A Thematic Landscape Designed Masterplan Integrating Urban Ecology, Water Planning and Social Improvements

– A vision for the former airport Tejgaon and the district Karail, Dhaka City, Bangladesh

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Independent project • 30 credits
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Landscape Architecture for Sustainable Urbanisation - Master's Programmme
Uppsala 2022

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Credits:	30 credits
Level:	Second cycle, A2E
Course title:	Independent Project in Landscape Architecture, A2E – Landscape Architecture for Sustainable Urbanisation– Master's Programme
Course code:	EX0945
Program/education:	Landscape Architecture for Sustainable Urbanisation - Master's Programme
Course coordinating dept:	Department of Urban and Rural Development
Place of publication:	Uppsala
Year of publication:	2022
Cover picture:	Illustration Nuzat Naila Islam
Copyright:	All featured images are used with permission from copyright owner.
Online publication:	https://stud.epsilon.slu.se
Keywords:	Green and blue infrastructure, Informal settlements, storm water flooding, urban ecology

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Abstract

The aim of this thesis paper is to integrate three important thematic aspects i.e., improve qualities in the urban ecological situation, provide ideas for handling stormwater flooding and ideas to improve socio-economic aspects for inhabitants. The integration of ideas is illustrated in a masterplan program-sketch in three phases.

Dhaka is the capital of Bangladesh. Dhaka is a densely populated fast developing city. The chronological changes of the natural setting due to rapid growth of urbanization in Dhaka city creates an imbalance with nature and disrupts urban ecology. The green and blue structures are replaced with built areas and hard surfaces. The situation for urban ecology in the city of Dhaka affects storm water flooding and social wellbeing.

The methods used for background knowledge to this proposal are literature reviews, document searches, interviews, GIS analysis and a study of role models from different countries and contexts where a variety of solutions, proposals and functions inspired me in my own sketching.

The methods and the background for this thesis were used to formulate guidelines to support the overall program-sketch for the three phases in a masterplan.

The first phase program-sketch includes redesigning the informal settlements in Karail into better living conditions for the dwellers according to Patrick Geddes theories by keeping the overall road- and block structure and provide new shelter, job opportunities and adding recreational values to the area. The second phase concentrated on re-establishing of water streams in a green park according to the philosophy of Fredrick Law Olmsted, and in the third phase the former airport Tejgaon to become a large green area for social meetings, recreation activities for the Dhaka city inhabitants and provide job opportunities for the informal dwellers.

The discussion on strengths, limitations, challenges, and further development ends with a conclusion that it is of great importance to work integrated with the three thematic aspects urban ecology, storm water flooding and social wellbeing on an overall level and with understanding of the issues among both specialists, politicians, and inhabitants to be able to implement necessary change towards sustainability.

Keywords: thematic aspects, masterplan, landscape architecture visions, green and blue infrastructure, informal settlements, storm water flooding, urban ecology, socio-economic wellbeing

Popular science summary

This thesis investigated the current emerging issue based on three different thematic aspects i.e., improve urban ecology and greenery, manage stormwater flooding, and improve the social and economic condition of living within a particular part of Dhaka city. This particular part includes the former airport in Tejgaon and the informal settlement area in Karail.

The study area has a scope of improvement and re-establishing the connectivity within greenery and waterbody. The integrated design sketch at program level in three phases and the guidelines considering the three thematic aspects are proposed to improve the quality of urban living and achieve sustainability.

This thesis consists of nine chapters.

• **Chapter one,** the introduction, gives an overview of Dhaka city and the study area. The background presents existing conditions of the city and a general idea about the site surroundings of the study area. This chapter further explains the gradual loss of greenery and water body over the years in Dhaka city. Lack of policymaking in urban planning in Bangladesh and the problem statement leads to the chosen three thematic aspects and formulations of the aims, objectives and the research question of this thesis.

• **Chapter two** is about the methodological approach and analysis. The methods such as literature reviews, document searches, interviews, GIS analysis and study of role models from different countries and contexts are described. This chapter clarifies the methodological procedure.

• **Chapter three** contain the literature review with focus on the three thematic aspects of this thesis, urban ecology, stormwater flooding and social sustainability. This chapter gives an overview of the concept of Fredrick Law Olmsted and Patrick Geddes theories of city development and the comprehensive understanding of the benefits of urban green space that I have used in my thesis proposal on urban ecology, causes and effects of stormwater flooding in Dhaka city and the necessity resettlement of the informal dwellers in Dhaka city. Besides, this chapter explores tree inventory to improve urban ecology in the context of Dhaka city. Reviewing various literature was highly beneficial in terms of formulating guidelines and sketching the overall masterplan.

• **Chapter four** is about the online survey questionnaire in Dhaka city. This helped to understand local people's situation and to gather expert's opinions. The survey gave an opportunity for the local people to share their experience and sufferings. Their suggestions and demands to reduce the effects of stormwater flooding and increase greenery and improve the socio-economic status of living motivated me to formulate the guidelines and propose the masterplan program-sketch.

• **Chapter five** contain analysis from GIS maps which helped to understand the existing condition and surroundings of the city. The GIS analysis includes the following topics:

- Land use
- Green and open spaces
- Informal settlements
- Loss of wetlands and waterbody
- Flooding analysis

• **Chapter six** contains studies of role models around the world. The examples from different contexts address the similar issues as this thesis deal with. These role models helped to gather knowledge and act as an inspiration to me in formulating the guidelines and sketching out the visionary masterplan program-sketch.

• **Chapter seven** includes findings, guidelines, and the result in a proposal for a masterplan program-sketch. This chapter discusses the interpretation of the main findings from performing the methodologies. The SWOT analysis reflects over the strengths, weakness, opportunities, and threats of the study area. The guidelines provided are based on the main findings from performing the research methods and the SWOT-analysis. The results of the thesis in an overall masterplan program-sketch of the integrated green and blue infrastructure are proposed in three phases. The description of the phase-wise development in this chapter reflects over how the proposal can be implemented and refers back to the main findings.

• **Chapter eight** contains the discussion on strengths and limitations of the result and recommendations for further work.

• **Chapter nine** contains the conclusion of the thesis that it is of great importance to work integrated with the three thematic aspects urban ecology, water flooding and social wellbeing on an overall level and with understanding of the issues among both specialists, politicians, and inhabitants to be able to implement necessary change towards sustainability.

Preface

People used to call me a child of nature. Before my birth, my grandfather dreamt a child was playing within the lap of nature and flowers. Right after that, I was born, when my grandfather saw me, he said, “This was the child that I saw in my dream!!!!”. During my childhood, my love for nature was quite noticeable. Whenever, I paid a visit to my grandparent’s house he used to take me to his office which is situated at Rajshahi university within Rajshahi division, Bangladesh. The university area was huge and full of natural elements. My grandparents’ house was also surrounded by nature. Every day I used to go with him outside and used to pick a lot of flowers and gifted them to my grandmother. It was like a daily routine for me.

I grew in Dhaka city, Bangladesh, in a government quarter. The quarter was also surrounded by natural settings. My mornings used to begin with collecting flowers and later during my leisure I used make neckless with these flowers. I was also very fond of arts and paintings. These were my main interest points in my early childhood. I used to enjoy the rains a lot. I always sit beside the window and enjoy the rain a lot. The smell of wet soil during rain attracts me the most.

Around 2008 we shifted to our own apartment in Dhanmondi, Dhaka. The area was full of buildings and no natural settings at all. Gradually I started to miss nature very much. The disconnection with nature began from there. The only greenery I could enjoy was at my grandparent’s home. But after a few years, they reconstructed their house, and the greenery was also lost from there. This kind of scenario is quite common in Dhaka city nowadays. Today’s generation might never enjoy nature that much like their earlier generation had enjoyed.

Gradually I also started to develop my interest in arts and architecture. I took my admission to an architecture school around 2010. Since then, I had an urge to work for nature and landscape at least to do something to improve urban greenery and ecology in Dhaka city to create a better environmental quality for future generations. I had a great desire to pursue my master’s degree in landscape architecture. Meanwhile, I got married and had to move to Sweden around 2018. Here I got an opportunity to study Landscape Architecture for Sustainable Urbanisation (LASU) programme at the Swedish University of Agriculture and Science (SLU), Uppsala, Sweden. During my study period, I learnt a lot about Swedish culture, planning process, sustainability, urban ecology etc.

During my study period at SLU, I had an opportunity to attend the “Urban Ecology” course under the guidance of Sofia Eskilsdotter, Emma butler and Marcus Hedblom. They taught me a lot of things about urban ecology, and I also worked with street trees to improve urban ecology and manage stormwater flooding on streets. This inspired me further to choose my thesis topic. During this course, I thought that stormwater flooding is a very serious problem in Dhaka city

that should be addressed properly. The urge to work for urban greenery and the learning experience during the ‘Urban Ecology’ course about how stormwater flooding can be managed in Dhaka city set up a base for me to choose this as a thesis topic. Later based on this I choose a study area in Dhaka city where I can address these issues and can provide a possible solution regarding this. Further Frederick Law Olmsted´s philosophy (Nicholson 2004) of considering the social and economic aspects, helped to formulate the aims and objectives, research questions. Formulating research method finally helped to provide guidelines and helped to conceptualize in deriving into the final designed visionary masterplan proposal.

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Abbreviations

RAJUK	Rajdhani Unnayan Kartripakkha
BBS	Bangladesh Bureau of Statistics
DCC	Dhaka City Corporation
WASA	Water and Sewerage Authority
DWASA	Dhaka Water and Sewerage Authority
FD	Forest Department
DAP	Flood Action Plan
CEGIS	Centre of Environment and Geographical Information Services
IWFM	Institute of Water and Flood Management
IWM	Institute of Water Management
MDB	Meteorological Department of Bangladesh
BWDB	Bangladesh Water Development Board
BCAS	Bangladesh Centre for Advanced Studies
BAPA	Bangladesh Poribesh Andolon
GIS	Geographical Information System
WSUP	Water and Sanitation for the Urban Poor
SIP	Slum Improvement Project
LGED	Local Government Engineering Department
BNBC	Bangladesh National building code
NUSP	National Urban Sector Policy
NHP	National Housing Policy
DNCC	Dhaka North City Corporation
DSCC	Dhaka South City Corporation
PWD	Public Works Department

1. Introduction

Green and blue infrastructure is an important factor for our physical, mental, ecological, and social wellbeing. A century back as human being we used to think that the world is full of unlimited greenery and water bodies (Cronon 1996). One-third of the earth is full of water. Now a day's greenery and waterbodies are completely lost in most of the cities. The cities are becoming more and more dreary without these integrated green and blue infrastructures. Loss of greenery, wetlands and waterbodies, unplanned development causing urban heat island effects, stormwater flooding, imbalance in ecology on both small and large scale are the result of rapid urban growth. Regaining the connectivity of green and blue structures will benefit the environment as well as improve the quality of living.

1.1. Background

Bangladesh is a densely populated country. Large amounts of the population move to cities and urban development increase day by day in the cities. Unplanned development, cutting down trees, landfilling on water bodies and wetlands are making the problems with growing cities more severe.

Dhaka is the capital city of Bangladesh. The area of Dhaka is almost 300 sq.km with a estimated population of 21,741,090 (WPR 2021)**.** According to the Bangladesh Bureau of Statistics (BBS), a city like Dhaka is highly dense. Almost 23,234 (WPR 2021) people lives in per sq.km in Dhaka city. In Dhaka city, almost 300,000- 400,000 poor rural people move into cities each year (WSUP, 2007). Due to the ever-growing population and lack of job opportunities in rural areas people are moving towards Dhaka city to find better opportunities. A huge number of people are establishing their settlements in the slum areas. As a result, informal settlements such as slums are increasing day by day in Dhaka city. The density within these informal areas is also increasing. This also creates extra pressure on land and raise the unemployment situation in the city.

