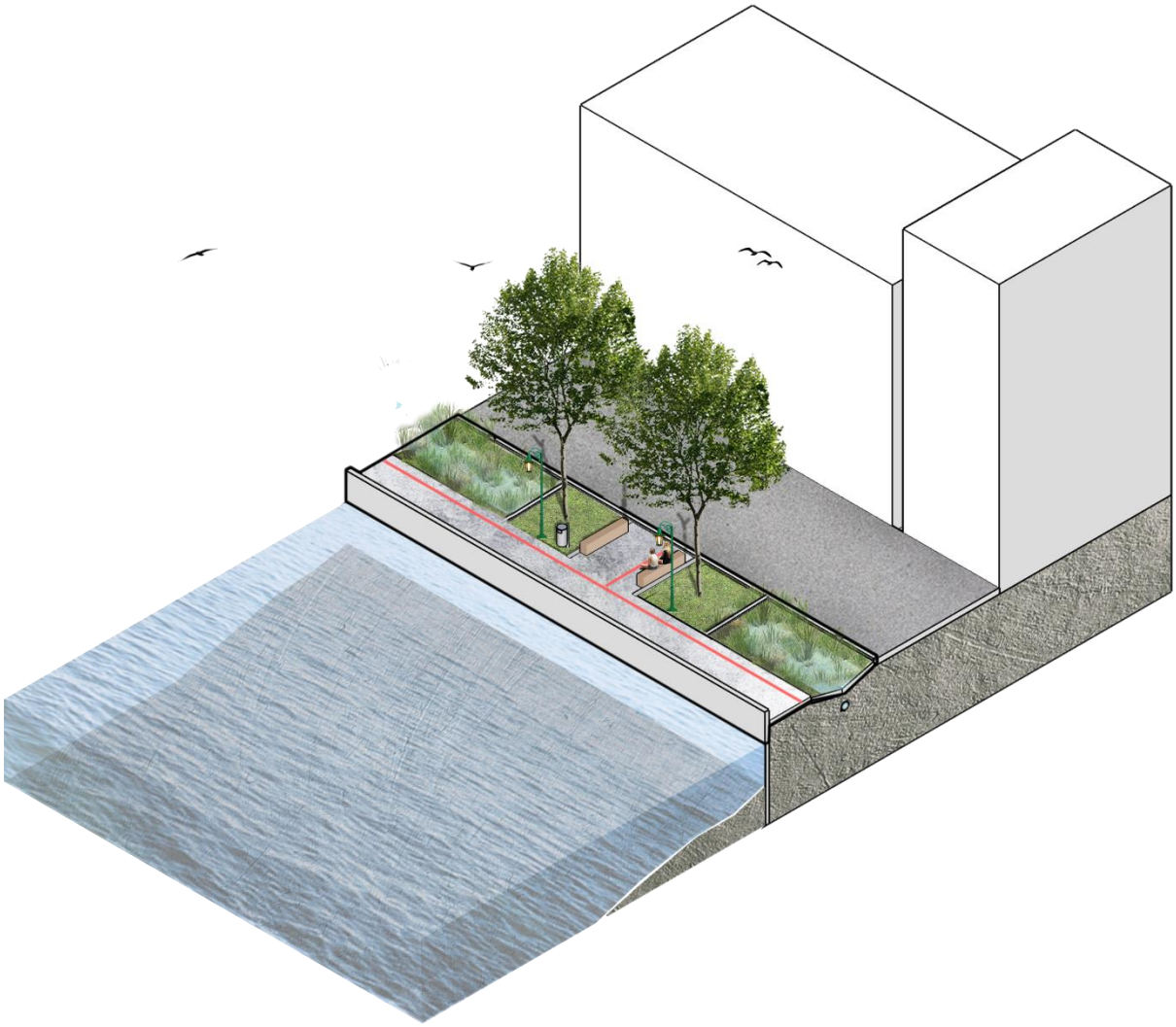


Figure 6.12: Solitary Seating Area. No.9

These solitary seating areas will be scattered around the ponds.

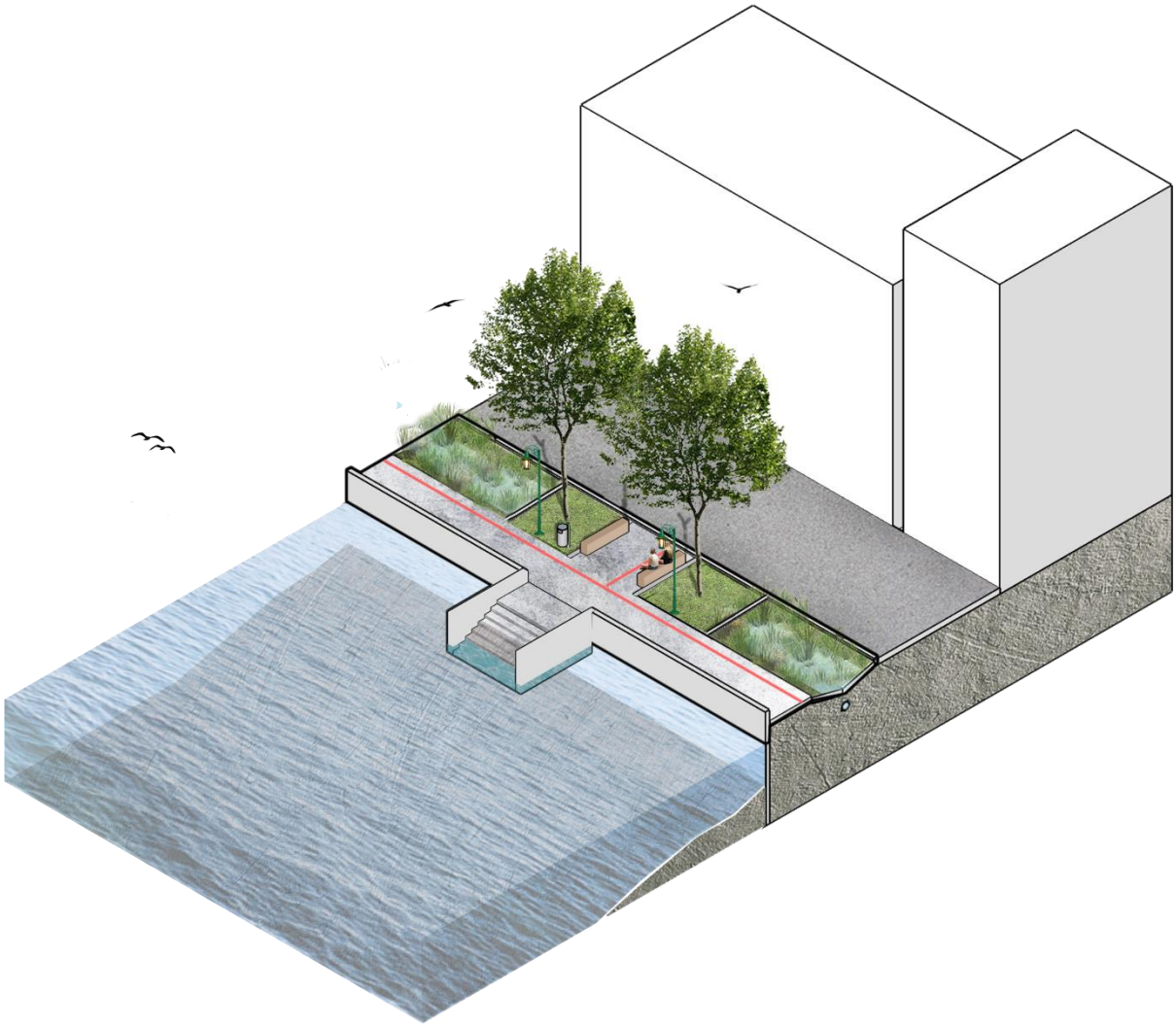


Figure 6.13:Ghat. No.10

These Ghats will be build alongside the existing Ghats and in new positions.

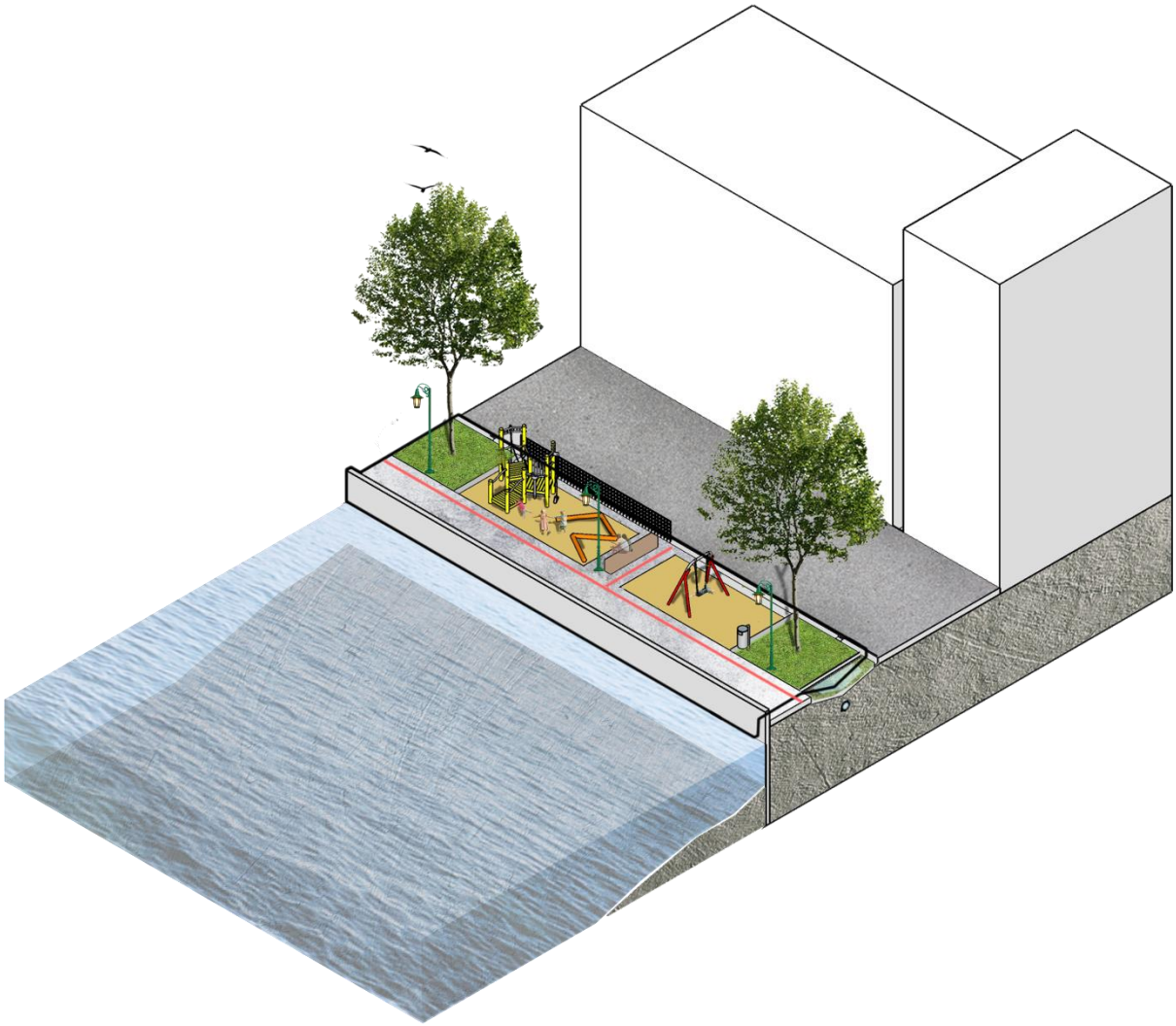


Figure 6.14:Children Play area. No.11

Children play area with seatings for parrents. Fences are provided for toddles and small children.

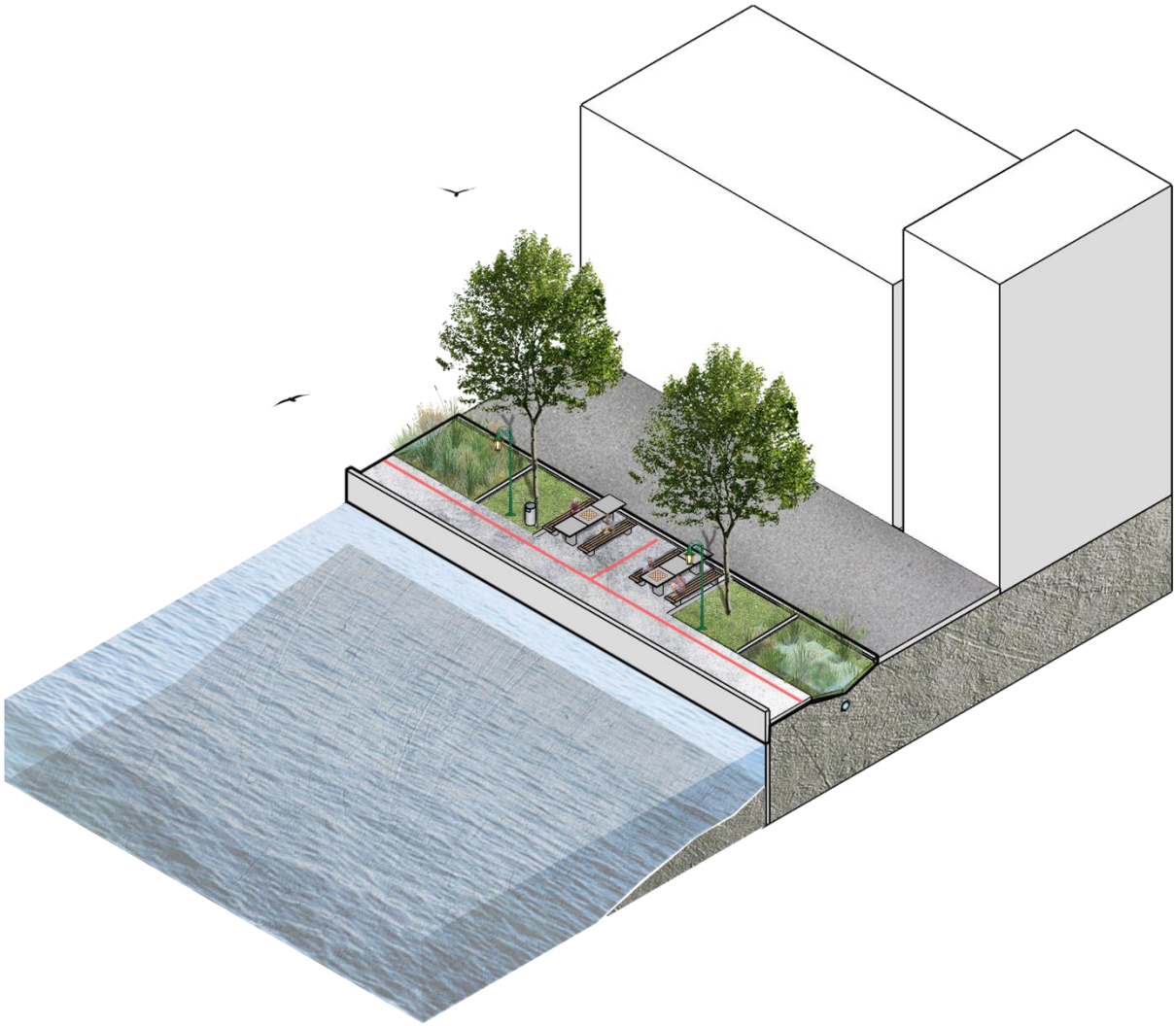


Figure 6.15: Space for Senior Citizens. No.12

A section for senior citizen to contemplate, play board games and experience outdoor.

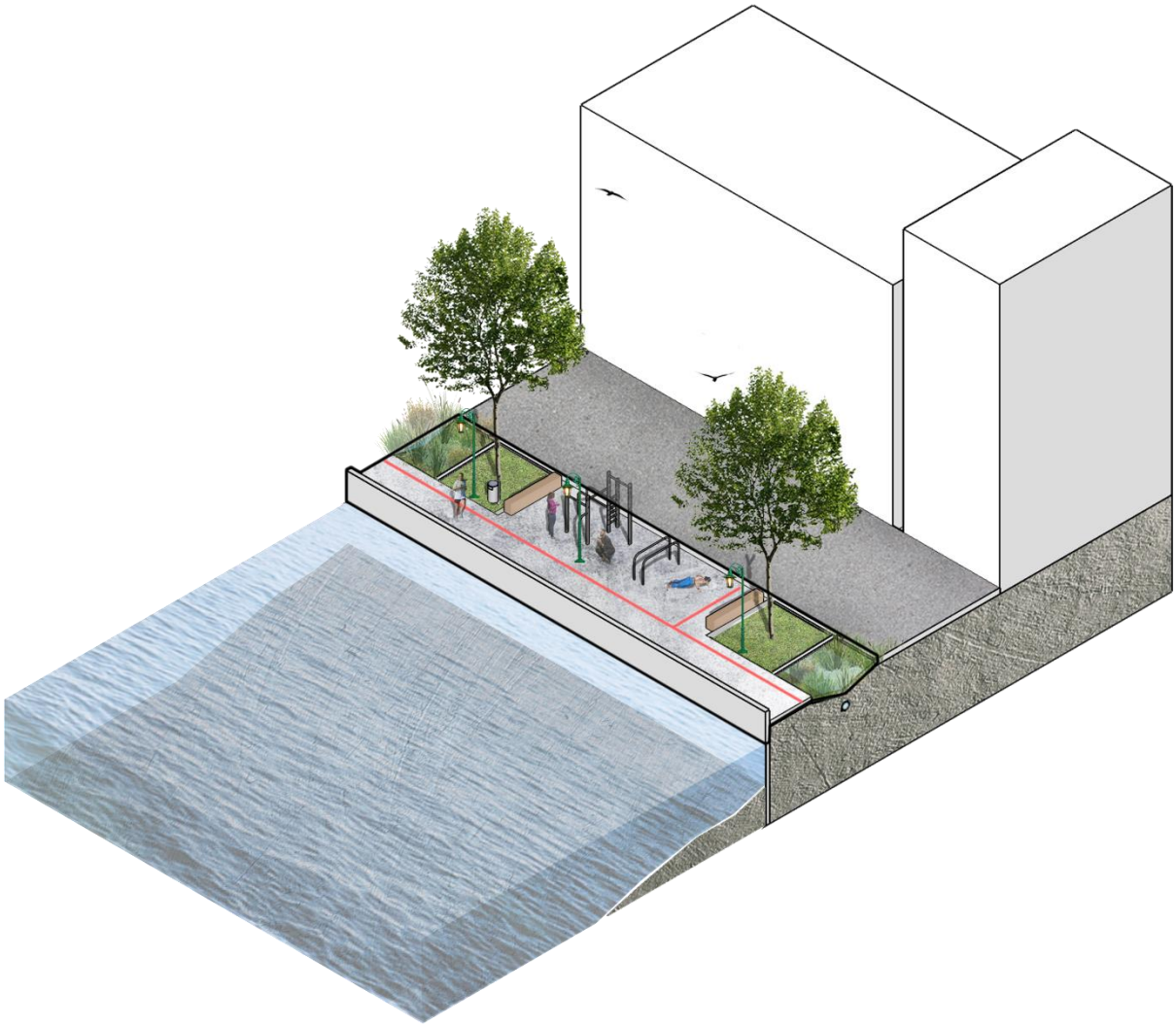


Figure 6.16:Exercise area. No.13

Exercise area with basic instruments.

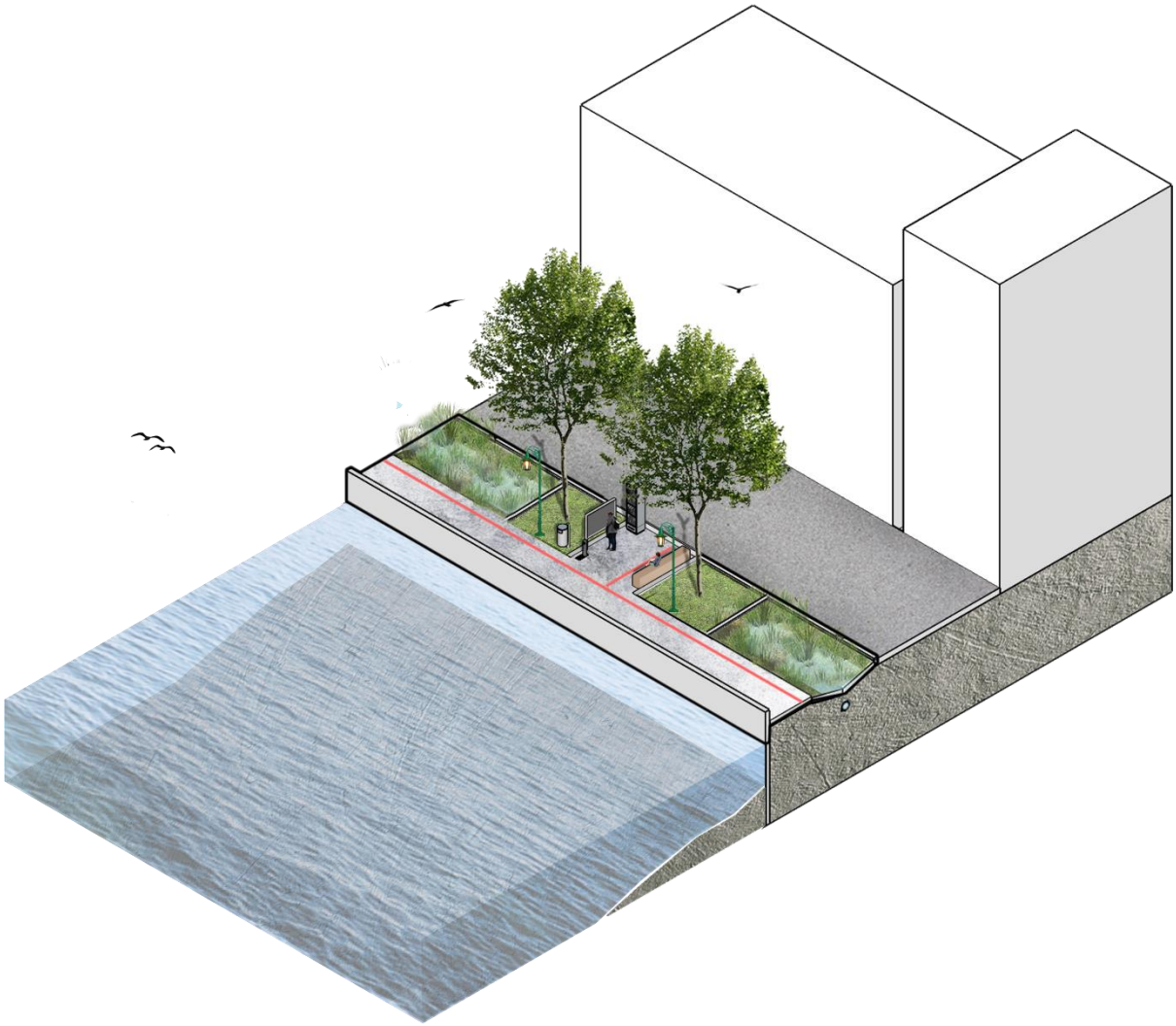


Figure 6.17: Books and Community board. No.14

A small area with books that will be organised by the community. There will be a notice board for everyday notifications and a drinking water fountain.

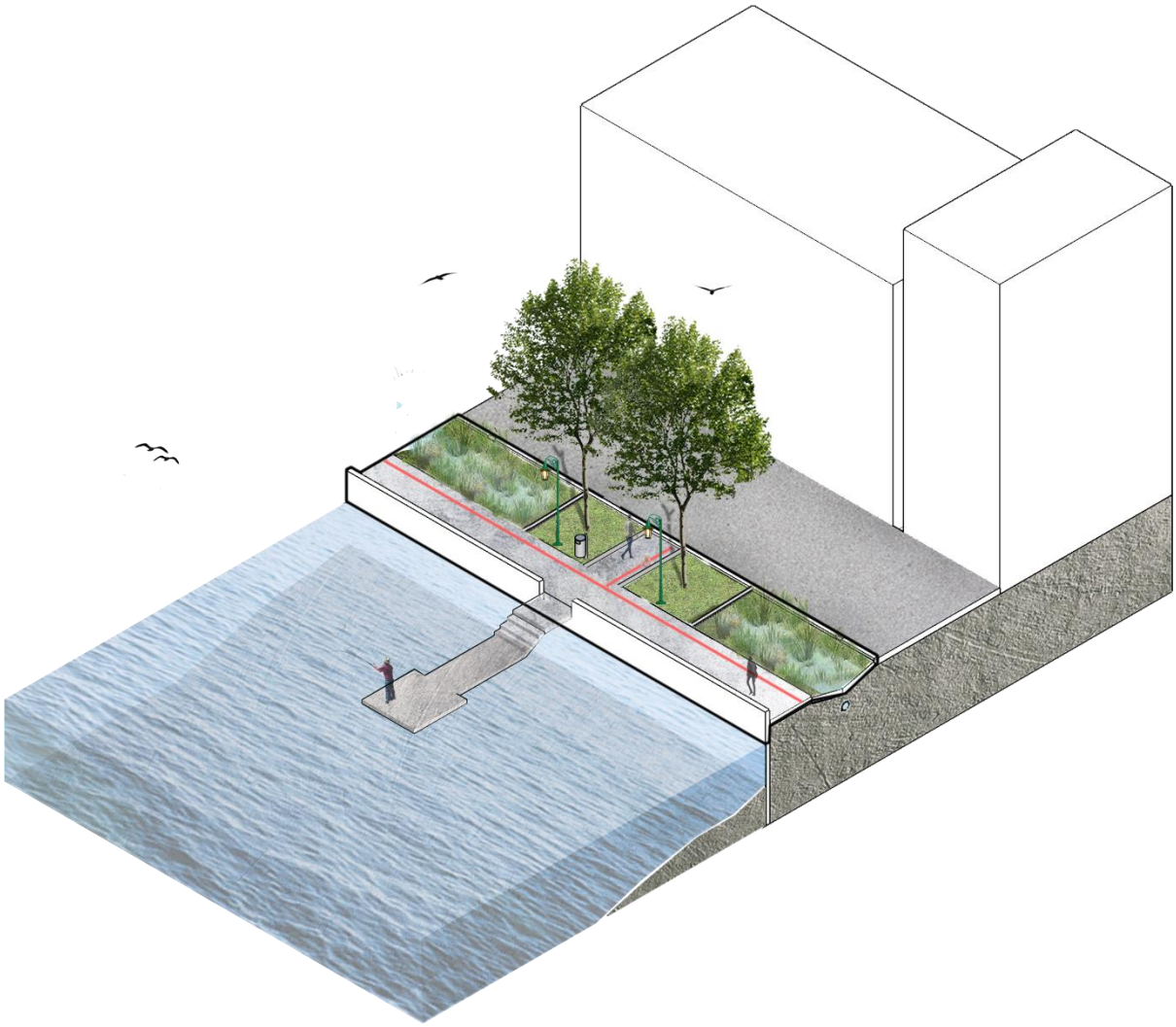


Figure 6.18:Fishing Decks. No.15

Fishing decks also viewing decks.