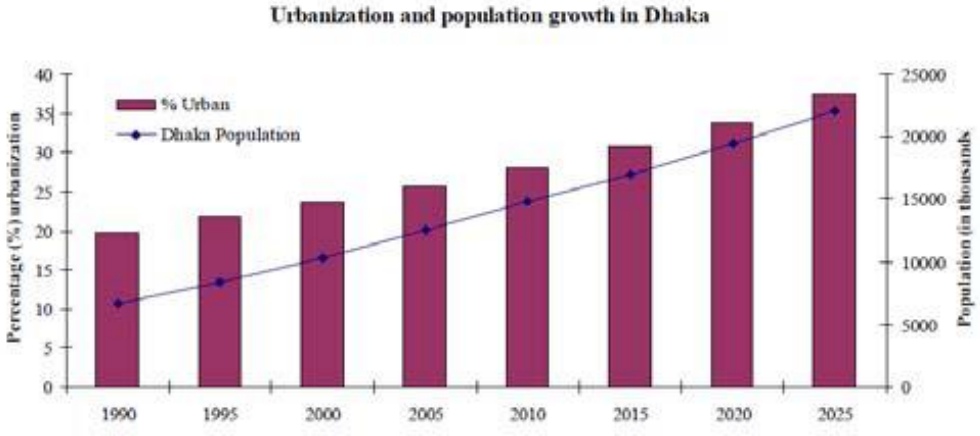


Figure 1: Urbanization and population growth in Dhaka (Sinthia 2013).

Figure 1 showing the gradual increase in urbanization and population increase ratio in percentage from 1990 to present 2020 to a possible growth within 2025 (Sinthia 2013).

1.1.1. Existing condition of overall Dhaka city and the study area

Bangladesh is situated at the south of Asia riverine where at the north the world´s largest mountain the Himalaya is situated. The place of origin of most of the rivers of Bangladesh are from the Himalaya. The rivers and their branches have surrounded the country as a mesh, that is why Bangladesh is often called the mother of rivers. Due to a lot of waterbodies, natural topographical settings and climate change Bangladesh often suffers heavy flooding due to the rise of temperature and melted snow from the Himalayas (Figure 2). The unexpected climate change causes unexpected droughts and noticeable changes in regular rainfall patterns. Frequent flooding and river erosion have become quite a common occurrence. The rise of sea level is also one of the major impacts due to climate change. Flooding from the sea, stormwater flooding has become quite problematic in the Bangladesh in recent years.

This section will describe the existing topographic condition of Dhaka city and try to explore the chronological changes due to urbanization, loss of greenery, and water bodies over the periods of time.

Topography analysis

Ganga and Brahmaputra are the two delta rivers and the main source of these two rivers is from the Himalayas. These two rivers carry a huge amount of alluvial soil and then combined with the another river Meghna which is a non- Himalayan river creates one of the largest deltas in the world. They together flow towards the Bay of Bengal (Figure 2).

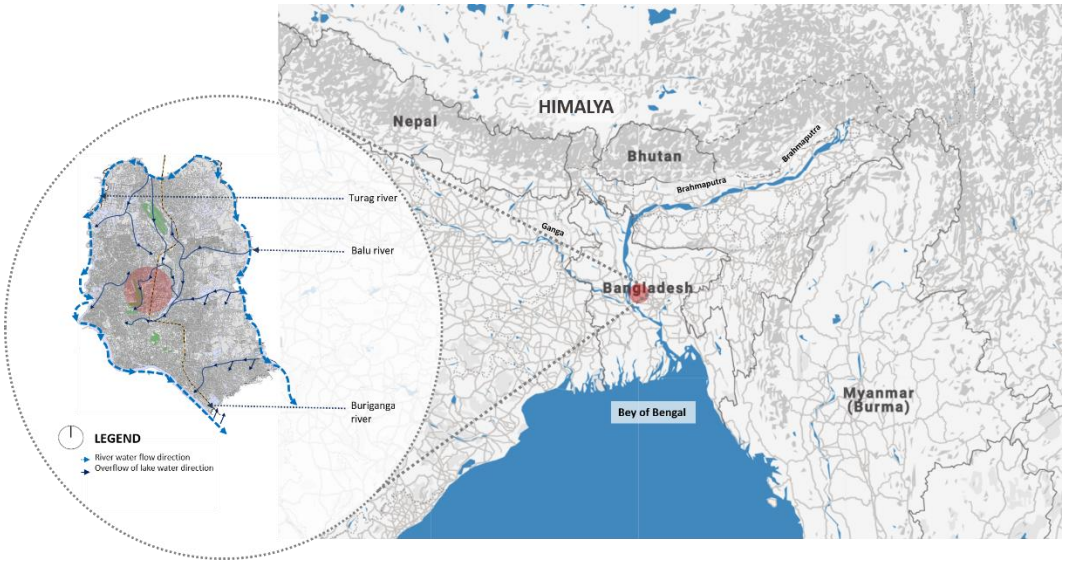


Figure 2: Map showing surrounding rivers of Dhaka city and the water flow direction of rivers, the red circle shows the study area. The map is collected from(Google Map Styles 2021) and the map is edited by the author.

The existing topographic condition of the capital city Dhaka is quite flat. Dhaka city is bounded by three major rivers. Figure 2 showing that the Balu river situated at the east, the Turag river to the west and the Buriganga river to the south. These three rivers are the branches of the Brahmaputra. The water flow of all the rivers is downstream and then it flows towards the sea the Bay of Bengal which is situated at the south. Dhaka city is often called a delta city due to its surrounding topographic condition. The city core or the central part of the city is at a higher level and it is gradually levelled down towards the east, west, and south direction where the three major rivers Balu, Turag and Buriganga are situated. The northern part of the city is situated at higher level.

Historical changes in waterbody and greenery in Dhaka city

Once upon a time the capital city Dhaka used to be covered with a lot of greenery. During the time of the Mughals (1608-1764), different types of parks and plantation were constructed by different Mughal Emperors. Among them, the Ramna park and the Baldah garden still stand as a remembrance of that periods in history (Mukti 2006). The greenery has been faded away gradually due to unplanned development and unplanned population growth. Trees have cut down without any consideration to provide accommodation and other facilities. Population increase, unplanned development, lack of proper urban planning, lack of urban greenery creates different problems. Trees are one of the main elements of nature, and our wellbeing are cut down without even thinking twice. People are getting disconnected from nature and greenery. Urban ecological balance and diversity are completely lost in the city due to rapid urbanization (Farrell 2018).

Different government organizations such as FD (Forest Department) of Bangladesh and DCC (Dhaka City Corporation) has started the project the “Dhaka city Beautification” project for tree plantation and beautification of the city (Mukti 2006). WASA (Water and Sewerage Authority) has also started some projects

regarding stormwater flooding, drainage, and management system (Subrina & Chowdhury 2018). But results did not come out fruitful as it was expected due to the neglects of the suggestion from the experts such as urban planners and landscape architects. Urban planners and landscape architect's duty not only to concentrate on increasing the beautification of the city. They need as well to provide solutions so the city can function

It is recommended by the UNEP that there should be 25% of open space combinedly with greenery and water body in cities but there is less than 5% greenery in Dhaka city (Shuvo & Serajul Hakim 2014). The greenery has been gradually disappearing from Dhaka city. And gradually the city is become an uninhabitable city.

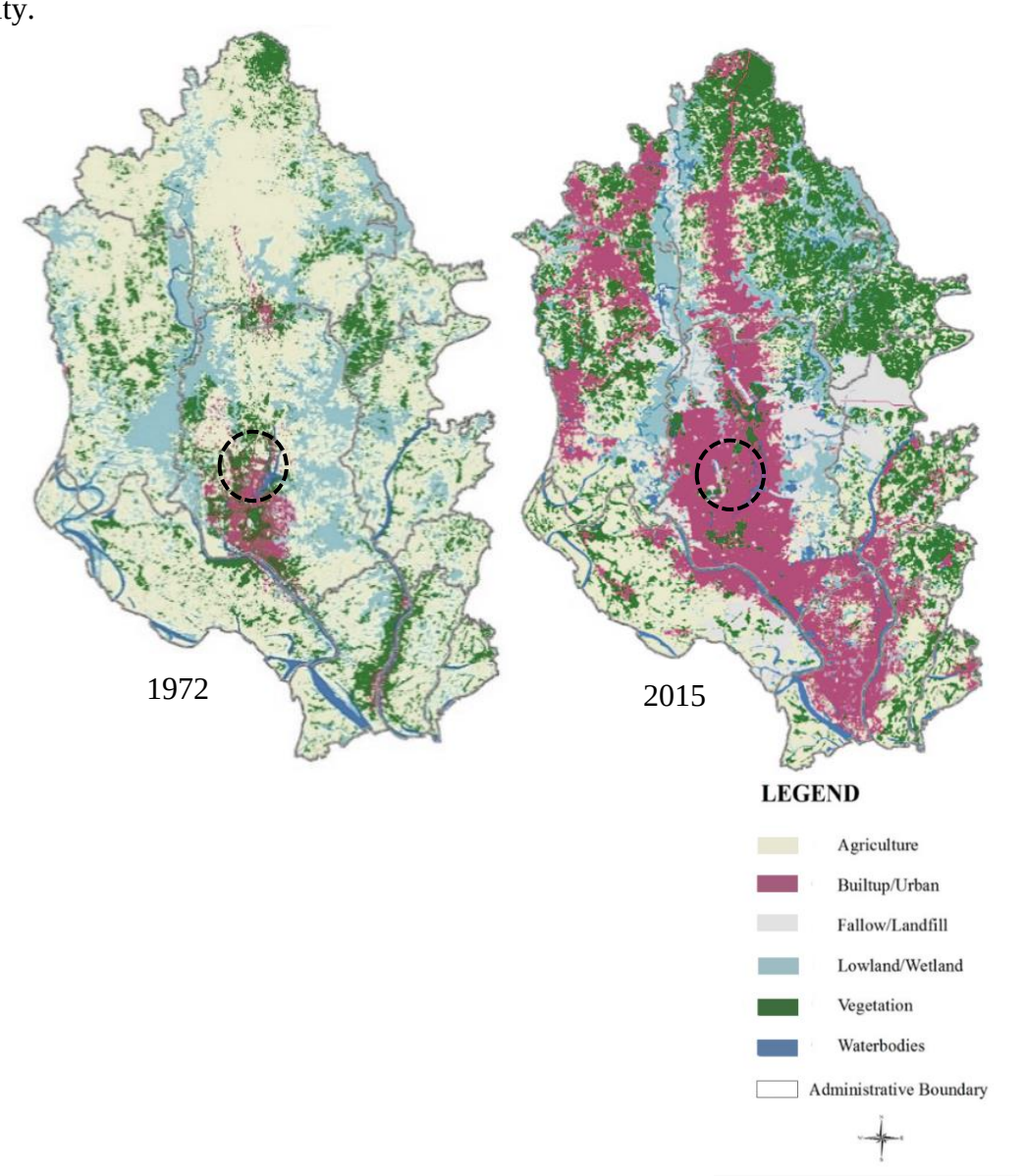


Figure 3: In these two maps from 1972 and 2015 it is very easy to compare the difference of greenery, water body and urban built-up areas (Hassan and Southworth, 2018) the circle within the maps is the study area for this thesis. The map is edited by the author.

People are illegally grabbing land by the river in Dhaka city. The river and canal beds are filled with sand in an unplanned way to provide more land for the increasing amount of population. As a result, stormwater floodings during the rainy season is becoming quite common in Dhaka city. The suffering of the local inhabitants is too unbearable to explain. According to the survey performed in 2012, by CEGIS 75% of wetland has been lost from Dhaka city since 1967 (*The disappearing wetlands of Dhaka* 2018). The situation causes manmade disasters quite frequently. The unplanned drainage system, lack of porous material on the surface, lack of wetlands and natural drainage system causes severe stormwater flooding on the streets. Figure 3 and Figure 4, reflects the gradual changes of waterbody, wetlands, and greenery over the years due to rapid growth of urbanization.