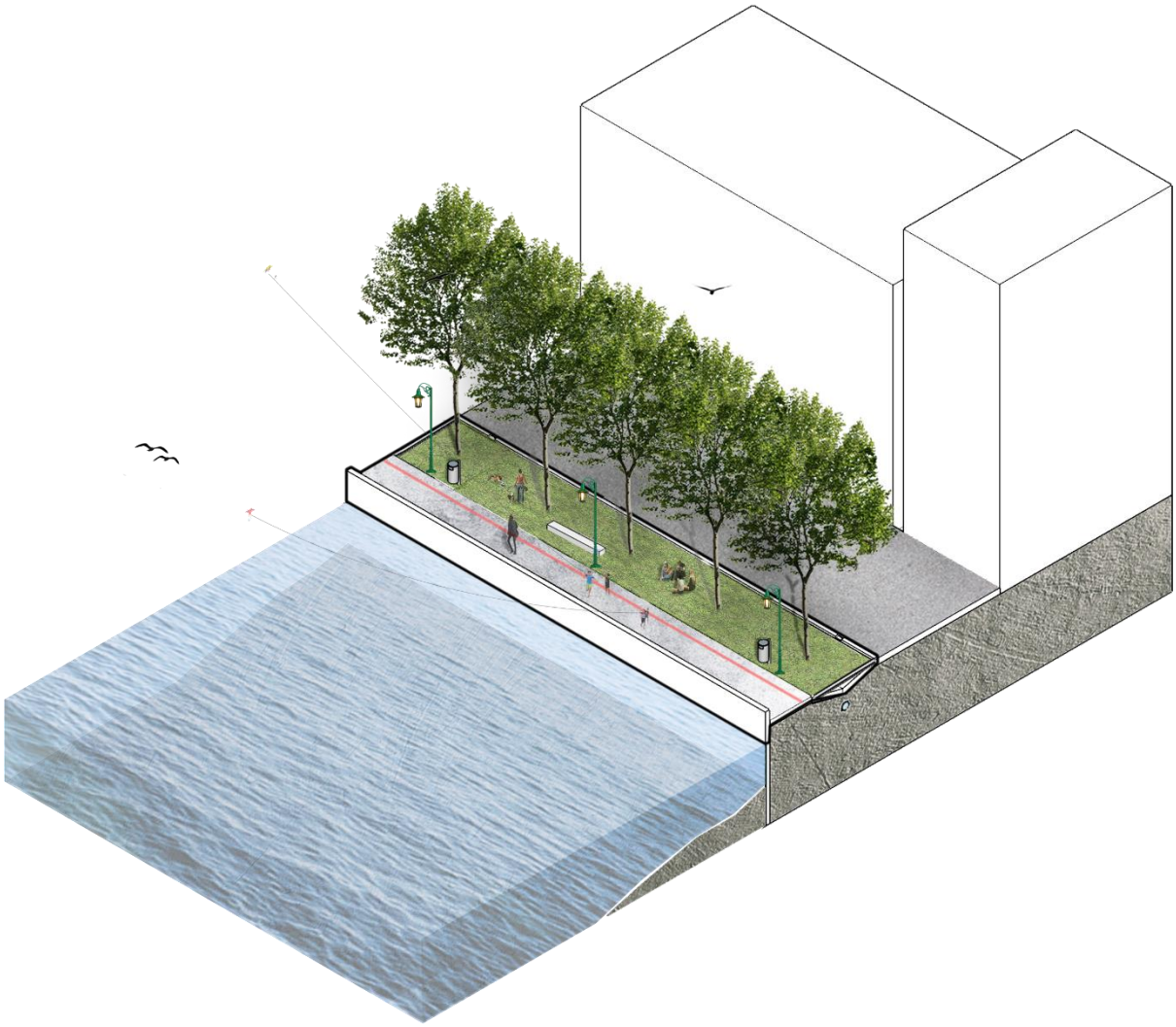


Figure 6.19: Lines of trees. No.16

Lines of trees with grass bed for a little shade in the summer

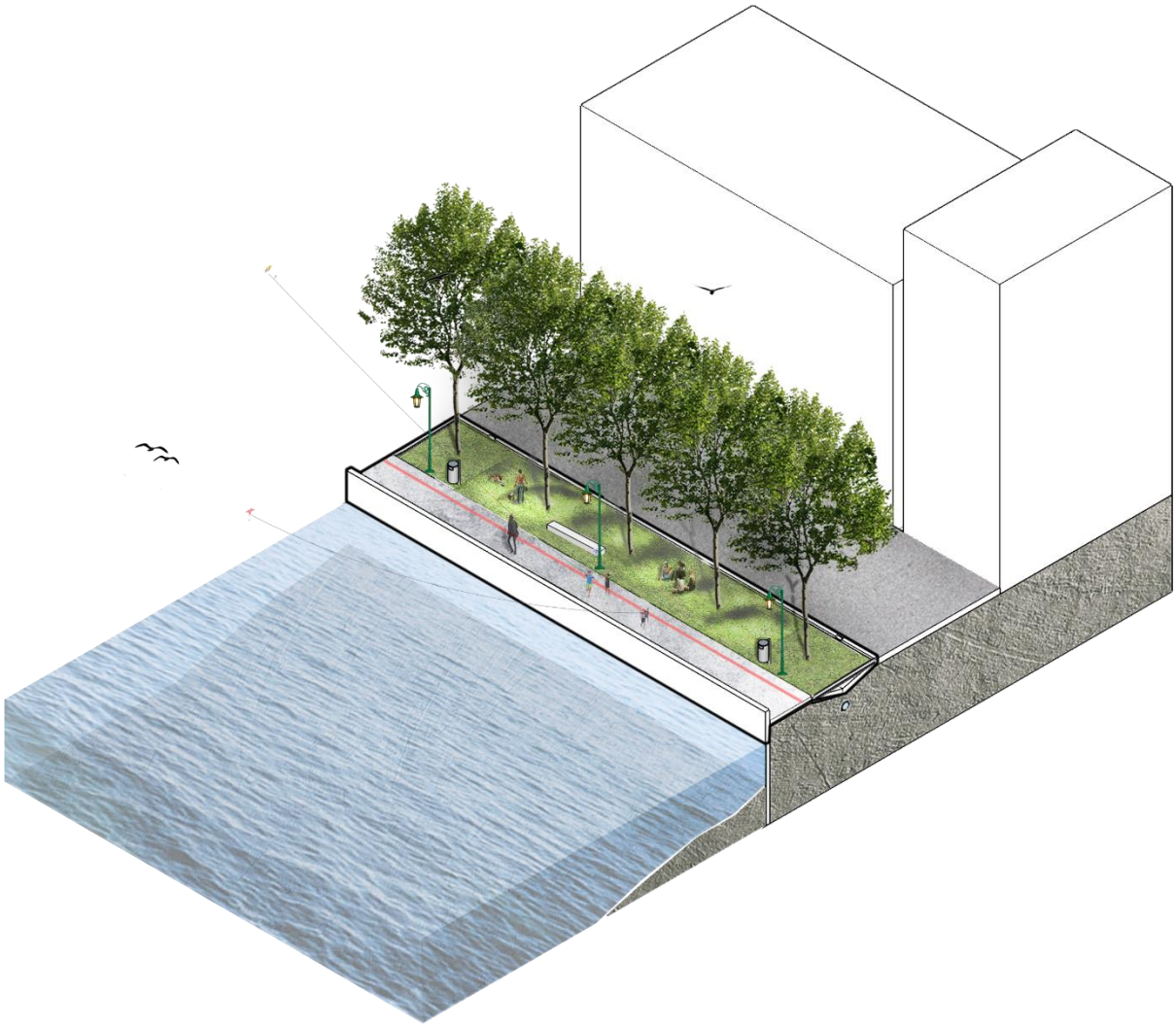


Figure 6.20:Hills with trees. No.17

Earth that comes from earth modification will forms small hills that will make a wonderful landscape.

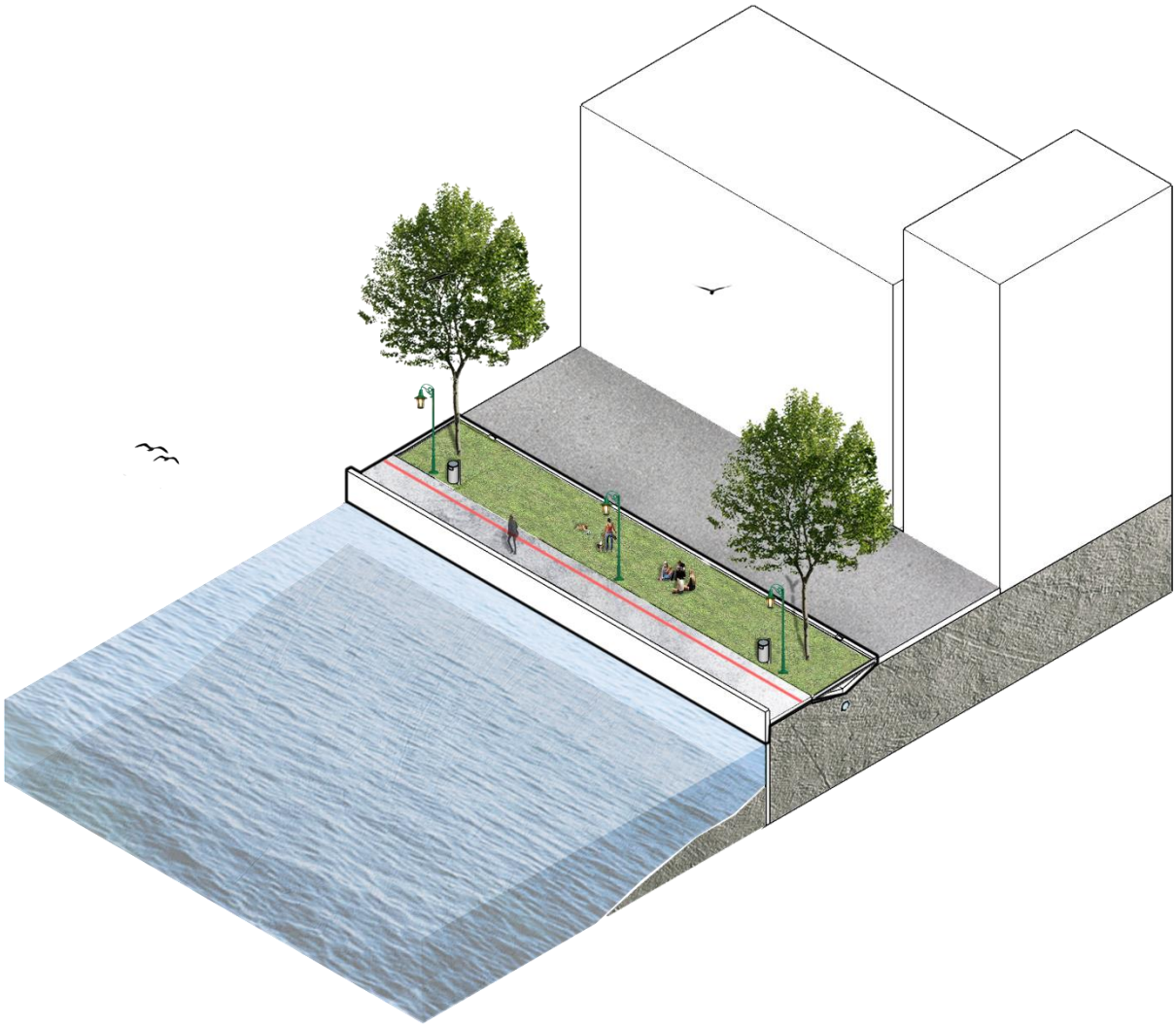


Figure 6.21:Green Meadow. No.18

A green meadow area will provide open space events and picnic activities.