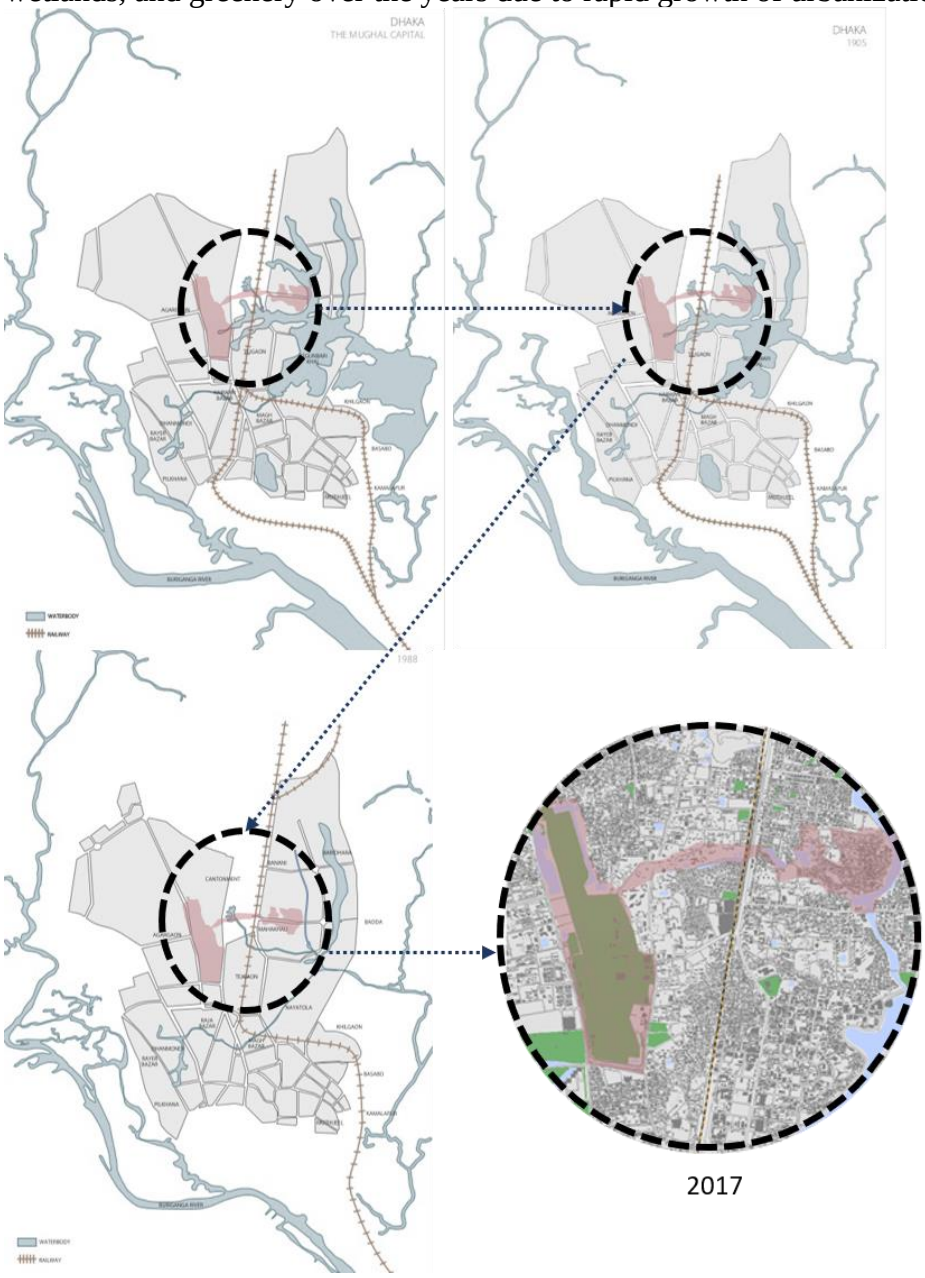


Figure 4: Gradual disappearance of waterbody from the Mughal period (1608-1764), 1905, 1988 (Onindo Ahmed 2016) and present 2017 for the site of my thesis. The maps are edited by the author.

Study area and surroundings

The study area for my thesis is situated at the central part of Dhaka city. The study area consists of the old Tejgaon airport, Banani lake and the informal settlement/slum area in Karail. The Figure 5 showing the study area location within Dhaka city, Bangladesh.

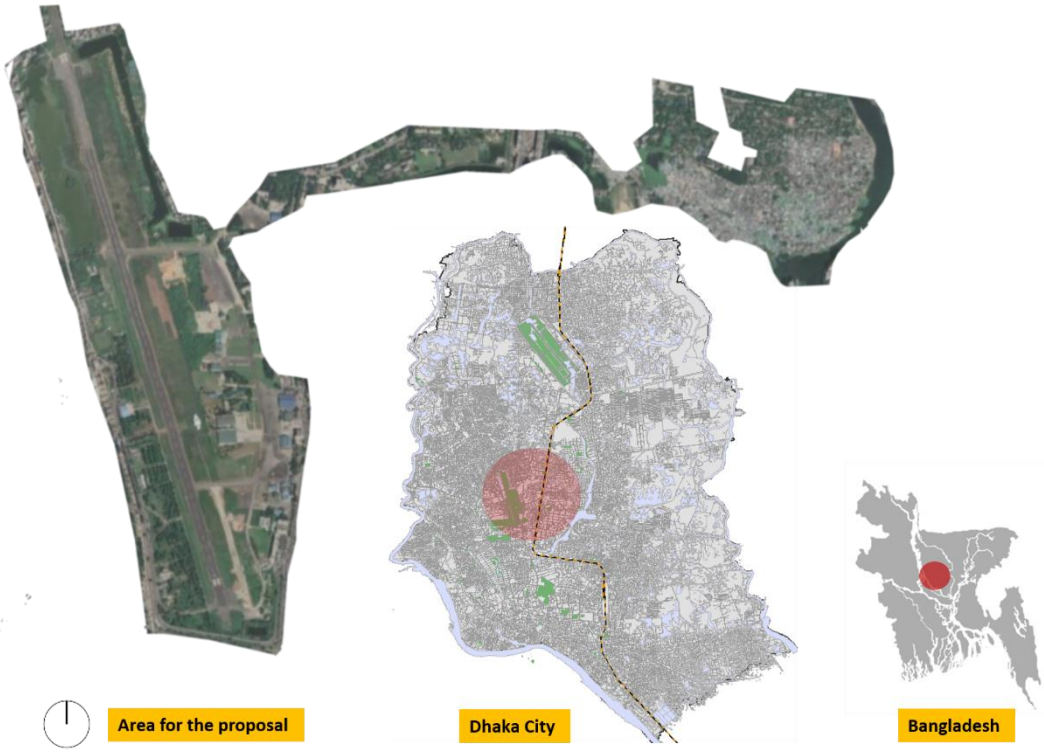


Figure 5: The maps with the red circle shows the location of my thesis study area (to the right) in relation to Dhaka city and to Bangladesh. The map is collected from the (Google Maps 2021), the illustration is produced and edited by the author.

The old airport in the Tejgaon area is a huge piece of land almost 415 acres (Holmes 2015). This airport is no longer functional. Sometimes this area is used as an air force training ground for flying fighter plane and parade training.

The informal settlement of the Karail slum was established during the Pakistani period around 1961 (Sinthia 2013). The informal settlement area in Karail slum beside the Banali lake is almost 100 acre. A huge amount of people live in this area. The estimated population is 59,516 inhabitants 2017. Almost 18,067 households are accommodated in Karail at this time 2017 (Hasan & Mollah 2017). Figure 6 illustrates the location of my thesis area, the existing surrounding site condition of the old Tejgaon airport, Banani lake and the informal settlement/slum area Karail, in relation to the city and to the country Bangladesh.

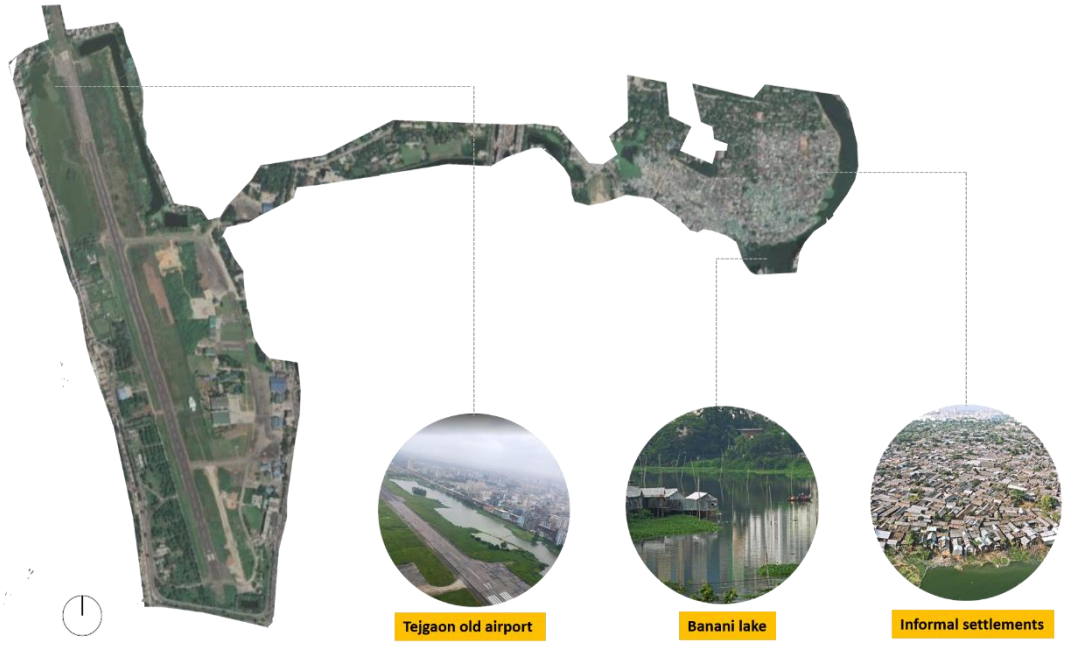


Figure 6: The existing site surroundings of the study area. The map is collected from (Google Maps 2021), the images are collected from the right respectively (Mollah & Islam 2020; Roy 2021; Nobes n.d.). The illustration is created and edited by the author.

Figure 6 illustrates the existing site surrounding of my thesis area. To the left is the Tejgaon old airport, the middle picture show Banani lake and the right picture show the character of the informal settlement area, (Karial slum) beside the Banani lake.

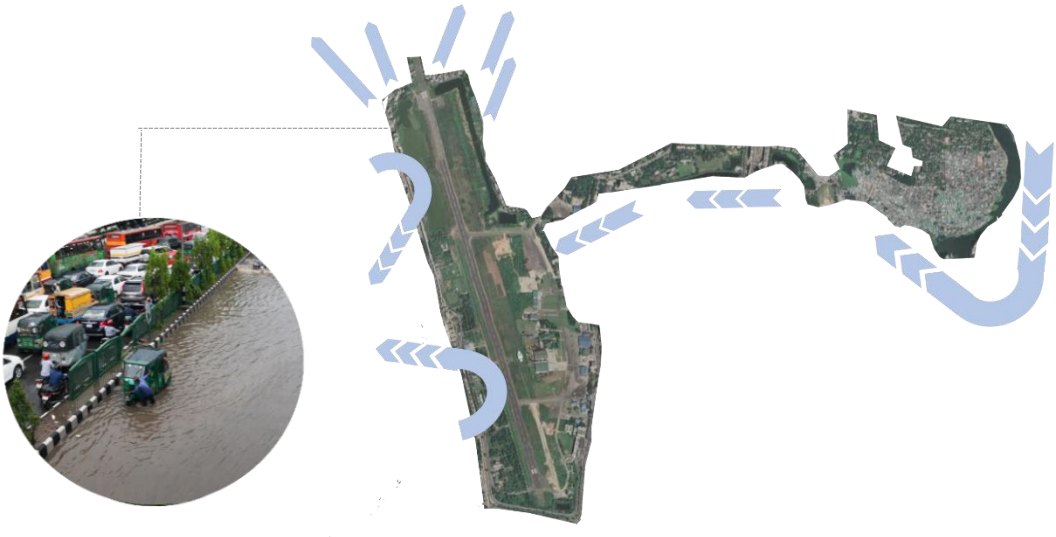


Figure 7: Figure show the flow directions of stormwater flooding on streets during heavy rainfall on the site area. The map is collected from (Google Maps 2021) and the image is collected from (Manun 2018.) The illustration is edited by the author.