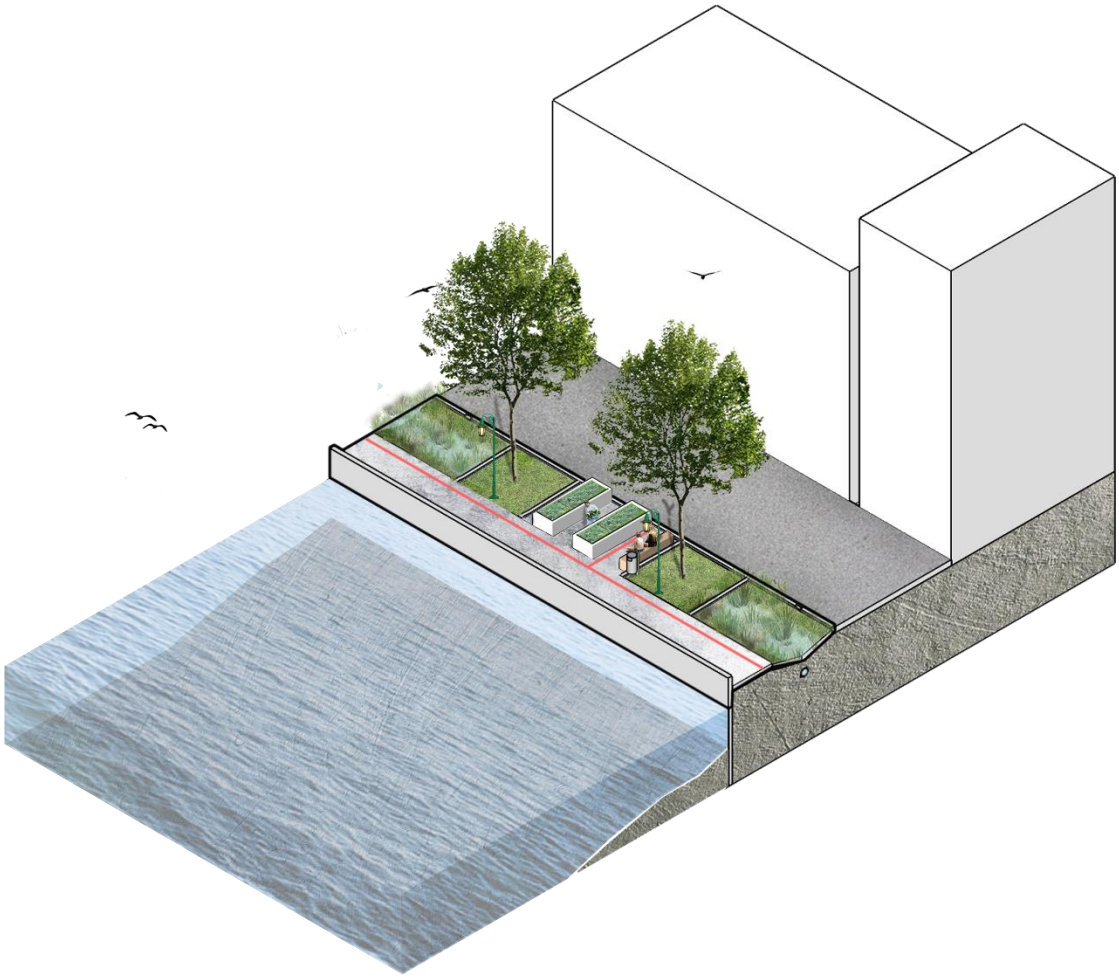


Figure 6.22:Community Garden. No.19

A Community Garden area

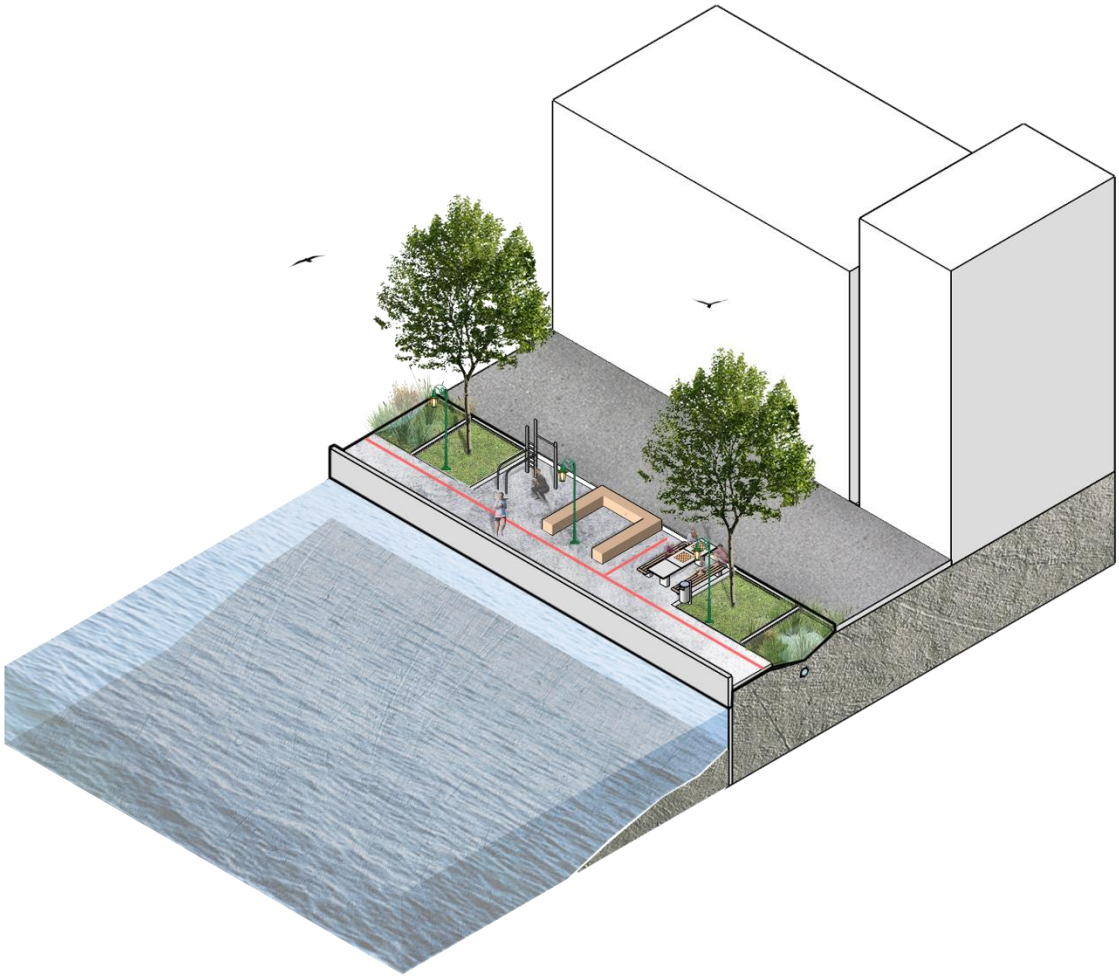


Figure 6.23:Mixed community functions. No.20

A small area with some mix community functions. Areas that don’t have enough spaces to build other sections can use this stitch.

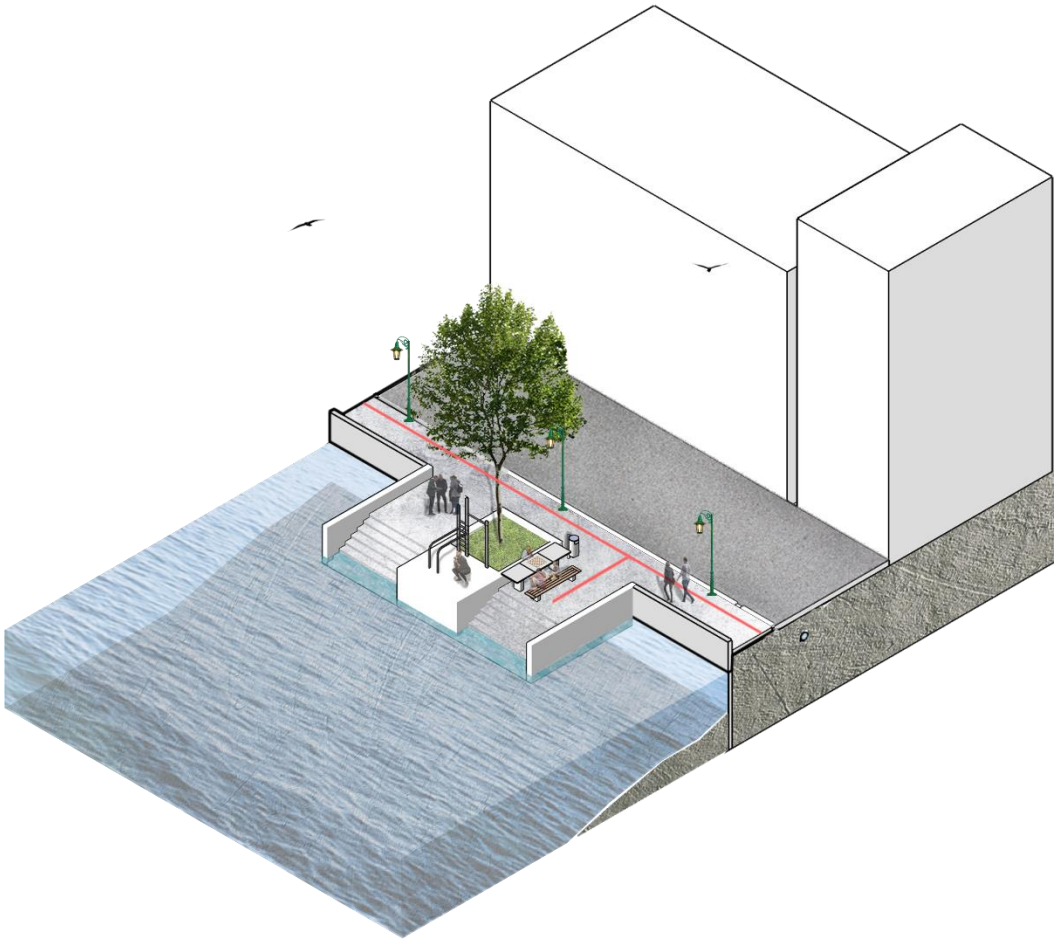


Figure 6.24:Extended Ghat. No.21

Ponds that does not have enough space will empoy this design. This ghat have similar functions as the previous one that can serve a small community.

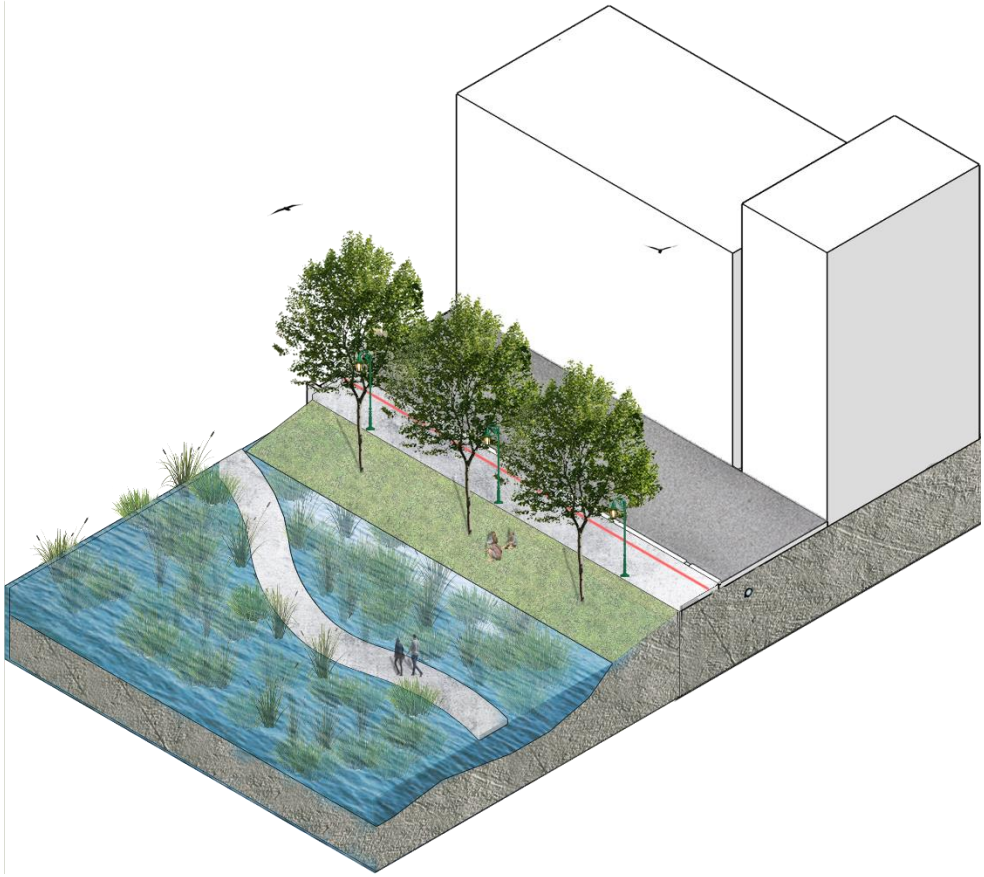


Figure 6.25:Walking along the eco-wetland. No.22

Eco-wetland will not have strong boundary lines. They will have bordering trees and aquatic plants to filter water into the core area.

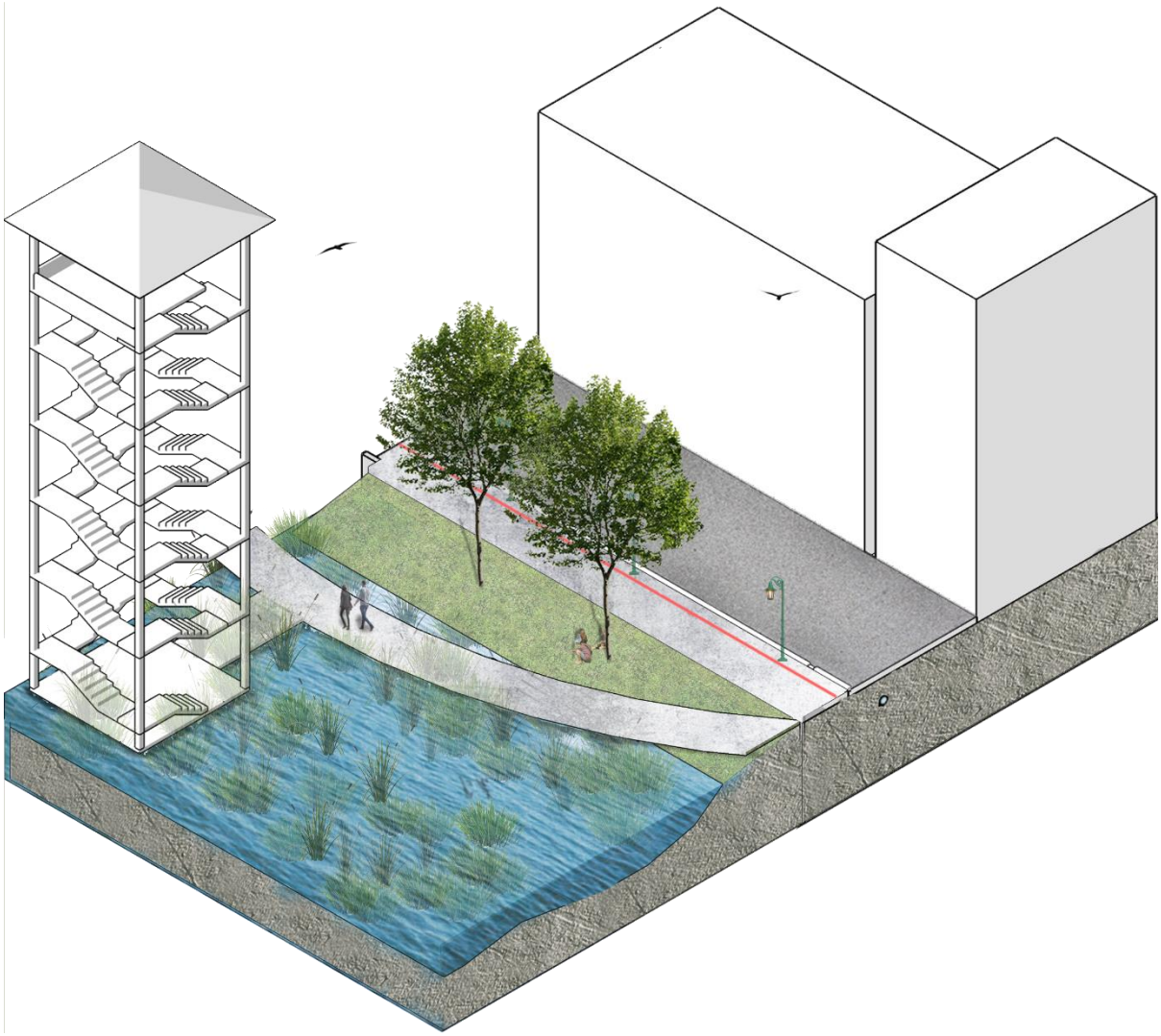


Figure 6.26: Watchtower to view nature. No.23

These watchtowers will be integrated within the walking path to look into the wetlands' natural vistas.