The poor permeable soil condition and increased, unplanned settlements on land that is filled up rivers, canals, ponds and wetlands has interrupted the excess water flow. The rainwater during monsoon rises the water level and interrupts the natural water flow. The rainwater cannot be transmitted into the rivers, canals, and pond quite smoothly. That is why rainwater sometimes got stuck on the ground. To solve this issue there is a natural tendency to develop urban structures by raising the level up from the ground and thus the rainwater gets logged on the streets and create stormwater flooding during heavy rainfall (Figure 7, Figure 8). In an informal interview, a Bangladeshi architect Iqbal Habib said, *"After a little rainfall all the roads look like a canal".*

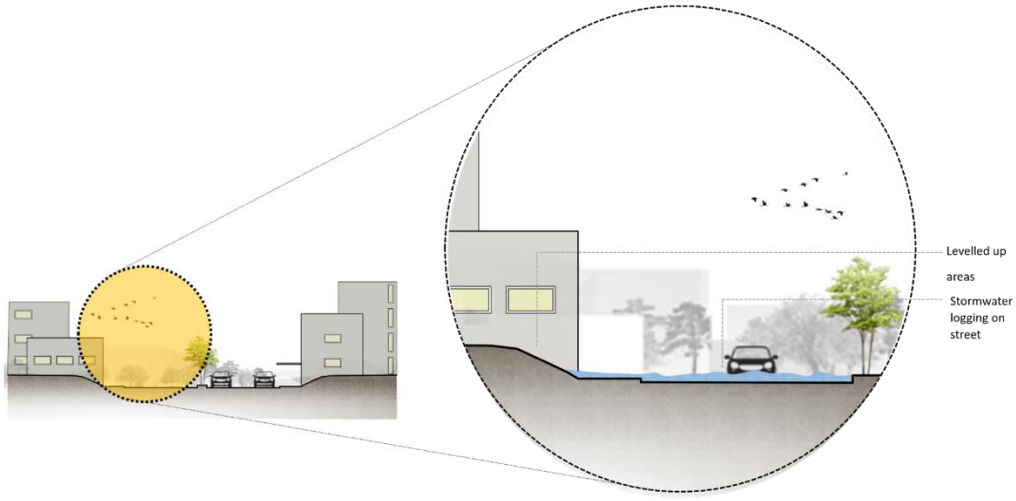


Figure 8: Illustration of how stormwater floods the street close to levelled land for buildings during heavy rainfalls. Conceptual section by the author.

On a small scale the land is levelled up protect private built area, and the streets get flooded by rainwater. On a larger scale, a higher elevated area gets rid of the stormwater flooding problem by levelling up of certain places, but other places suffer due to the lack of holistic master planning of the green and blue infrastructure for stormwater.

1.1.2. Lack of planning and development policy in Dhaka city

There are 11 city corporations in Bangladesh in present time. Dhaka city has two city corporations one is Dhaka North City Corporation (DNCC) and the other one is Dhaka South City Corporation (DSCC). The study area with Old Tejgaon airport, Karail Slum and Banani lake is under DNCC (Figure 6)

According to National Housing Policy 1993 (Table 1), Rajdhani Unnayan Kartipakkha (RAJUK) and the National Housing Authority (NHA) and Public Works Department (PWD) are working for providing housing facilities to the general poor people (Farzana Tuli 2004; Sinthia 2013).

Table 1: Public housing for different income people (Farzana Tuli 2004).

Public sector housing provider	**High income people**	**Middle to low income people**	**Refugees and resettlement**
RAZUK	260	420	----
PWD	Rental units for 10% of public service holders		
NHA	----	2969	18268

Physical planning and development in urban areas require key planning documents compiled with rules, regulations, building acts, sector-wise specific planning policy etc. Among them most important documents for planning are Bangladesh National building code (BNBC) 2006, Imarot Nirman Bidhimala 2008, National Urban Sector Policy (NUSP) 2011, National Housing Policy (NHP) 1993 (Roy et al. 2018).

The urban planning and landscape planning for Bangladesh is outdated (Mridha et al. 2009). The policy for urbanization lacks fundamental rules and regulations that is why the rules are not capable enough to face the recent challenges. The gradual growth of population is creating pressure on essential services and it also lacks micro-level policy (Mridha et al. 2009). The holistic urbanization policies lack proper governance, skill and coordination. (Mridha et al. 2009).

1.2. Problem statement

The dense city like Dhaka is becoming drearier without integrated green and blue infrastructures. Loss of greenery causes the urban heat island effect. The ecological balance of the city is almost lost, and it disturbs the physical and mental well-being of human and other organisms (Yılmaz & Mumcu 2016). Climate change, the urban heat island effect and lack of ecological balance are the evidence of this unplanned urbanization. The temperature will rise up 0.4% higher by 2050 than the regular temperature today (Islam 2009).

Landfilling of canals and rivers and forcefully grabbing the lands for unplanned development makes the situation worse. As a result, stormwater flooding and frequent flooding have become quite common. It creates disruption in the regular urban life. Due to poor drainage system, mismanagement of wastes, deduction of water catchment, lack of proper channels to flow stormwater causes stormwater flooding. The problem becomes more severe during the month from May to October when the rainy season starts (Figure 13).

Unplanned urbanization is getting harder to cope with. Population increases and migration of rural poor people is increasing unplanned urban developments. The number of slum dwellers or informal dwellers is increasing as well (WSUP, 2007). The informal dwellers are often deprived of their basic facilities, and this leads to a very poor quality of living. The incident of manmade hazards and the impact of natural hazards is quite common here. The unhygienic and poor standard of their building settlements also makes their living condition worse (Ahmed 2014). The dense settlement within the city made it difficult to maintain social distancing during the pandemic situation like COVID-19.

1.3. Concept, theory, and inspiration

Landscape architecture itself a complex subject. Landscape architecture is not about planning or designing a piece of land and follow the implementation according to the planning proposal. It is an artistic approach of planning which considers several aspects and visions. In this regard two famous landscape architects from Frederick Law Olmsted and Patrick Geddes and their theories acted as an inspiration and helped to conceptualize the thesis.

Frederick Law Olmsted was famous American landscape architect and a social critic. He was also known as a father of landscape architecture profession (Nicholson 2004). According to him the responsibility of landscape architects should not be just to design park or green spaces. In broader sense that designed space should have to certain values, functional and meaningful (National Association for Olmsted Parks n.d.). His philosophy was to keep landscape as close to urban inhabitants. Through following this philosophy surely promote a quality of life where people can escape from their daily life and to regain peace of mind.

Patrick Geddes known as a father of modern town planning (Clavel & Young 2017). His motto was to co-relate nature and culture. He also tried to focus on unifying different disciplinary. His new approach and theoretical ideas of regional and town planning concepts always had a holistic view towards people and integrate a link between nature and social science (Talukder 2015), Which is one of the important essence of this thesis. Geddes understood the importance of nurturing, the reflection of past essential elements of human evolution. He also understood that a space expresses a specific moment, local identity, pride of past traditions (Rubin 2009). Geddes´s theories also helped me to understand the value, need and concerns of community helps the designer to consider certain factors in conserving the value of the place.

Landscape is not an independent subject. It considers multiple aspects. Multiple aspects and themes are interdependent. To achieve the vision of the author, the thematic aspects played an important role. The thematic concept and inspiration derived from Frederick Law Olmsted and Patrick Geddes. These two theories are widely discussed further in the literature review chapter.

Three thematic aspects are considered in this thesis, they are as follows:

- Improve urban ecology &
- Solving the stormwater logging
- Consider socio-economic wellbeing

These two theories of Frederick Law Olmsted and Patrick Geddes both complemented my vision of thematic master plan program sketch. Connecting urban green and blue structures by taking inspiration from these theories will help to achieve sustainability, increase greenery, add ecological and aesthetics values to the city. The background and problem statement not only influenced but also the theories of the two famous landscape architects inspired the author and helped to conceptualize in formulating the aims and objectives and research question further on.

1.4. Aim and Objective

This master's thesis aims to provide guidelines and a visionary masterplan program-sketch for a specific part of Dhaka city that solves the imbalanced urban ecology, stormwater flooding problems during the rainy season integrated with improvements of the social and economic wellbeing for the informal dwellers.

A holistic urban ecology-water project can lead towards a better quality of living both for nature and humans. The observations and analysis through theories and findings were used as basis to formulate the guidelines for the final masterplan program-sketch in three phases.

1.5. Research Question

Specifically, one research question has been formulated to achieve these aims and objectives of this master's thesis paper. The research question as follows:

1. How can urban green and blue structures help to improve urban ecology, solving stormwater flooding, and improve the socio-economic quality of living for the informal dwellers?

2. Methodology

This Master's thesis paper involves a systematic approach with several methods. The following diagram in Figure 9 illustrates the content of this systematic approach.

The research method involves –

1. Study of documents and literature review
2. Online survey questionnaire
3. GIS analysis
4. Study of Role models

The study of documents and literature review helped to explore the possibilities to gain knowledge about the benefits of urban greenery, urban ecology, identify the causes and effects of stormwater flooding and identify the necessity to improve the living condition of the informal dwellers mostly in Dhaka city. This chapter helped to explain how the different data information, maps and photographs within this thesis topic had been collected and organized. The process of data collection was done by collecting different documents from both government and other private sources. Other sources such as newspaper articles, statistics, maps, images, videos etc. was also used and analysed.

The second approach was the online survey questionnaire. The voice of people was the most important factor in any kind of research which was helpful in my thesis to understand the causes and effects of loss of greenery, urban ecology and stormwater flooding. The online survey questionnaire also helped to observe the overall present condition of Dhaka city and how the social and economic benefit can be achieved to lead to a better quality of living.

The third approach was GIS analysis. The shape and layer files helped to pinpoint at the exact problem and present condition of the study area.

The fourth approach was collecting examples from different parts of the world, considering the issues related to this thesis topic.

From literature reviews, online survey questionnaire and GIS analysis a SWOT analysis was formulated. The Swot analysis was basis for guidelines to my thesis proposal.

A masterplan program-sketch presented in illustrations and text with references to my guidelines built on the SWOT analysis of my findings in the literature review, online survey, GIS analysis and study of role models is the result of this thesis.

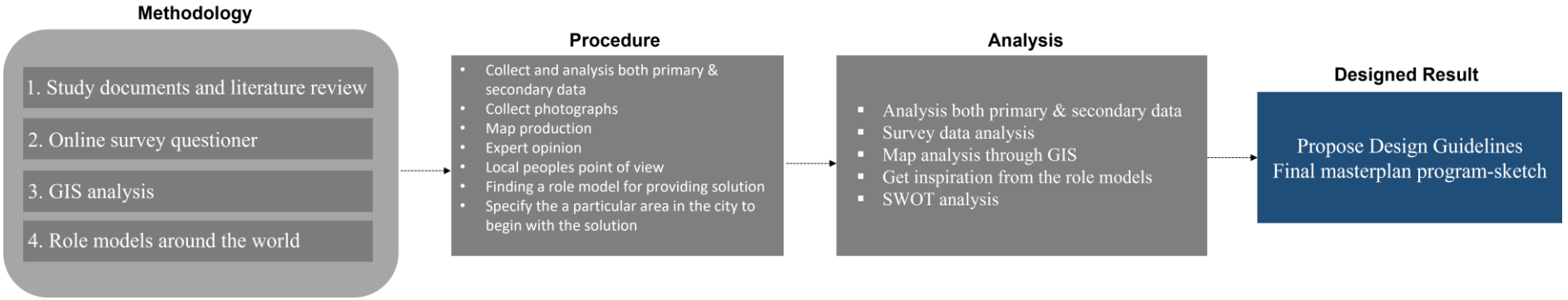


Figure 9: The diagram reflects the methodology produced by the author.