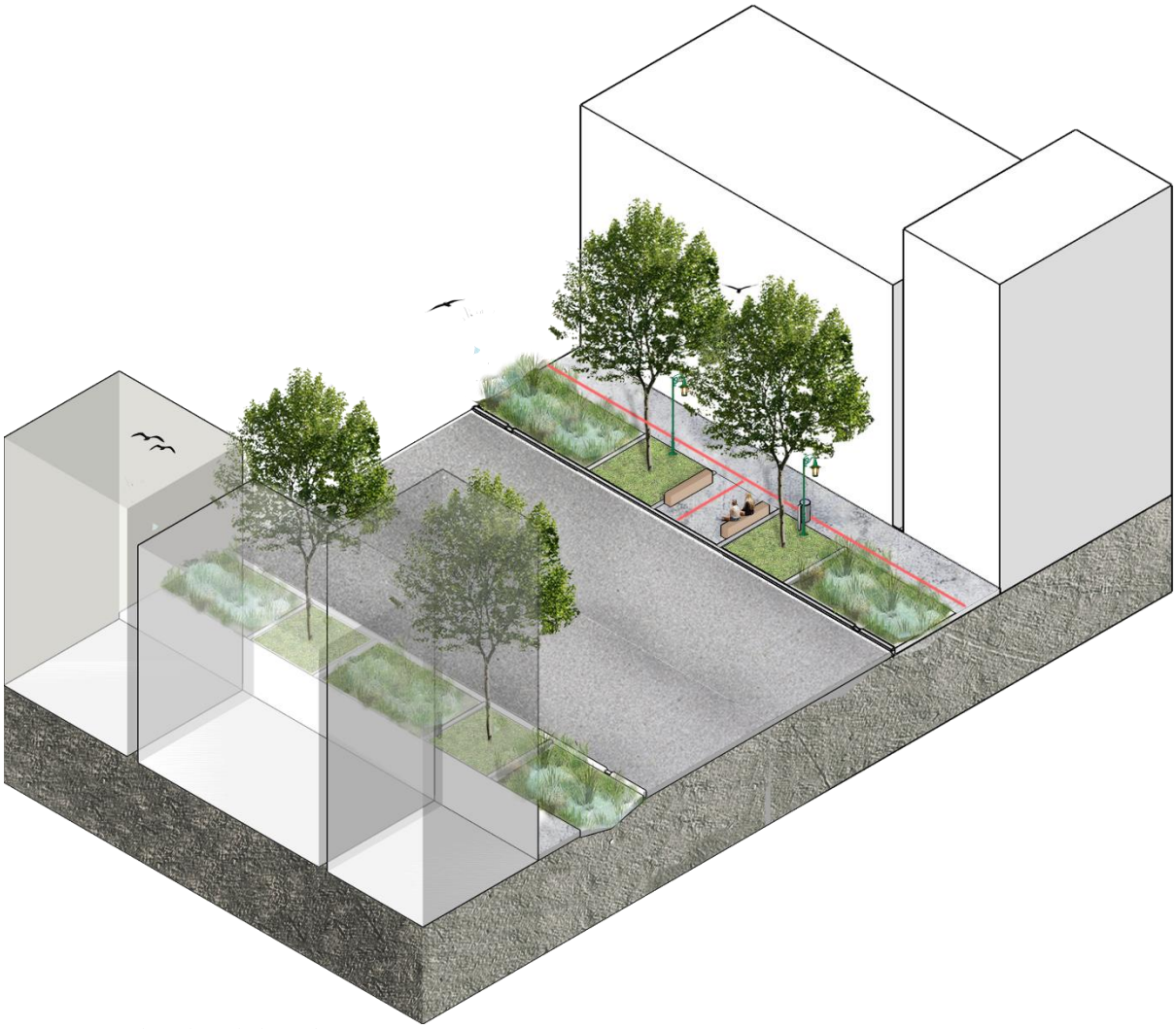


Figure 6.27:Blue Thread along the streets. No.24

The city requires green corridors and other connections to connect further the Blue and Green infrastructure of the city. The blue thread can occur in such streets wherever there is enough space. This will also provide retention areas for rain and active public zones.

6.4.Public Ponds

Based on survey results and context, eight ponds are categorized as Public Ponds. These ponds will be equipped with most of the active function that will provide the community and the city people.

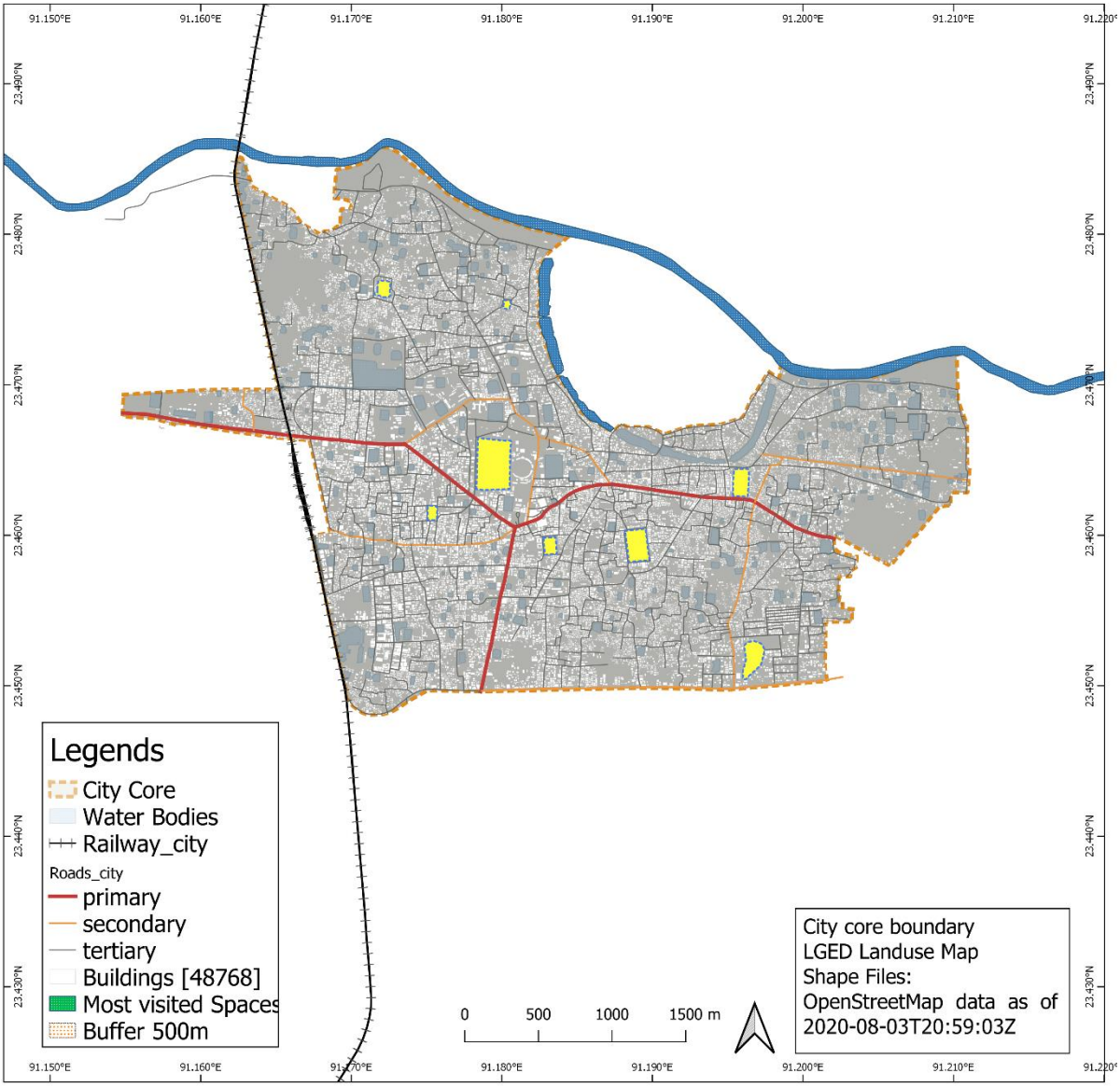


Figure 6.28:Category 1:Public Ponds

These eight ponds differ in size but are distributed consistently around the city. Criteria to select these ponds are their popularity, as mentioned in the survey report. Public ponds will always have a loop around them. Three of these ponds already have all the banks connected, and the rest of the ponds need new structural changes to their banks to accommodate the blue thread. Connected banks with live functions will create the atmosphere of a city pond.

Corresponding Maps are marked with numbers with stitches shown in the previous section.

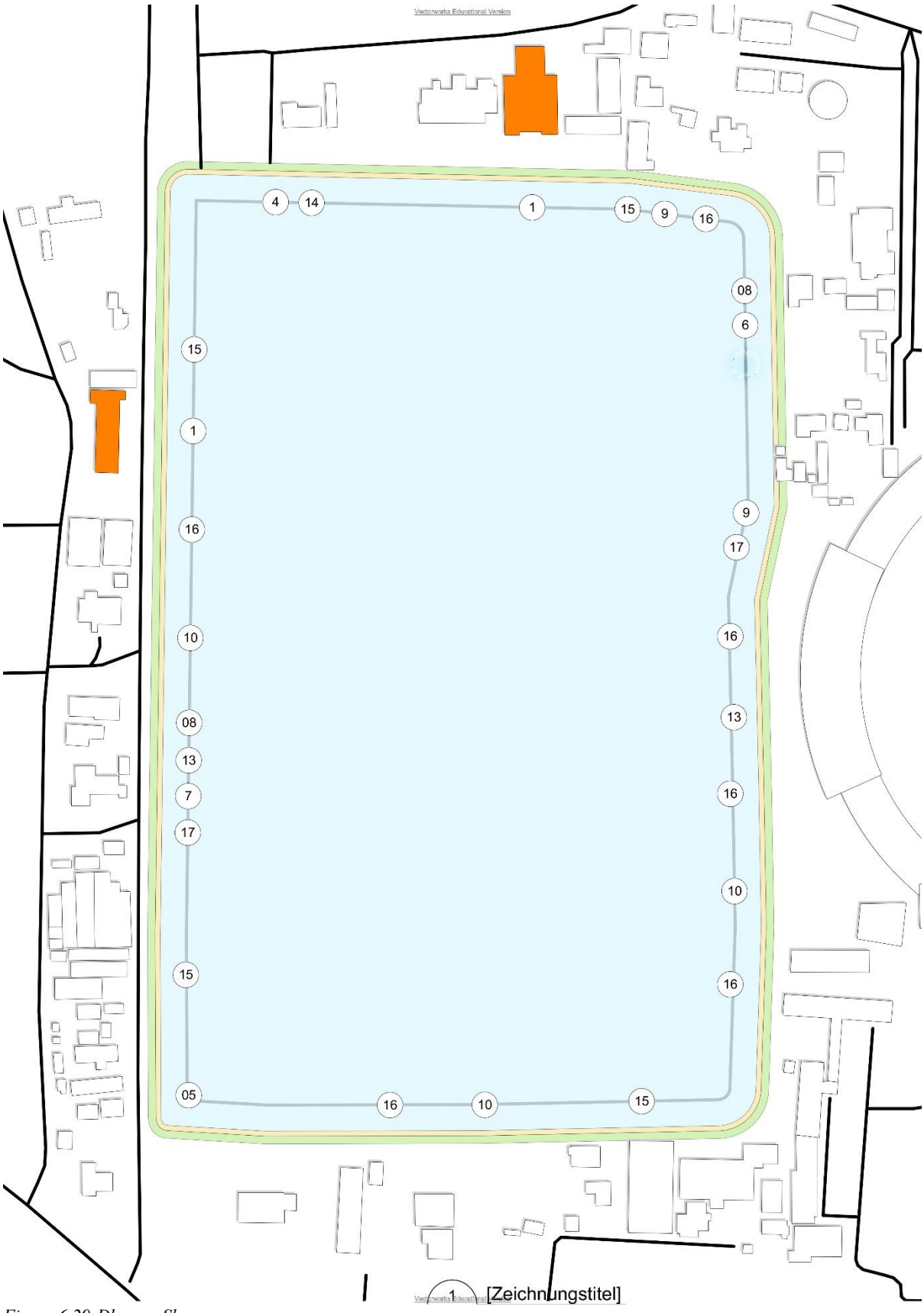


Figure 6.29:Dhormo Shagor

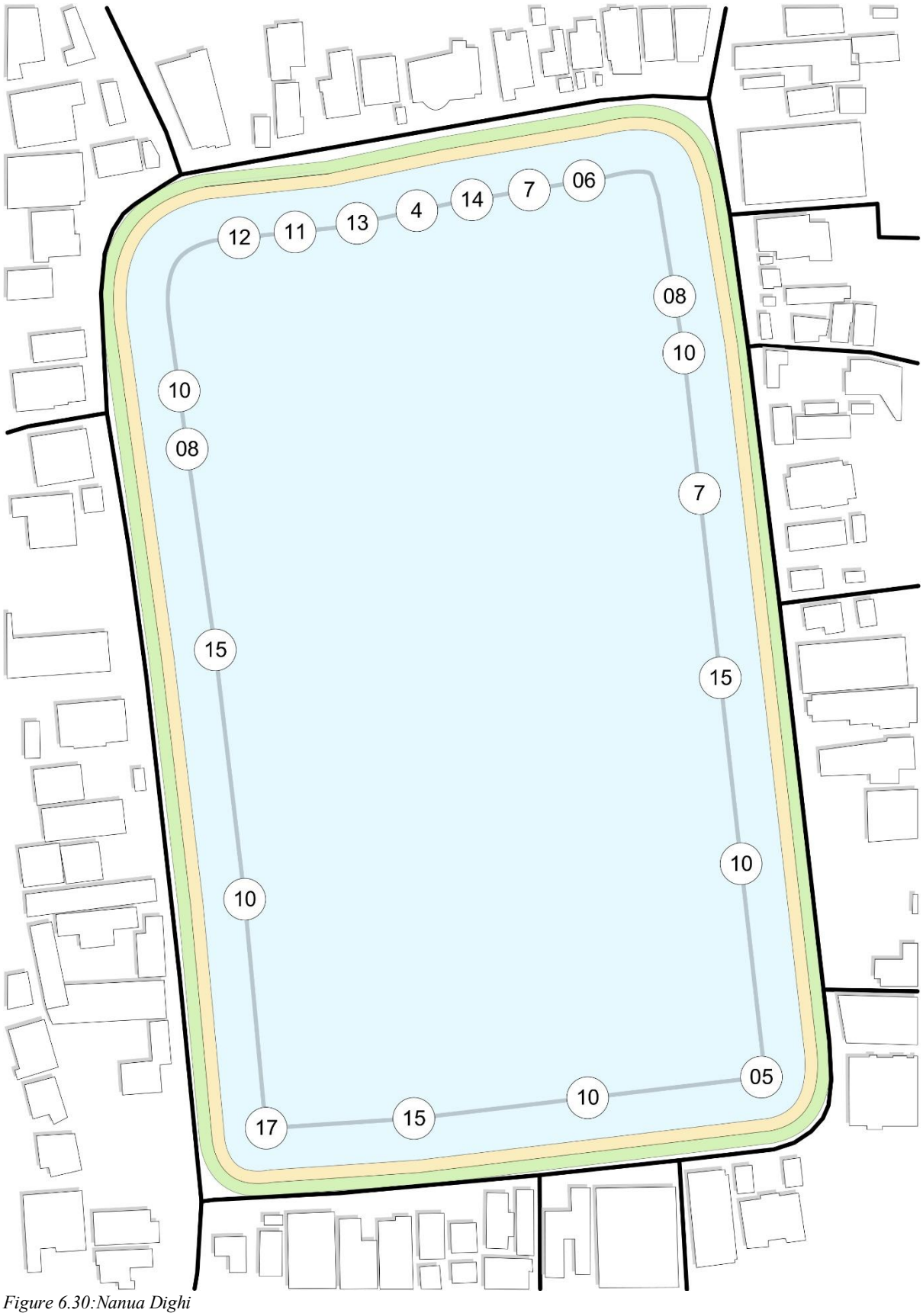


Figure 6.30:Nanua Dighi

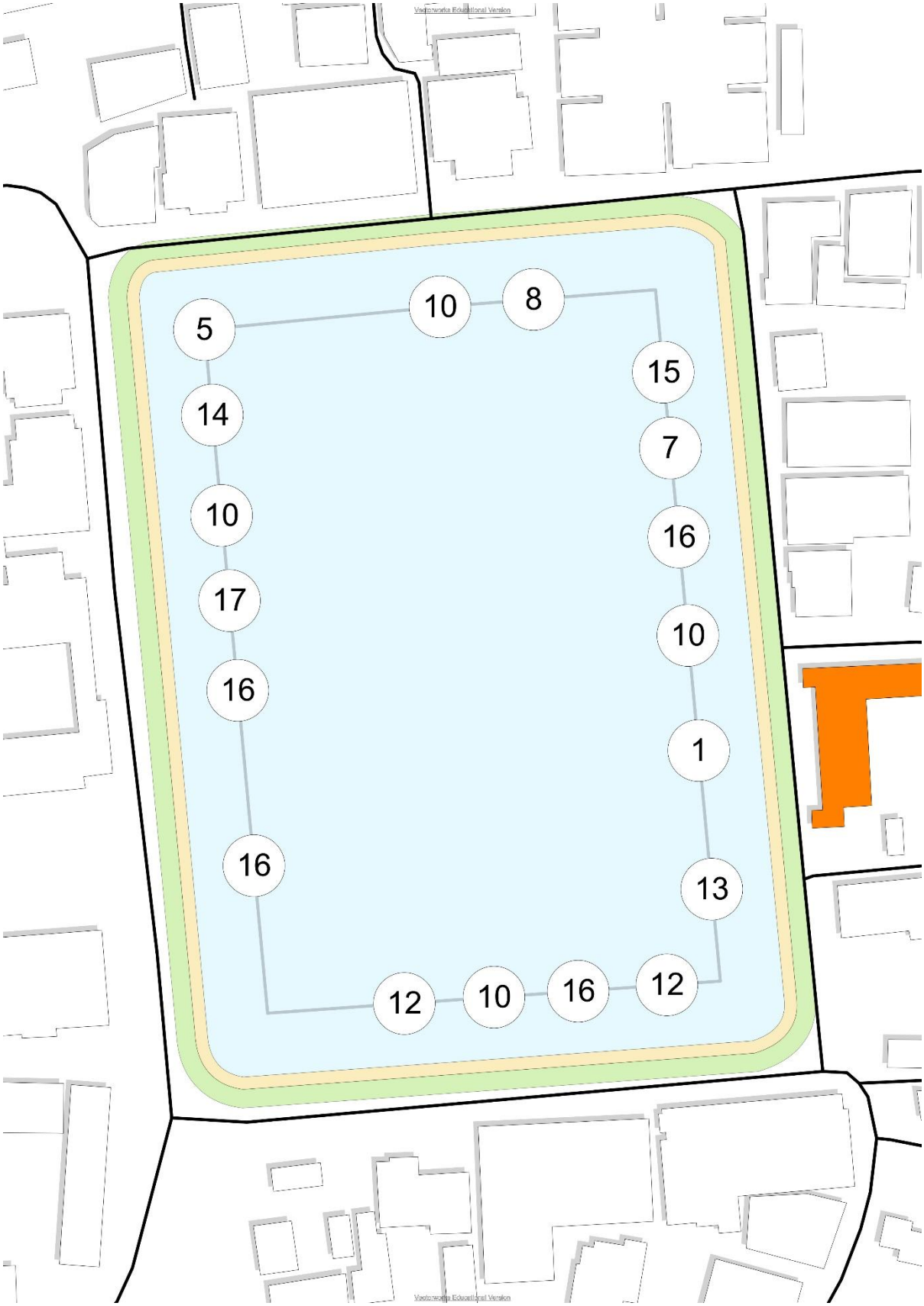


Figure 6.31:Ranir Dighi

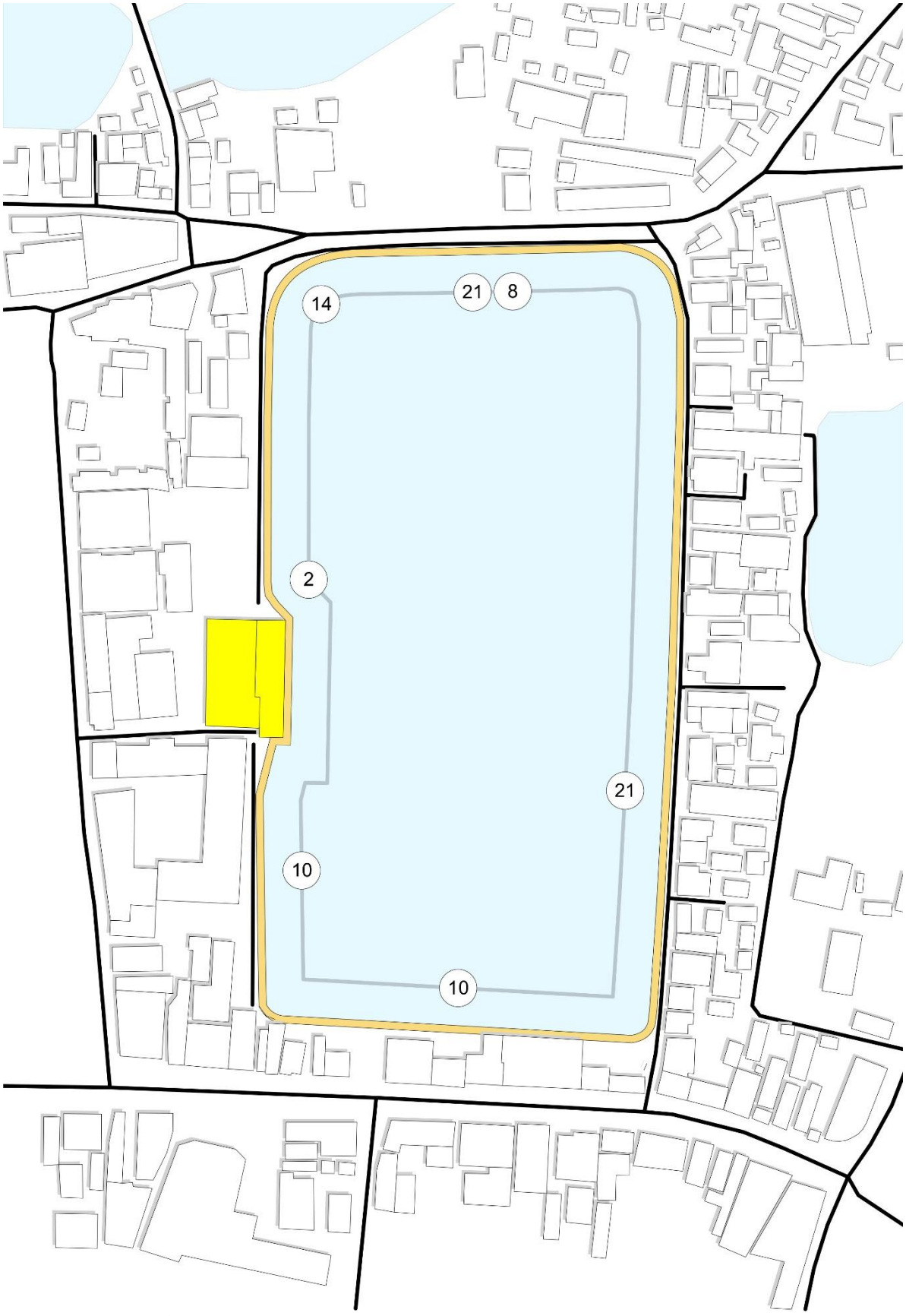


Figure 6.32:Amir Dighi

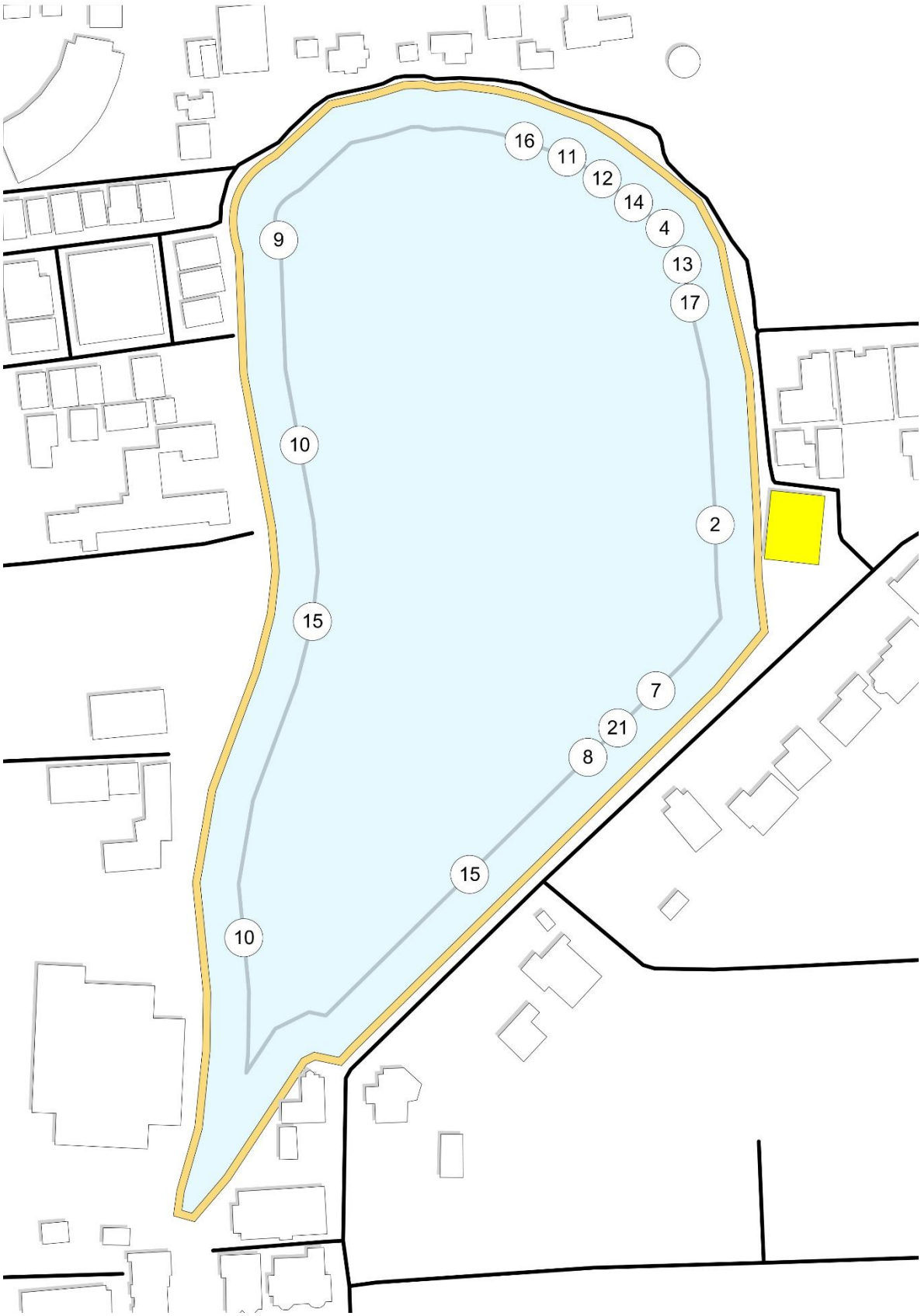


Figure 6.33:Lau Dighi

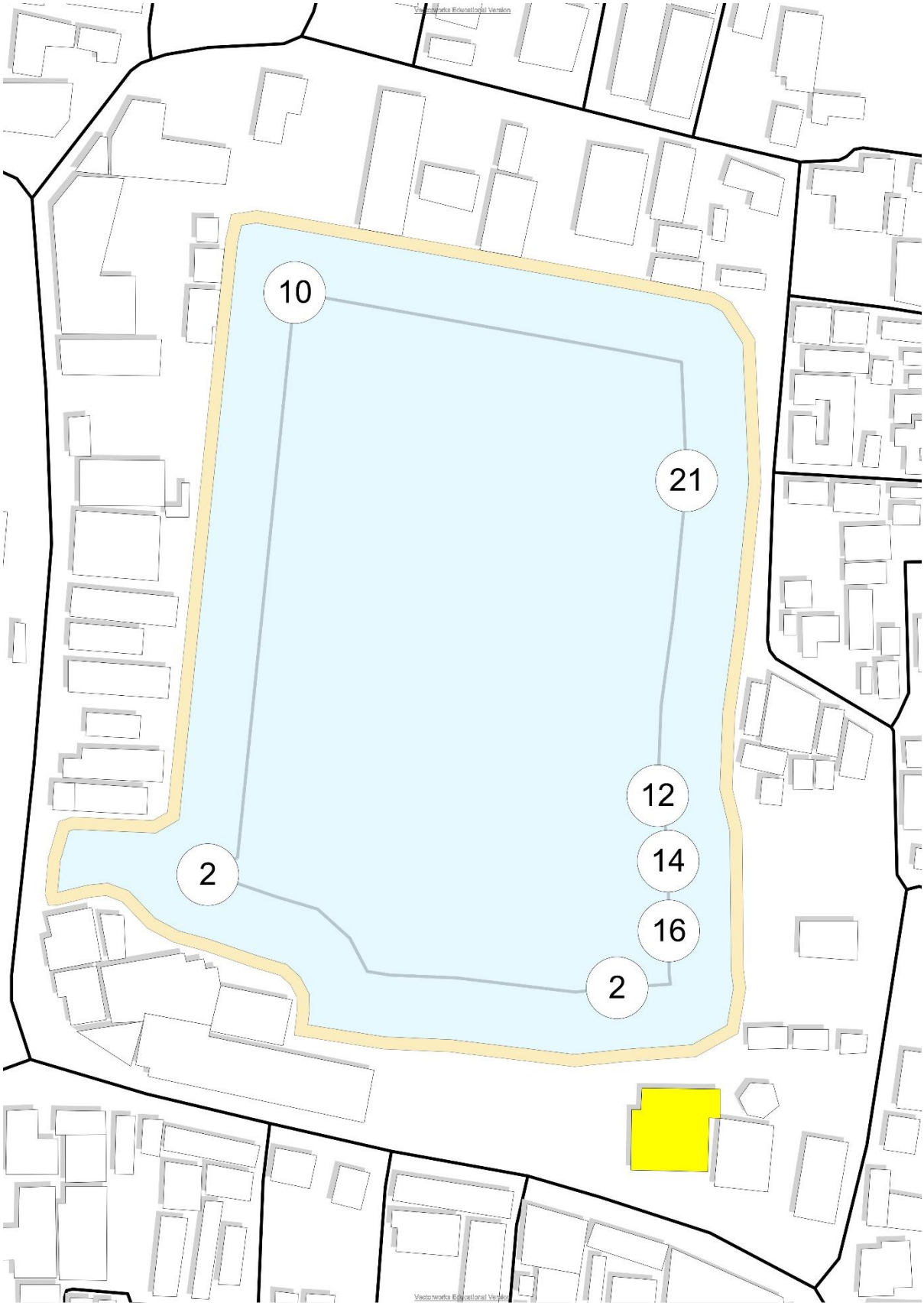


Figure 6.34:Kaliyajury Boro Pukur

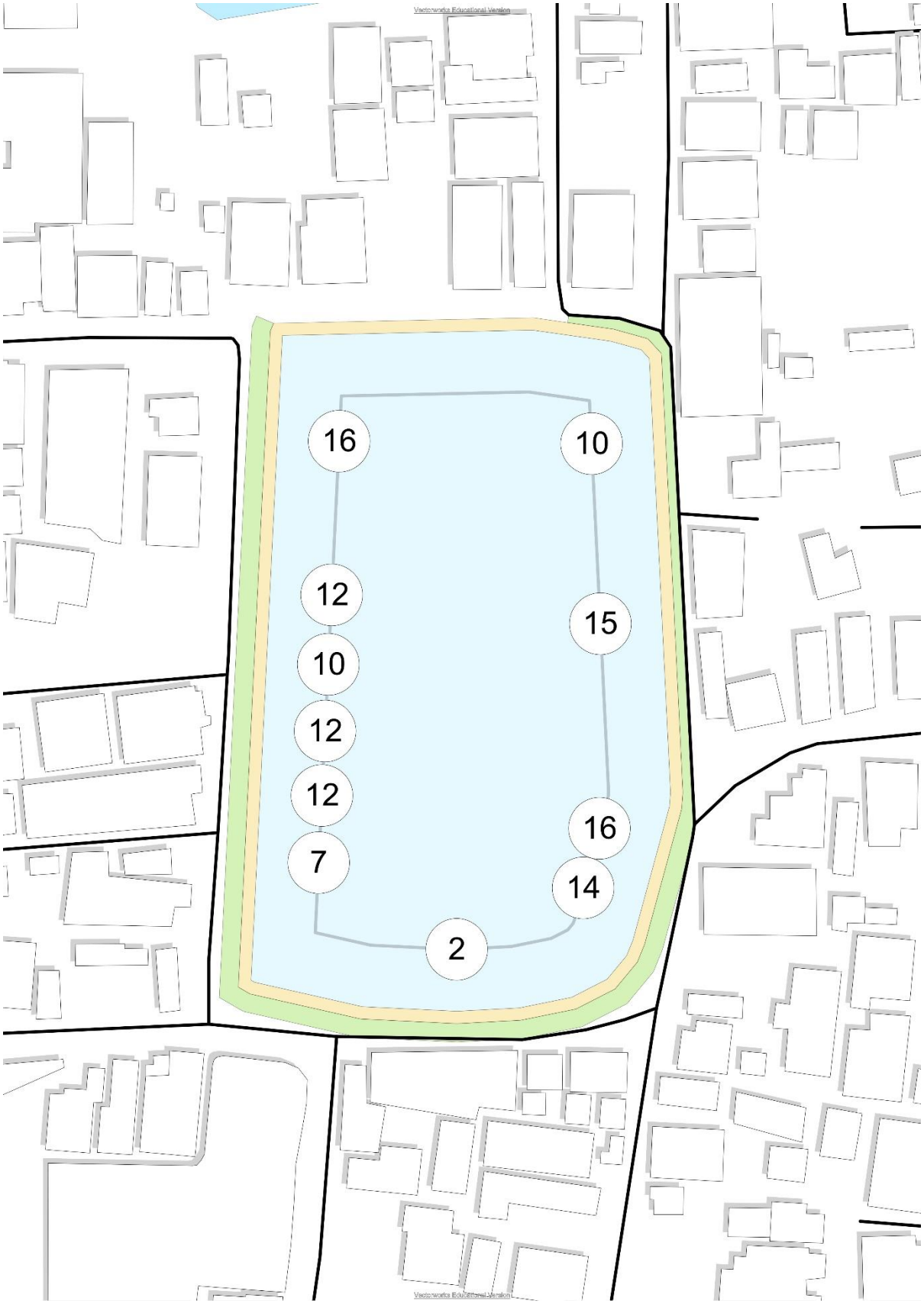


Figure 6.35:Tal Pukur

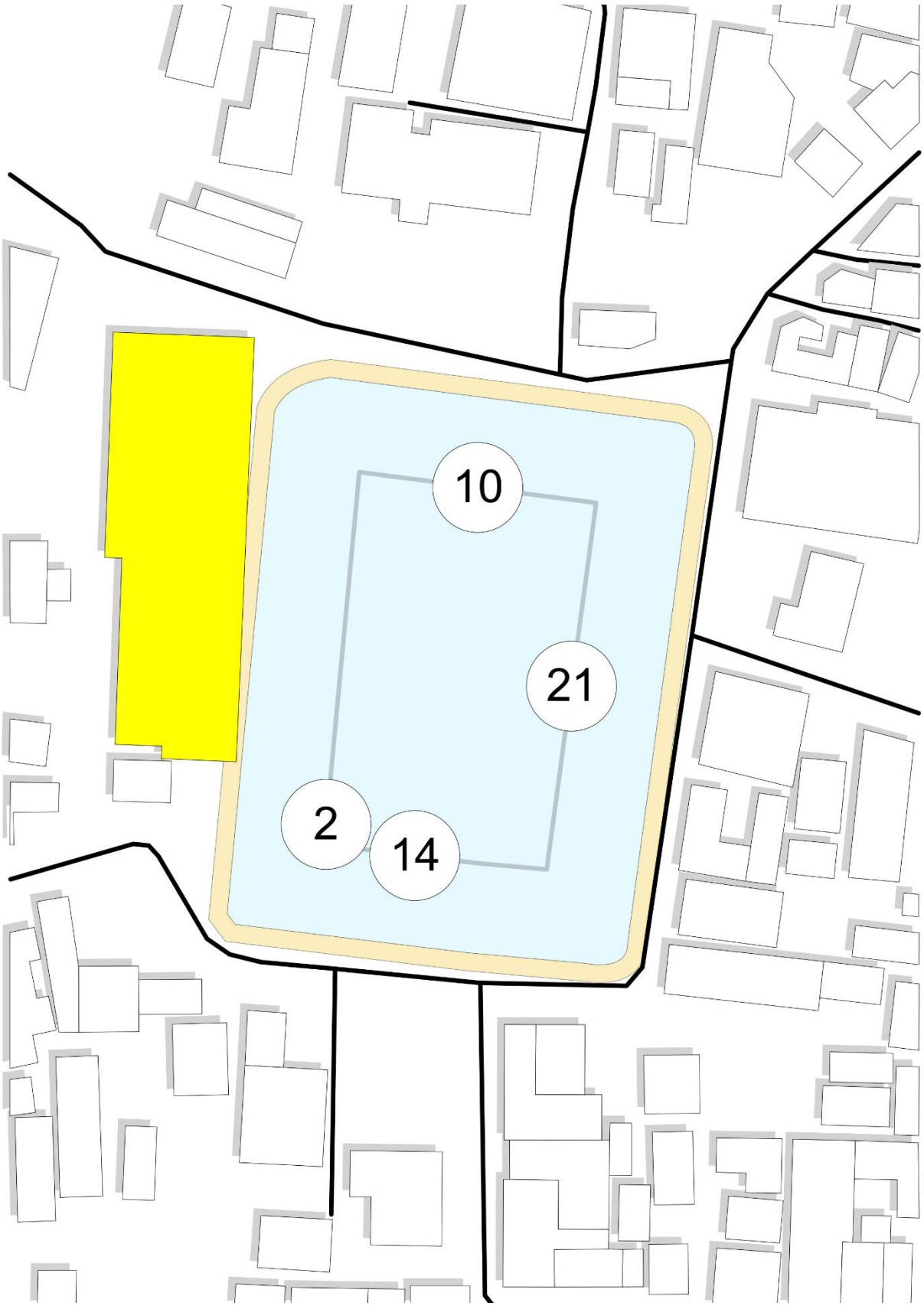


Figure 6.36:Bepari Pukur

6.5.Community Ponds

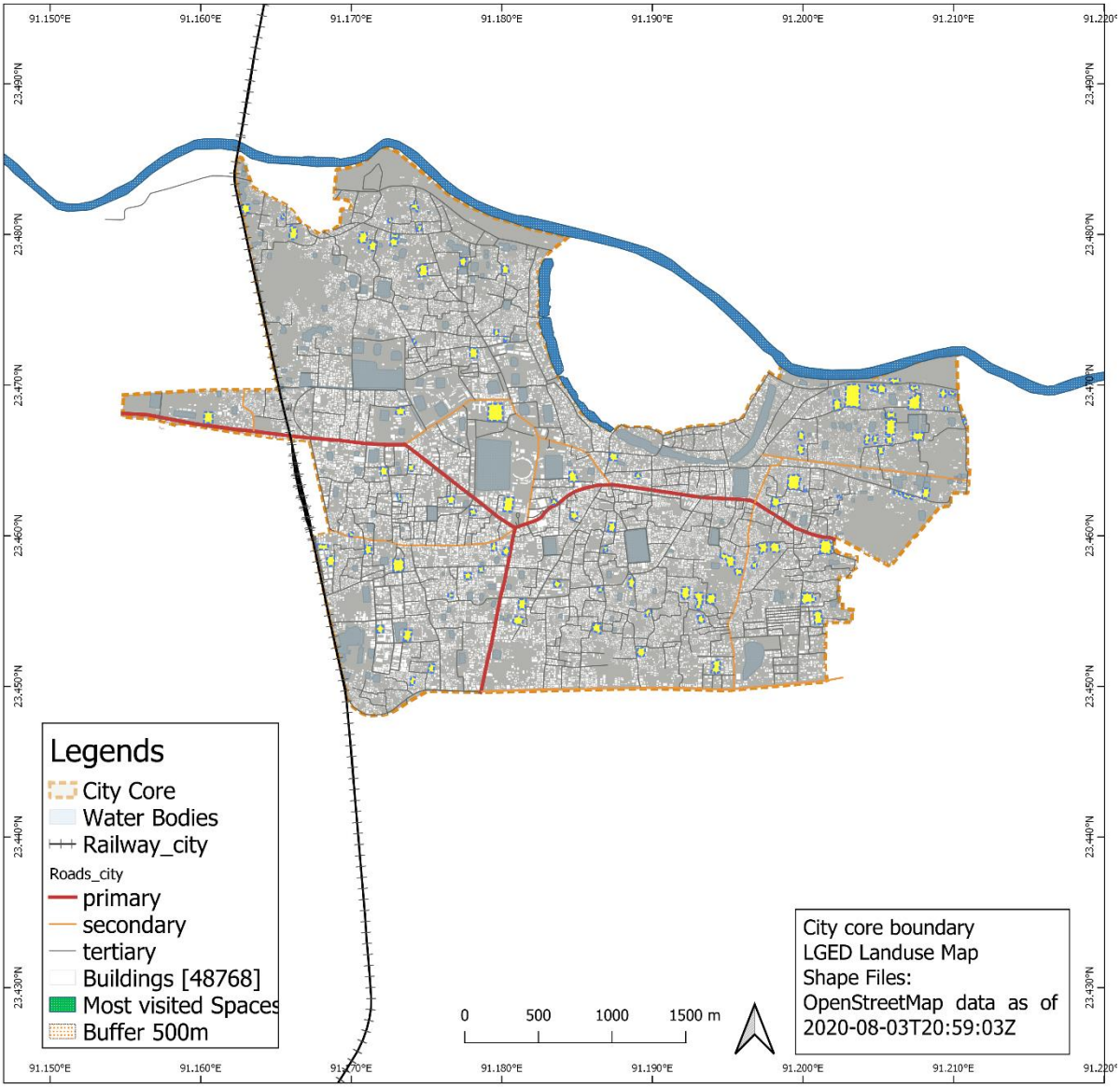


Figure 6.37:Category 2: Community Ponds

At the community level, all the design criteria of the public ponds should be maintained. Not all the banks are connected in these ponds. So the first target will be to connect these banks and to create a loop around the pond. Implementation of the design solution should be a community effort. In other cases, the banks that are adjacent to the road will be used as community spaces. Sticht 19,20,21 are exceptional cases for communities with tight areas.

6.6.Ecologically Important Wetlands

There are wetlands within the city that are diverse in bio-diversity, and winter birds come here every year. Nevertheless, the area is now diminishing, and the water quality is also worsening. A standard surrounding guideline is required to preserve these wetlands.