The diagram in Figure 9 illustrates the overall outline of the methodology. In this chapter the methodologies such as literature review, online survey, GIS analysis and study of role models are described. The procedures for this thesis explains how the data collection and analysis were done and lastly how the designed result with guidelines and masterplan program-sketch was created on basis of my findings.

2.1. Study of documents and literature

The tudying of different documents and literature helped to explore the possibilities to gain knowledge about the benefits of urban greenery, urban ecology, identify the causes and effects of stormwater flooding and identify the necessity to improve the living condition of the informal dwellers.

The literature review and data collection were conducted simultaneously through a broad series of online searches through Google and used other search engines such as Google Scholar, Research gate, open Library, SLU library etc.

Several keywords were used to collect literature such as urban ecology, urban greenery, stormwater, informal settlements etc. Collecting and reviewing scholarly literature as well as different analysis documents and data from the different government organizations to get the hold of relevant documents and information.

2.1.1. Literature review

This thesis paper concentrated on the basic three thematic aspects i.e., to upgrade urban ecology within Dhaka city, manage the stormwater flooding and benefit the informal dwellers both socially and economically so that it could lead the path towards a better quality of living. The theoretical part was based on addressing these three thematic aspects to gain the main aims and objectives of this thesis and helped to answer the research question.

The first theme of studying literature concentrated on urban greenery and ecology to understand the importance of greenery and urban ecology. The second theme of this studying literature part was to gain a basic understanding of the causes and effect of stormwater flooding. Lastly, the third theme was understanding the importance of resettling the informal dwellers and observe the basic problems within the informal settlements and how their living condition can be improved.

The literature review helped to clarify the background to my thesis result. The social and economic aspect of the city has to be studied in combination of the three themes in my thesis; environmental benefit, added recreational values and improved quality of living, to achieve physical and mental wellbeing for nature and humans. The philosophy of Frederick Law Olmsted´s (Nicholson 2004) inspired the work with the thesis un urban ecology and social wellbeing. Patrick Geddes theories inspired the masterplan program sketc in this thesis to keep the overall road- and block structure to hold the memory and character of the Karail area. Thus, the studying literature associating with urban ecology, stormwater management, bettering of the living quality of the informal dwellers considering improving social and economic aspect guided this thesis paper to the basic

guidelines and in proposing the overall green and blue structure in a thematic masterplan program-sketch.

2.1.2. Study of different documents and collecting data

Data and research papers on stormwater flooding, drainage, and flooding issue in Dhaka city were collected from reliable sources from relevant literature and documents from a different government organization. The existing land use data were collected from RAJUK (Rajdhani Unnayan Kartripakkha). The population density data were collected from BBS (Bangladesh Bureau of Statistics). The topographic data were also collected which was prepared by IWM (Institute of Water Management). The stormwater drainage data, drainage pipes, box-culverts etc were collected in detail from DWASA (Dhaka Water and Sewerage Authority) and the drainage department of DCC. Rainfall data were collected from MDE (Meteorological Department of Bangladesh) and BWDB (Bangladesh Water Development Board). The Table 2 below described shortly the data sources and what types of data were collected.

Table 2: Data types and sources, the table is produced by the author.

Data type	**Source**
Land use	RAJUK
Population density	BBS
Topography	IWM
Drainage infrastructure	DWASA, DCC, IWFM
River flow	BWDB
Rainfall data	MDE, BWDB
Urban waste	BSAC

The research study had been conducted by collecting secondary data sources which included map collection and collecting photographs.

2.1.3. Map collection

Maps had been collected from relevant literature and documents from different government organizations. The existing land use map was collected from RAJUK and the existing drainage network layout was collected from IWFM (Institute of Water and Flood Management). The drainage infrastructure, pipelines, culverts etc. were collected in detailed format from DWASA. River flow maps were also collected from BWDB. Literature illustrated with related maps also helped to analyse the present condition.

2.1.4. Photograph collection

To identify the missing information from the literature and documents in some cases images and photographs were collected to understand the water flooding situation and the effects on urban life. Photos of trees to build a character of greenery in Dhaka city were also collected which is attached to Appendix A under

Table A1 section. Related photographs had been directly collected from different internet websites and newspaper articles.

2.2. Online survey questionnaire

Formulating an online survey questionnaire was one of the primary data collection sources for my thesis. The designed online survey questionnaire was formatted in such a way that the participants could share their personal experience of stormwater flooding impact, loss of urban greenery and express their opinions on related social issues. Both open and close-ended questions were included in the online survey questionnaire so that the answers could provide in depth understanding of the present situation. One of the benefits of formulating open-ended question was to provide the respondent freedom of speech. The online survey questionnaire was performed by using the Type form. Type form is a platform where online surveys or interviews can be conducted through formulating certain questionnaires. Then all the responses were summarised in one excel sheet. The responses were calculated in percentage and represented in graphs or pie charts so that online survey questionnaire results can be easily analysed and reflect on.

Two types of online survey questionnaire had been created one with the local inhabitants and the other one with the experts within the related fields in Dhaka city. The survey questionnaire were set from various literature survey, thesis documents and inspired while conversation with various experts in different fields.

54 local inhabitants participated in the survey. The links to the surveys were generated from the Type form and shared on Facebook to collect feedback from the local inhabitants in all over Dhaka city. As the interviews were conducted remotely it was not possible to reach to the informal local dwellers and stakeholders to learn their opinions. The survey was conducted on the all over Dhaka city and tried to grasp the overall point of view as the overall scenario is quite familiar to them. The online survey questionaries are added in the Appendix B section under Table B2.

Experts of different fields from different government and private organizations were contacted by mail. Eleven experts have responded to the online survey questionnaire in this thesis. The questionnaires are added in the Appendix B section under Table B1. The interview questionnaire to experts were aimed to gather the opinion on improving urban ecology, causes & effect of stormwater management and addressing social issues. The participants were chosen based on their experience and expertise in different fields from different renowned govt. and private organizations. The experts were expertise in water supply, sewerage & stormwater drainage management, water resources & water modelling, water resources management, flood, drainage system planning, green architecture, urban planning, civil engineering, urban engineering, biologist etc. Both open and closes ended questionary have been asked. Their responses were calculated in percentage so that online survey questionnaire results can be easily reflected. From the open-ended questions, common answers or suggestions were also categorised and calculated in percentage. Then represented in graphs and pie charts in the section with findings.

Collecting secondary opinion was also considered in performing this method. Arranging meetings via zoom, interviews through the newspaper articles, media interviews are addressed as informal interviews in this thesis paper. Informal interactions are essential part to observe a participant's point of view (Swain & Spire 2020). Informal interviews from the newspaper articles, news media had been collected. Another way of communicating with the experts and multiple informal communications had also been conducted via zoom meetings to gather knowledge and information. The formulated guidelines for the designed master-plan program-sketch benefited from.

2.3. GIS analysis

A most important method for background knowledge has been GIS (Geographical Information System) analysis. By combining different map layers on a digital map, it became clearer how different planning decisions interact or contrast with each other in a spatial context. This is the simplest of geographical analyses, which was included in basic courses in GIS. The GIS tool used in the thesis is ArcGIS. The data, layer files and shapefiles had collected from different websites and also collected personally from the GIS experts from different organizations who work with GIS software and related project analysis through GIS.

The GIS analysis is formulated based on the aspects named below:

- Land use
- Green and open spaces
- Informal settlements
- Loss of wetlands and waterbody
- Flood analysis

A GIS analysis with other map layers provided information about the land use, green and open spaces, informal settlements, loss of wetlands and waterbody, flood analysis. This thesis paper was able to identify the basic problems such as loss of greenery, water bodies, identifying flood-affected areas and informal settlement areas etc. through the GIS analysis. In combination with the literature review it was possible to draw conclusions about necessary measures to reach goals for the thesis.

The documentation of the GIS analysis was done by creating a separate map layer, SVP.shp, where information about land use and land cover, green and open spaces, informal settlements, loss of wetlands and waterbody, flood analysis was stored. By analysing these maps which place is affected by orientation decisions, the spatial analysis can contribute to solving the related issues within the study area.

2.4. Study of Role models

Role models of various relevant projects for the thematic aspects in my thesis from North America, Europe and Asia were analysed. This part of the analysis

was very important to have a clear grip of understanding the overall situation in different parts of the world and what types of measures or solutions can be used in the final masterplan and providing guidelines and proposals in the study area. The solutions complemented the basic three thematic aspects of this thesis i.e., urban ecology, stormwater management and benefiting the socio-economic aspects.

This study of role models acted as an inspiration to analyse the thematic problems, find relevant solutions and also learn from these project's design challenges or limitations to avoid the possible mistakes in my own sketching in the context of Dhaka city. These role models acted as an artistic inspiration in providing the basic guidelines and the result in a masterplan program-sketch.

2.5. Procedure

The performed methodologies from 1 to 4 i.e., Study of documents and literature review, Online survey questionnaire, GIS analysis and Study of Role models have produced findings that have been used integrated to become background for the SWOT analysis and the guidelines for my proposal.

This thesis used both uses both inductive quantitative approach and deductive qualitative approach to gather data. The inductive approach is concerned about facts and experiences on individual as well as collective levels. This approach is a series of search patterns, it starts from observation then gradually develops into explanations, theories and a set of hypotheses (Bernard, Harvey Russell (2011)).

On the other hand the deductive or qualitative approach focused on things that are up for discussion and debate (Kabir 2016). Deductive or qualitative approach is a combination of collecting and analysing both primary and secondary sources better for understanding certain phenomenon (Creswell 2014). This approach uses surveys and observations such as formulating interviews, data collection from journals, articles, newspaper or even audio or video materials etc. Qualitative approach is used in this thesis basically to come up with a hypothesis rather than to predict something concrete (Kabir 2016). That is why in my thesis qualitative approach resulted the collected observations and information into three thematic aspects.

The study of literature, data from different documents included both secondary data and primary data sources. The voice of people was one of the most important factors in this thesis since important to listen to people in any kind of research concerned with people´s wellbeing. Formulated interviews were a primary source of data collection. Besides, interviews both with local people and experts also formal and informal meetings had been arranged within this thesis. Some secondary sources such as interviews from newspaper articles also influenced in formulation of the guidelines as basis for the final result.

Another primary data source was GIS analysis, which helped to formulate an analysis of the overall current situation for Dhaka city and the study area. Values, challenges, and shortcomings was described based on this analysis in the following section. A SWOT analysis of the study area in Dhaka city were formulated based on the literature review, online survey questionnaire and GIS analysis,

Examples or role models from different parts of the world were studied and analysed on particular phenomenon such as urban ecology, stormwater flooding and

addressing different social issues. Some solutions helped to conceptualize strategic plans to formulate guidelines and the final result in a thematic masterplan program-sketch.

After collecting and analysing the data the final guidelines and the masterplan program-sketch was illustrated in form of a conceptual sketch, 3d visualization, plans, sections, and maps in the following result section.

3. Literature Review

The literature analysis and review included literature, published and unpublished documents, scientific articles, journals, thesis papers, newspaper articles, websites, maps, images, and videos etc. The literature were collected simultaneously through a broad series of online searches for scholarly literature to get the hold of relevant documents and information. As it is mentioned earlier that this thesis paper will concentrate on three different aspects. One is urban ecology, the second is stormwater flooding and the third one is addressing the social issue. In this thesis paper, this section is structured based on addressing these issues. There are many research papers on addressing the urban ecology, green infrastructures, stormwater flooding and social-economic issues which helped to provide guidelines and to conceptualize the final thematic masterplan program-sketch.