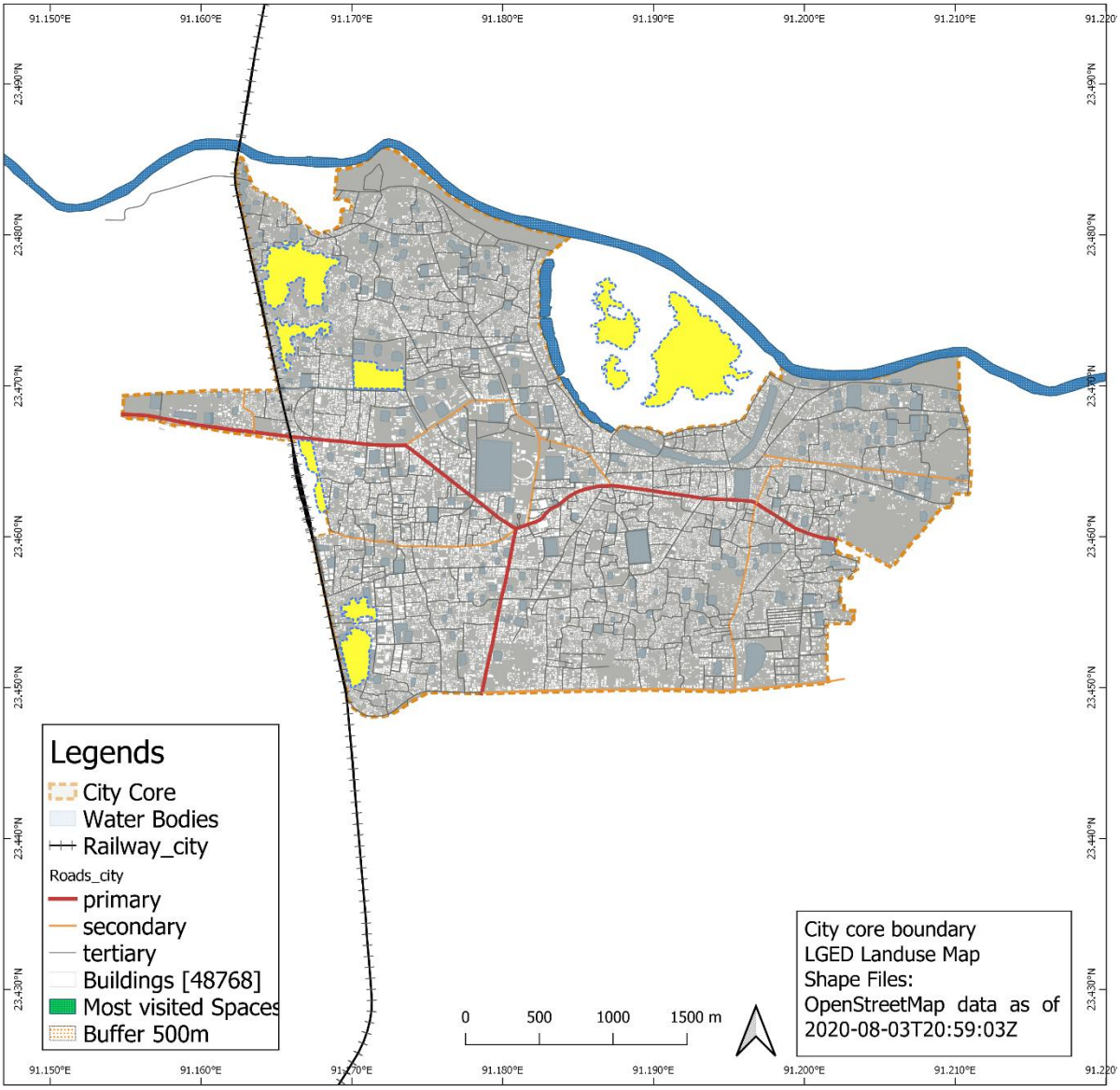


Figure 6.38:Category 3: Ecologically Important Wetlands

Aquatic plants that are hardy in both dry and wet seasons can withstand such banks and reduce runoff water velocity. Roots of the plants will then filter off heavy metals coming with the water. It will also reduce the murkiness that is harmful to the organism living in the water. A live ecosystem will sustain that can nurture nature, replenish underground reservoirs, hold habitats of the surrounding biodiversity and give city dwellers healthy living.

A band of these aquatic plants will surround the whole waterscape. Then a pathway floating through the water will be built for people to meander into nature. There will be watchtowers to observe birds and nature. Stitch 22, 23 will be used for all the Eco-Wetlands.

6.7.Stitching through the city

These stitches will not only connect the pond banks, but also run through the city. The Blue ribbon will run on both sides or one side of the street depending upond the width of the street. This will also be beneficial for the city rainwater management system. Also, to create a dialogue and an Image for the city, these repetitions are needed. Open spaces within the city that forms may be in a small open area or at the intersection of roads, can follow these guidelines. Stitch 24 is an example of how this can be done. There are some street that has broad areas by their sides. In these cases, the retention areas can be widened. Alternatively, an active avenue can be developed. The main focus should be to connect the Green and Blue Infrastructures.

6.8.Vegetation

To implement such a project budget is a critical matter. For the vegetation, I have chosen only native plants. Native plants are easy to grow, maintenance cost is less, and are suitable for the ecology. The bio-retention swales require plants that can withstand water and also hardy in dry conditions. The same goes for the wetland filtration band. Trees are selected based on their effectiveness to create an oasis for bio-diversity. The lists of plants are listed below according to their forms.

Not all aquatic ponds can be planted in the swales. Floating plants such as lilies will be only seeded in Eco-wetlands. Also, plants that are very high will be planted at the edge of wetlands.

Aquatic Plants

Botanical Name	Local and other Names
Schumannianthus dichotomus	Shitolpati, Murta
Arundo donax	Nolkhagra, Giant Cane
Eleocharis atropurpurea	Pani Chech, Purple Spikerush
Chrysopogon zizanioides	Binna Ghash, Vetiver Grass
Marsilea quadrifolia	Shushni, Four Cloved Clover
Ludwigia adscendens	Keshordam, Creeping Water Primrose
Nymphaea rubra	Rokto Komol, Red Water Lily
Nymphaea nouchali	Shaluk, Blue Water Lily
Nymphaea pubescens	Shapla, Water Lily
Colocasia esculenta	Mukhi Kochu, Water Taro
Nelumbo nucifera	Poddo, Lotus
Alternanthera sessilis	Shachi, Sessile Joyweed
Lemna perpusilla	Khudi Pana, Minute Duckweed

Ipomoea aquatica	Kolmi Lota, Water Spinach
Sesbania bispinosa	Dhoincha, Prickly Sesban
Alternanthera philoxeroides	Maloncho
Typha domingensis	Hogla, Southern Cattail
Leersia hexandra	Arail, Southern Cutgrass
Schoenoplectiella mucronata	Soktochechra, Bog Bulrush
Hydrilla verticillata	Water Thyme, Hydrilla

Table 6.1: List of Aquatic Plants

Trees

Botanical Name	Local and other Names
Amherstia nobilis	Raj Oshok, Pride of Burma
Cassia javanica	Lal Shonail, Pink Shower
Grewia asiatica	Falsha
Caesalpinia pulcherrima	Radhachura, Peacock Flower
Lagerstroemia speciosa	Jarul, Gian Crepe-Myrtle
Terminalia catappa	Kath Badam, Bengal Almond
Azadirachta indica	Neem
Bombax ceiba	Shimul, Red Silk-Cotton
Barringtonia acutangula	Hijol, Indian Oak
Pongamia pinnata	Koronja, Koroch
Ficus hispida	Dumur, Hairy Fig
Neolamarckia cadamba	Kodom
Diospyros peregrina	Gaab, Indian Persimmon
Ficus elastica	Rubber Bot, Indian Rubber
Delonix regia	Krishnochura, Royal Poinciana

Table 6.2: List of Trees

Depending on the site, in some places, shrubs will be planted in place of trees.

Shrubs

Botanical Name	Local and other Names
Alocasia macrorrhizos	Man Kochu, Giant Taro
Nerium oleander	Korobi, Oleander
Baleria lupulina	Shurma, Hophead Barleria
Phyllanthus reticulatus	Chitki, Roast Potato Plant
Calotropis gigantea	Akondo, Crown Flower
Carissa carandas	Koromcha, Karonta Fruit
Vitex negundo	Nishinda, Five Leaved-Chaste Tree
Lawsonia inermi	Mehedi, Henna
Gloriosa superba	Ulot Chondal, Flame Lily
Artabotrys hexapetalus	Kathali Chapa, Climbing Lang Lang

Table 6.3: List of Shrubs

For meadows and other green areas these ground coverings will be used.

Ground Covering

Botanical Name	Local or other Names
Glinus oppositifolius	Gima Shak, Pot Biroot
Imperata cylindrica	Ulu, Cogon Grass
Cynodon dactylon	Durba Ghash, Bermuda Grass
Panicum paludosum	Shama Ghash, Panic Grass
Cyperus rotunda	Mutha Ghash, Java Grass

Table 6.4: List of Ground Covering Plants

These plants listed here are the primary selection for the design. However, the design is not limited to these plants only. Local knowledge from neighborhoods and suggestions from specialists will be taken on the site of implementation.

6.9.Scenario

The first participation process was the survey where I learned about people's wishes and visions for these ponds. Nevertheless, to implement the design, it is essential to let them choose from various design solutions that I have designed. Here is a scenario where different stitches with a variety of functions sewed together to form the Blue Thread. A live atmosphere is created through public activity and nature.

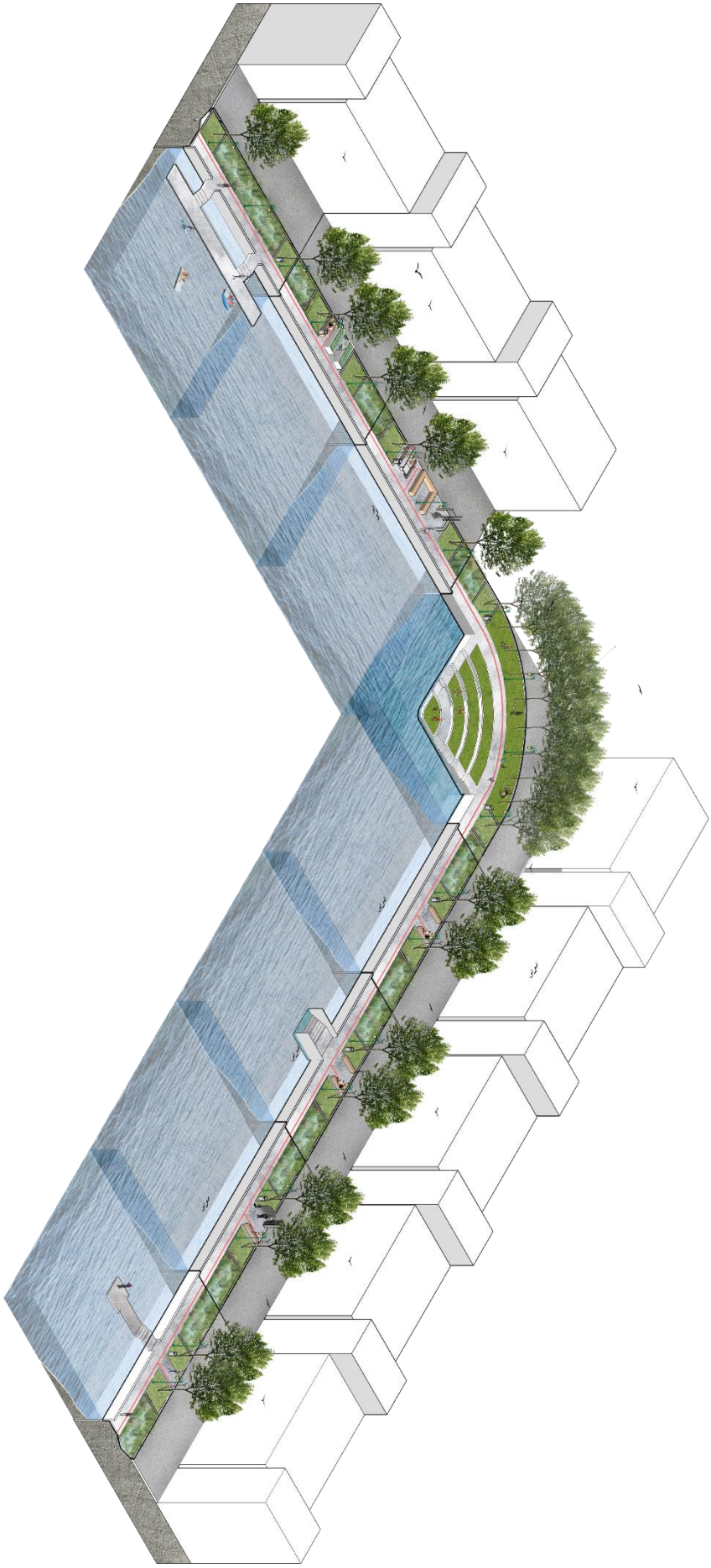


Figure 6.39:Stiches sewed together by the Blue Thread

6.10. Limitations of this Design Solution

For this thesis, my focus was to explore the possibilities to preserve the ponds by transforming them into Open Spaces through a design toolkit and conservation and creating soft corners into the hearts of the city dwellers. However, there are still some problems that can not be solved by these solutions.

Ox-bow Lake

The ox-bow Lake is integrated into a densely populated urban sprawl, disintegrated in several pieces. Used as a dumping area, polluted water, and hindered by the settlement are some of the problems. To preserve and revitalize this lake, a greater planning involves urban scale modification of the city. Although my design can be implemented in some place, it will not be a continous connection that will be very unsafe.

Active Rainwater Management

Active rainwater management is not present in the city. The uncovered drainage system blends with sewage, Canals are polluted and are not connected. My design can restrict surface water runoff to the ponds and a certain degree of water retention. But when the swales are overflown, the water will be released into the drainage system. So my solution is a tiny part of the rainwater management system now, but a grandeur and more detailed system is necessary.

Green Connection

We saw in the Green Infrastructure chapter how small the green patches are. And how scattered they are. It looks pretty critical to connect them. Maybe only green corridors are not enough. There should be new guidelines from the city corporation to expand the green patches and make new green areas. That will enable a good functioning Green-Infrastructure that will provide ecosystem services more efficiently.

Sustainable City

For a sustainable city, it is necessary that all these Blue infrastructures, including natural canals, ox-bow lake, sustains them. But the development of Green Infrastructures, Green Roofs, Green Walls, more Trees, Renewable Energy, Sustainable Waste Management System, and many other current world problems are needed to be addressed.

A grand scheme strategy is needed with a multi-disciplinary team to build a masterplan for the future city.

6.11. Conclusion

Being active with the blue elements of the city, people will be more eager to preserve them. A well-built public open space has more things to provide than just joy of life.

Preserving these ponds with active participation from the people will create new stories and revive old legends. Together with all these interpretations, my vision to revive the city's pond base image will be achieved.

For a sustainable future city, it is the first step to start with the water. Other things should follow.

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