3.1. Landscape and the concept of Frederick Law Olmsted

Undoubtedly landscape architecture is as ancient as civilization. In 1863, Frederick Law Olmsted was the first person who used the professional term landscape architecture for complex master design projects in public open spaces (Nicholson 2004). The concept of formulating the aims and objectives of this thesis paper derived and inspired from Frederick Law Olmsted who was a famous American landscape architect and a social critic. He was also known as a father of the landscape architecture profession. Many of his well-known landscape projects and urban parks reflects a vision of American culture and society (National Association for Olmsted Parks). He was also concerned about social and political issues, which had a huge impact on landscape design. According to him the role of a landscape architect is not just to design park or green spaces. In a broader sense, it must be functional and meaningful as well. He could visualise landscape beyond current trends and fashion. His design concepts used to fulfil human psychology's fundamental demands. That designed spaces also contained values such as recreational and cultural values etc. His philosophy was to keep the landscape as close as possible to urban inhabitants (National Association for Olmsted Parks). Through following his philosophy, the society would surely promote a quality of life where people can escape from their daily life and regain peace of mind. Particularly prominent was the part in his landscape design, where he created views in which the people would end up inundated. This is an experience of his, he termed as an unconscious process. To achieve this result, all the elements should serve a single purpose to create the experience of landscape more significant (Nicholson 2004). The Seven ‘S’ of Olmsted’s Design Concept are scenery, suitability, style, subornation separation, sanitation, service. These seven design principles of Olmsted’s are applied in formulating guidelines for the masterplan program-sketch and used in the plan for the design. These seven ‘S’ Olmsted’s Design Concept will be discussed in the following sub-sections.

3.1.1. Scenery

The scenery is a type of design principle where there is no obstacles or boundaries which gives a viewer a sense of openness. Frederick Law Olmsted used to love travelling at an early age and there he developed the concept of scenery (Nicholson 2004). This principal considers avoiding hard edges, designed structures and formally designed planting. This creates a sense of openness, connectivity with nature and greenery (The Seven S's of Olmsted Design 2021).

3.1.2. Suitability

Frederick Law Olmsted always tried to keep the uniqueness of the place which he termed as "genius of the place" (National Association for Olmsted Parks). He always tried to respect land, topography, and natural scenery. This helps to utilise the positive and negative aspect of the site. It maintains the naturalness of the site, benefit ecology and promote sustainability.

3.1.3. Style

Frederick Law Olmsted's projects followed specific styles mainly "Pastoral style" and "Picturesque style". "Pastoral style" is a type of style which includes scattered trees, open green space and water bodies which restore the sprit. On the other hand, "Picturesque style" plays with light and shadow and creates a sense of mysterious environment. It also tries to portray benevolence and richness of nature (Nicholson 2004).

3.1.4. Subordination

According to Frederick Law Olmsted, "Art to conceal Art"(The Seven S's of Olmsted Design 2021). He always visualized landscape as a unified composition. Any element which creates a barrier or disturbance in achieving the desired goal should be eliminated or subordinated (Nicholson 2004).

3.1.5. Separation

The urban area is always busy that is why Olmsted tried to separate spaces according to their uses so that user can fully enjoy the landscape and can avoid possible conflicts (Nicholson 2004; The Seven S's of Olmsted Design 2021).

3.1.6. Sanitation

One of the important aspects that Olmsted focused on the impact on health and sanitation due to landscape. Proper adequate drainage system and other engineering considerations promote the physical and mental well-being of the people (Nicholson 2004).

3.1.7. Service

Parks can bring nature and human closer. Proper planning with proper utility services fulfils the social and psychological needs. According to Olmsted

(Nicholson 2004), *"So long as considerations of utility are neglected or overridden by considerations of ornament, there will be no true Art*".

3.2. Patrick Geddes's theory of city development

Patrick Geddes is regarded as "The Father of Modern Town Planning" (Clavel & Young 2017). If correctly speaking Patrick Geddes's innovative thinking in the field of urban planning and sociology is known to all. He developed new approach and theoretical ideas in regional and town planning. His concepts always had a holistic view towards people and integrate a link between nature and social science (Talukder 2015). He stresses that successful planning decisions must be founded on a comprehensive and coordinated survey that helps to identify the natural settlements and surroundings of the study area as well as it's socio-economic prospects and constrains. His town plans for social improvements of existing urban areas was characterized by keeping street patterns and block structure in respect for the inhabitant's experience of identity in their neighbourhoods.

His fundamental principal of town planning is based on "place, work and people" (Talukder 2015). Climate and geographical settings influence a lot in shaping an individual lifestyle. On the other hand, individual's act at the same time is also shape the place through economic process. This is a continuous transition within place and people.

"Think Global, Act Local" is another Geddes concept of city planning (Var 2019). In fact, his concepts have been implemented and considered as a way of parallelly conservation approach with other planning aspects. Before implementation of any project cultural background, tradition and characteristics of locality should be considered.

A space is a series of memories and drama. According to Geddes (Clavel & Young 2017), *"A city is more than a place in space; it is a drama in time"*. A collective sequence of activities of a society or a particular area expresses an expression of a specific moment, local identity, pride of past tradition. The concept of awareness of protecting the identity and tradition derived from the from Patrick Geddes. According to Geddes (Geddes 1915), *"It is interesting sometimes to stop and think and wonder what the place you are currently at used to be like in times past, who walked there, who worked there and what the walls have been".*

Geddes understood the importance of nurturing the reflection of past essential elements of human evolution. In the words of Patrick Geddes (Geddes 1915), *"We have to realise and keep in view the spirit and individuality of our city, its personality and character, and to enhance and express this, if we would not further efface or repress it."* This perspective identifies a social process, and forms of belonging, practices, experiences (Garau et al. 2016).

Geddes revealed that community involvement is very important in the process decision making during urban development (Garau et al. 2016; Var 2019). *Cities in Evolution* is one of the significant work of Geddes, where he covered the relationship between the community and planner (Geddes 1915; Rubin 2009). As a planner he introduced many projects which include peoples' survey and participation to his projects. The success of the project depends upon community

participation. The value, need and concerns of community helps the designer to consider certain factors in conserving the value of the place.

3.3. The necessity of urban green spaces

Urban open and green spaces perform a wide range of roles such as environmental balance, ecological balance, improves physical and mental wellbeing and provides benefits socially and economically as well. It connects a bridge between human and nature (Bowman et al. 2009). It is important to understand what specific purpose we want to fulfil through urban greenery. Urban green space comes in different forms, shapes, and serves different purposes. They may vary from culture to culture, country to country.

This section of this thesis paper explained the benefits and importance of urban green space. Preliminarily, this thesis concentrated on environmental benefit, health benefit, recreational benefit, economic benefit, and social scope of benefit. The following diagram in Figure 9, reflects a summary of what are the main benefits of urban green spaces.

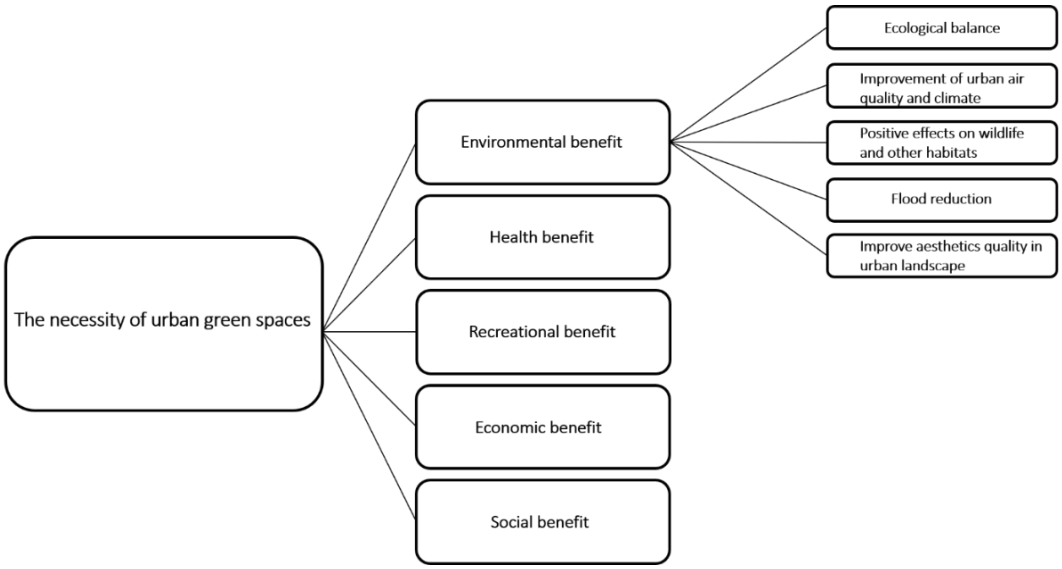


Figure 9: Diagram explains the benefit of green areas in urban areas, the diagram is produced by the author.

3.3.1. Environmental benefit

The environmental benefit is one of the benefits of urban green areas. In this section, the environmental benefits (Yılmaz & Mumcu 2016) are widely described including-

a) Ecological balance,
b) Improvement of urban air quality and climate,
c) Positive effects on wildlife and other habitats,
d) Flood reduction, and
e) Improve aesthetics quality in urban landscape.

a. Ecological balance:

Each species is important to maintain the balance of ecology and nature. Human being is superior to all other creatures of God but they failed to understand the importance of nature and miserably failed to respect nature *(Lehmann 2019)*. Humans are not excluded from the ecosystem of nature. The whole system will collapse then the existence of human will reach towards the end within no time *(Cronon 1996)*. Humans are getting disconnected from nature due to the rapid grown of urbanization. Greenery is gradually fading, and urban ecological balance is also disrupted.

It is not easy to repair this damaged ecosystem overnight. Sometimes, urban cities and nature both are considered as two separate things and oppose to one another (Kaika 2004). Nature and greenery themselves are an important part to maintain ecological balance. It is important to integrate urban city and nature. Landscape planners and architects can come forward and necessary ethics can be formulated to maintain the ecological balance. It will help to increase urban biodiversity benefit the environment and provide a better quality of living.

b. Improvement of urban air quality and climate:

An increase in urban greenery special trees, shrub and other types of greenery help to improve the quality of air and helps to protect from the climate change. Rapid urbanization, increased industrialization, an increment of motor vehicles creates air pollution. Moreover, it also creates an urban heat island effect (Yılmaz & Mumcu 2016). Trees are important for our survival as well. They inhale carbon dioxide and exhale oxygen. They absorb pollutants & other and infiltrates the air. Due to the lack of greenery in urban areas, heat island effect has become quite common. By planting, more and more trees will help to drop the temperature up to few degrees and will help to cool the rase of temperature. Therefore more, and trees plantation and greenery should be increased to improve the quality of the living environment in urban areas.

c. Positive effects on wildlife and other habitats:

Larger green areas not only improve the ecological balance but also provide habitat for other species. Thus, it increases biodiversity in the urban areas. Diversity in greenery results from diversity in species and wildlife (Yılmaz & Mumcu 2016). It is also a fact that all species do not find urban areas as a secured or comfort zone for their living. But certain species get used to the urban environment. Therefore, urban area develops different ecosystem than the rural areas. But increasing urban green spaces will always have a positive impact on wildlife and other habitats.

d. Flood reduction:

Urban areas have less permeable surfaces. During flooding season or heavy rainfall, water flooding is a common issue in urban areas. Green spaces can act as a natural drainage system (Matarazzo 2018). Trees can help to reduce the effect of flooding and can help to protect from soil erosion as well. Planting more and more trees and increasing urban greenery can reduce the flood risk in urban areas and reduce suffering.

e. Improve aesthetics quality in the urban landscape:

Rapid urbanization and the loss of green spaces made the cities lifeless. The urban area has become more concrete and boring. Providing a variety of greenery and creating activities around it will not only add aesthetics value but also functional value as well. Specific elements can emphasize the city character and hold a specific identity (Yılmaz & Mumcu 2016). Greenery will add aesthetics values, specific landscape character and most importantly a breathing and liveable area for living.

3.3.2. Health benefit

Urban green spaces play an important role in improving the quality of living of urban dwellers. It provides an escaping place from their busy and dull regular life. Greenery enriches our mind with pleasure and refreshment. A sense of peace and calmness also increases productivity and enriches the mind with creativity (Yılmaz & Mumcu 2016).

In many types of research, it is proved that greenery reduces a certain degree of stress, depression and improves our mental health (Dave Kendal et al. 2016). Open green space also increases the scope of our physical activity (Amano et al. 2018) which is also helpful for cardiovascular diseases (Morris 2003). It also encourages people to walk, run and cycling. Thus, urban greenery also encourages social gathering, interaction and improve neighbourhood well-being (Davern et al. 2017)

3.3.3. Recreational benefit

The recreational benefit is the most common benefit from urban greenery. Outdoor green spaces such as parks, open-air gymnasium, gardens, playground etc. are the primary source of the recreational area in nature. People of all ages need recreational facilities in nature. It helps to develop both mentally and physically. A study has been conducted on a certain number of children. Children who take active participation in nature for playing are more active than the children who have less contact with nature (Wolch et al. 2014). In another study, it is shown that people who have better access to nature have higher participation in different physical activities (Kabisch et al. 2017).

3.3.4. Economic benefit

It cannot be denied that how much greenery is important for the economy. In most countries, the whole economic system survives upon the food that is produced

from the green spaces. A developing country like Bangladesh the whole economy depends on agriculture. Urban green spaces at a smaller scale can also provide economic benefit and provide job opportunities for unemployed people. Fresh fruits and vegetables also feed the increased population in urban areas. It will not only benefit economically but also improve human health.

Other than food production greenery can attract many people. Many investors might get interested and provide a scope for tourism (Arvanitidis et al. 2009). It will also increase the scope of employment. Greenery can increase the value of real state property. The surrounding property and house owner might also get the economic benefit (Yılmaz & Mumcu 2016).

3.3.5. Social benefit

Urban open spaces and greenery are also important to gain benefit from a social perspective. Open spaces and greenery provide more scope of communication and interaction (Bertram & Rehdanz 2015). Community gathering for different festivals and social interaction is an important part of Bangladeshi culture. Due to lack of open space and greenery, the social interaction and bonding within the neighbourhood are decreasing. If greenery is increased, it will make the city more liveable and improve the social life quality.

3.4. Tree selection and inventory

There is an old saying, *"The Right Tree in the Right Place"* (Forestry Commission Scotland 2015). The wrong selection of trees not only create manmade hazards but also hampers aesthetics. The wrong tree at the wrong place or inadequate space hampers the trees to grow properly. Most of the trees within the island are 1 foot wide and depth 1-2 feet, which is very inappropriate for big trees to grow. A little storm causes these trees to fall and causes serious accidents (Figure 10).

Figure 10: Effect of wrong tree choice at the wrong place (Manik 2019).

Rows of trees add scenic view, and it is also very soothing to the eye. But rows of trees should maintain certain continuity or regularity. Different size and different shape of trees will not add any aesthetics value to the streets (Figure 11).

*Figure 11: Different size, shape, and types of trees (*Google Maps *2013).*

Table A1 in Appendix A section reflects the tree inventory for selecting an urban tree, which will not only add aesthetic value as well as ecological value. To increase urban ecology, it is important to select native plants to provide ecological balance and to provide shelter to the native species as well. But in some cases, the

exotic species has also become a part of our ecology, and do not serve any hamper to the urban ecology. These specific trees will add colours in different seasons, highly tolerant to different climatic condition and requires low maintenance. Creating list of trees is to reintroduce this species in a newly designed way which used to be quite familiar but gradually fading away from the cities due to urbanization. Table A1 in the Appendix A section shows different types of trees such as large trees, bushes, small trees, herbs, climbers, and aquatic plants etc. Table A1 in Appendix A is formulated based on some informal interview with biologists, urban naturalists and also from some websites (Ali 2019; Uddin 2020).

3.5. Causes and effects of stormwater flooding in Dhaka city

Stormwater flooding nowadays has become very common in urban areas. This section will shortly reflect on the causes and effects of stormwater flooding in urban areas. Unplanned development and inadequate drainage capacity make the situation even worse. Sometimes after a small time of rainfall stormwater causes flooding in different parts. The social, physical, economic, and environmental impact is huge due to stormwater flooding (Imdadul Islam 2020). The diagram in Figure 12, below reflects on the main source of storm water flooding and what are the visual expression due to this water flooding.

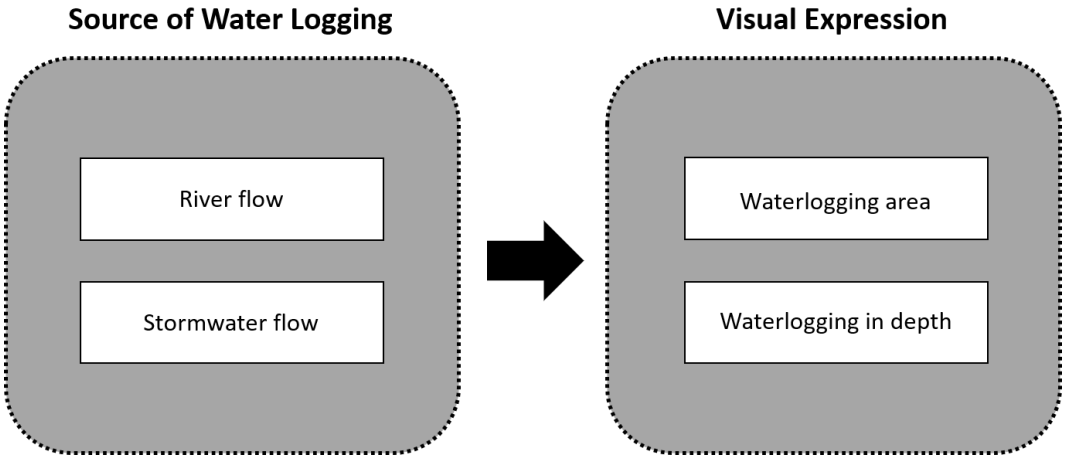


Figure 12: This conceptual diagram reflects the source and visual expression due to stormwater flooding; the diagram is produced by the author.

3.5.1. Causes of stormwater flooding

There are a lot of reasons for stormwater flooding. Some basic reasons are identified below:

- Excessive rainfall
- Unplanned drainage system
- Inadequate drainage capacity to serve
- Waste material blocking the flow within the drainage pipe

- Lack of maintenance
- The disappearance of natural drainage system etc. (Imdadul Islam 2020).

Some of the basic reason for stormwater flooding are described below in the Dhaka city context.

Excessive Rainfall:

Due to the climate issue, different country suffers heavy rainfall. If the drainage system is not properly designed the city will suffer stormwater flooding during the rainy season. Bangladesh is a tropical country. It rains during the monsoon season which lasts from May to October. The following chart in Figure 13 reflects the average rainfall in Dhaka city throughout the year.

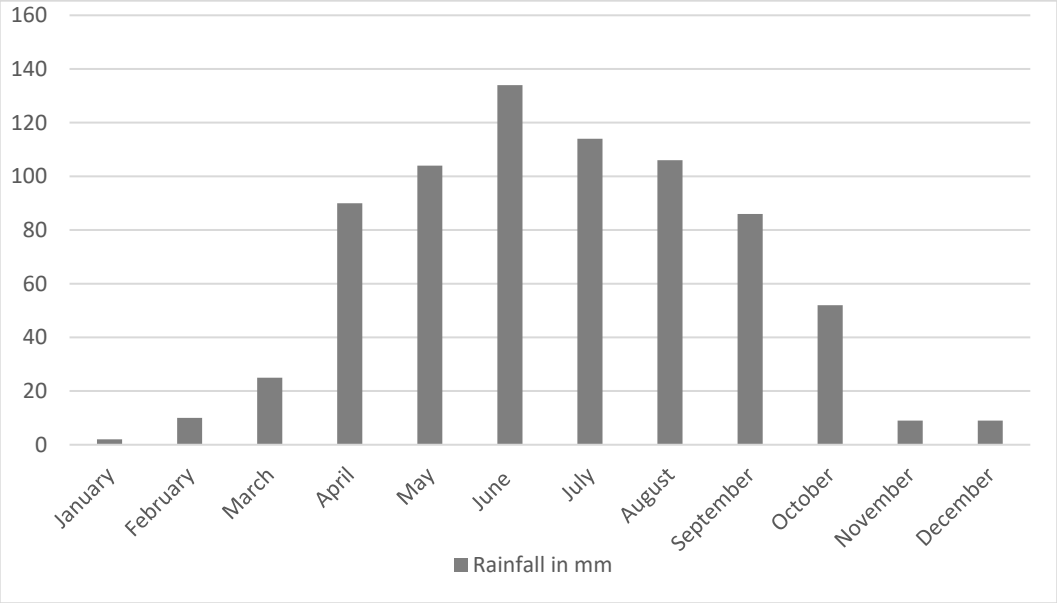


Figure 13: The chart shows the average rainfall data (mm) in Dhaka city. The data is collected from (Yu Media Group & D.o.o 2019), the graph chart is produced by the author.

The metropolitan city Dhaka experience huge stormwater flooding when it rains heavily. Due to climate change rainfall patterns also changed and the amount of heavy rainfall has also increased. Excessive rainfall has occurred during the year 2018 and 2019 and caused storm water flooding in different parts of Dhaka city (Sayed & Haruyama 2017).

Drainage capacity and waste management system:

The drainage system of Dhaka city is inadequate and not properly planned. The inhabitants of this city do not handle the drainage system properly. There is no proper management of waste. According to the estimation of DCC, the average daily waste production of Dhaka city is 4000 metric tons and about 400 tons remain on the roads and other open surfaces (Ahmed 2019). Stormwater washes them away and blockage on the surface drainage system. People dump different waste materials and cause blockage of water. Lack of regular cleaning and waste

management system has also created stormwater flooding more severe. The drainage system for stormwater is insufficient and unable to provide service if the rainfall surpasses the range of 20mm (Staff Correspondent 2017). The experts have mentioned that the city requires a completely new solution for the stormwater drainage system. Table 3 below reflects what types and what of solid waste is produced in Dhaka city.

Table 3: The characteristics and quantity of urban waste in Dhaka city (Imdadul Islam 2020).

Types of solid waste	Quantity (%)
Domestic	40-60
Commercials	2-5
Street Sweeping	20-30
Combustible	20-30
Non-combustible	30-40
Moisture	45-50

Disappearance of natural drainage system:

Natural drainage system waterbodies, wetlands are filled up with lands due to rapid and unplanned urbanization. This is one of the main reasons for the disappearance of the natural drainage system. Due to the loss of natural drainage system urban areas are affected by stormwater flooding. Dhaka city is not excepted from this fact. Most of its water body and wetlands are lost and causes storm water flooding during heavy rainfall (Imdadul Islam 2020).

3.5.2. Effects of Water flooding

In this section, the effect of stormwater flooding will be discussed. This section has concentrated on two different aspects of the effect of stormwater flooding. One is social impact and another one is the environmental impact. Disturbance in daily life, traffic jam, damage to life, health & property etc. is the social impact. On the other hand, pollution especially water pollution is one of the impacts of stormwater flooding. The diagram below in Figure 14 shortly reflects this.

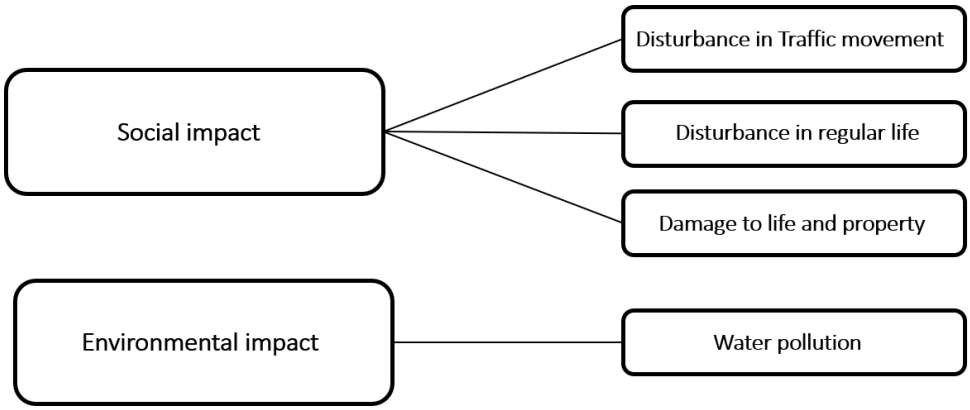


Figure 14: The diagram reflects the effects of stormwater floods; the diagram is produced by the author.

Social Problem:

Disturbance in daily life, disruption of traffic movement, damage to life health & property etc. are the social impact due to stormwater flooding (Imdadul Islam 2020) are described in this section below:

a) Disruption of Normal Life

The disturbance due to stormwater flooding is quite huge. This impact is huge on the lower-income people. Their house often gets flooded and due to that, they had to live in a very unhygienic condition. Moreover, loss of property, livestock also affects their economic condition. Due to water flooding it becomes quite difficult to travel from one place to another place. Local people have suffered a lot due to this condition. Overflow of water from the drains also causes pollution and creates health problems.

b) Disruption of Traffic Movement

Traffic jam is one of the most common and irritating effects of stormwater flooding. In densely populated cities the traffic issue quite huge but stormwater flooding makes it even more complicated. People get stuck on roads for hours and hours. This condition disturbance the movement of the passers-by as waters get stuck on the footpaths as well.

c) Damage to life health & property

Stormwater flooding sometimes becomes a threat to human life. Due to this flooding condition accidental case occurs. Peoples sometimes gets electric shocks from electric poles. In some places, due to maintenance, the manhole covers are removed due to carelessness people or vehicles fall into those holes and gets into accidents. Sometimes these are also life-threatening. People who work in grocery shops they deal with great losses. The stocked food products sometimes get rotten or damaged due to stormwater flooding. Construction works also get delayed. In some cases, the construction materials also get damaged. Stormwater flooding falls a huge impact on the economic conditions.

Environmental Impact:

Environmental pollution is one of the major effects due to stormwater flooding. One of the main pollution due to stormwater flooding is water pollution.

a) Water Pollution

Water pollution is one of the most common pollutions due to stormwater flooding. The rise of water level sometimes gets mixed with different toxic particles and causes water pollution. Sometimes domestic wastes also get mixed with the stormwater and causes water pollution (Imdadul Islam 2020). Overflow to water from the drains also causes water pollution and spreads water contaminated diseases. Dhaka city usually faces this problem during the time of monsoon during heavy rainfall.

3.6. Resettlement for informal dwellers

In urban area mainly lower-income people lead a very poor and difficult life. They dwell in informal settlement area which is usually known as slum. It is important to know the identification name of slum or informal resettlement as it has various names in different countries (Sori 2012). This thesis addressed slum as informal settlements. The informal settlement is a place within an urban area where a group of people/ family/ individuals lives under the same roof and are deprived of proper shelter, adequate water & sanitation etc. (United Nations Human Settlements Programme 2003).

3.6.1. Slum developing stages

Resettling the informal dwellers and carry-out this thesis work the Karail slum area is chosen as a study area. Informal settlements develop into different stages which are mentioned by various authors (Sori 2012). Turner divided informal settlements into four based on the development process. They are transient, provisional, incomplete & incipient, and complete (Turner 1966). According to character-wise development, Eyre categorised informal settlements into four stages, initial occupancy, transitional, secure a holding right on the land and absorption (Eyre 1972). Based on an open piece of land and neighbourhood Abebe developed three categories infancy, consolidation, and saturation (Abebe 2011). Similarly, Miller based on stability and security developed informal settlements into unstable, coper, strained and stable (Sori 2012). Sometimes external forces such as political or other administrative sectors influence the informal development stages (Sori 2012). In the context of Dhaka city, these external forces are quite common.

Based on various opinion from different authors, the author of this thesis tried to formulate the slum development stages in the Karail slum area. According to author, the Karail slum development has basic three stages, the beginning of establishment, the expansion and occupancy and then comes the absorption.

The first phase is the beginning. During the Pakistani period in 1961, the Karail slum started to begin. The original owner of this Karail slum was the department of T&T. Later in 1990, by breaking the initial agreement a certain amount of land approximately 90 acres was allocated to PWD. Then the previous owner of the land before T&T took legal action and this created a chaotic situation. Later these three parties came to an agreement and became the stakeholder of the Karail slum (Mridha et al. 2009). This is the beginning of the establishment of the Karail slum.

Then comes the second stage the expansion and occupancy. The individual stakeholders started renting land and houses to poor migrated rural people. As the renting cost was gradually increasing this slum area shortly got overpopulated for the lower-income people. Then gradually started to grow and expand. The Karail slum is situated beside the Banani lake, and the surrounding area is quite a posh area in Dhaka city (Sinthia 2013). Moreover, these informal dwellers serve the surrounding neighbourhood by working as their maid, driver, caretaker. Some also work in garments factories and small retail shops (Figure 15).

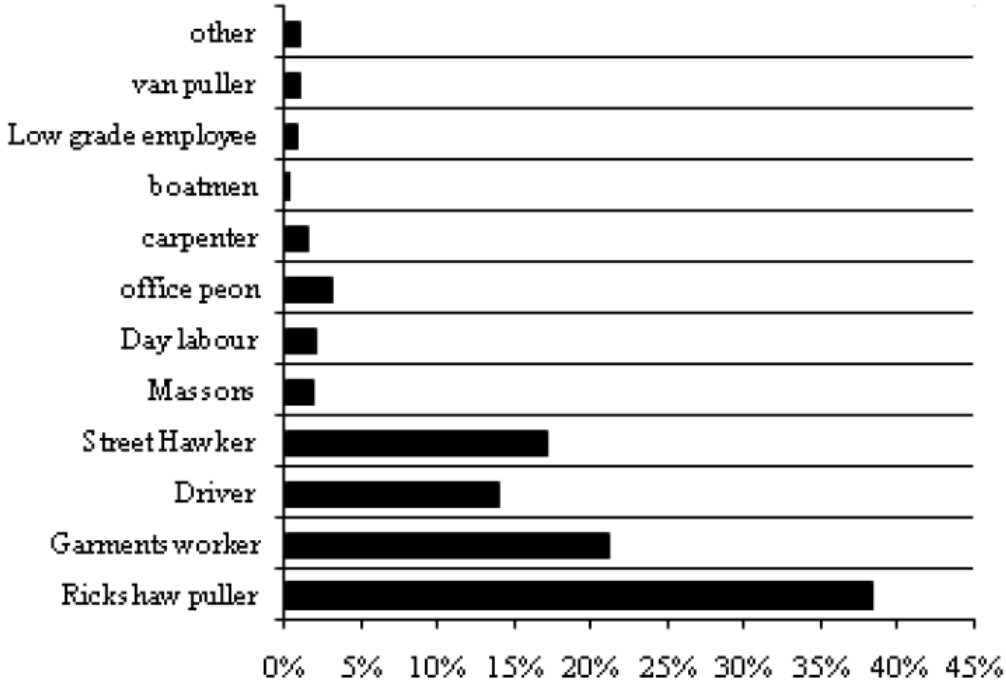


Figure 15: The percentage of people and their occupation in Karail slum area (Sohail 2007).

The figure is showing the occupation which they do for survival (Sohail 2007). They play a very important role to improve the economic state not only the Dhaka city or the surrounding area but also serve for the whole country.

Then comes the last stage absorption. At this stage, the slum continues to have further densification (Abebe 2011). Here hits the external enforces. The illegal way of land grabbing started on unoccupied lands. Political leaders, ward commissioners and other administrative leaders grabbed lands (Sinthia 2020). It is also seen that many local inhabitants in the Karail slum are buying lands illegally which is previously bought illegally from other owners as well (Sinthia 2013).

3.6.2. The importance of resettlement

The informal settlements are generally formed illegally. Considering humanity and provide basic human rights it has now become very important to provide these lower-income people proper resettlement. These lower-income people should not be thought of as a burden in urban areas as they play a very important role in the economy and enriches manpower. In Dhaka city, different NGOs are working in providing resettlement for these informal dwellers (Ahmed 2014). The houses of these informal dwellers are formed in a very disorganized, chaotic, irregular pattern. The gap between the houses is rarely 1 meter to 2.5 meters (Angeles et al. 2009). The houses are situated very close to the local streets and lack open or green spaces.

The following sections will discuss different issues that the informal dwellers are deprived of leading a normal life. The importance of resettlements of informal dwellers will be discussed in the following sub-sections.

Urban hazards

The rapid growth of population and unplanned urbanization causes different kinds of hazards. Manmade and natural types of hazards have increased in urban areas. The impacts of these hazards are truly pathetic and unbearable on lower-class informal settlers. Some of the basic urban hazards are discussed in this section below.

a) Floods and stormwater flooding:

Flooding and stormwater flooding is one of serious urban hazards in informal settlements areas. Riverbeds, canals, and waterbodies & wetlands are filled to form these informal settlements and gradually leads towards flooding and stormwater flooding. Excessive rainfall and inadequate drainage cause flooding and water-flooding in these informal settlement areas. Water pollution, contagious diseases, the unhygienic condition is quite common in these areas (Khan 2010). Floods and stormwater flooding affect these poor informal dwellers in many ways. Most of the informal dwellers are poor and they earn their livelihood through household works, labour workers, rickshaw pulling, working as street hawkers etc. Mostly they live from hand to mouth. Due to these flood and stormwater flooding, all this work gets affected (Ahmed 2014). The house they dwell in are very poor in quality. Sometimes these houses also get damaged easily just after a light rainfall and they become homeless. At this point, they had to find shelter in abandoned areas such as shaded under construction areas, schools, mosques, stations, even in open air or under temporary shade beside the roads (Ahmed 2014). Life becomes quite hard to survive under this condition.

b) Seasonal storms:

The seasonal storm is one of the common urban hazards. In Bangladesh "Kalboishakhi Jhor" is the most common storm that occurs during the month of March to May. There are also some windstorms also reported during the year (Ahmed 2014). As it is mentioned earlier that the house quality for informal dwellers in general very poor. Houses are hugely damaged and sometimes their roofs are blown away by the windstorms. These cause damage to property and accidental injury as well. Strong wind flows the stormwater inside the houses and causes property damage. During these seasonal storms, these poor informal dwellers face a tough situation and the recovery becomes quite difficult to overcome.

c) Earthquakes:

Experts have declared that the capital city Dhaka already situated in an earthquake risk zone. Excessive pressure on land due to urbanization is one of the reasons for earthquake other than the topographic structural condition. Heavily loaded building constructed with concrete; multi-stored high-rise buildings will create serious hazard due to earthquake in urban areas. It will cause serious impact on their lives and damage properties. On the other hand, informal settlement houses are built with light materials such as wood, clay, timber, tin shade, straw etc. and their multi-storied varies within 1-2 storeys. Therefore, the risk is quite low in informal settlement areas. But they cannot escape from the risk as these areas are quite

dense from other parts (Ahmed 2014). If some serious urban hazard occurs the rescue operation will be quite hard to handle.

d) Fire hazards:

Almost every month, the news of fire hazard in informal settlement area is heard in Dhaka city. During the dry season, from March to May fires hazard incidents takes place. The most common reason is the building material which gets easily caught by fire. The fire hazard situation gets worse because of the super dense settlements. Within a blink of a moment, the whole settlement is destroyed. Sometimes due to political reasons to evict these illegal informal settlements this kind of fire hazards are intentionally created (Staff Correspondent 2011; Ahmed & Johnson 2014). The informal dwellers lose all their savings, property, and other belongings (Staff Correspondent 2012). This also causes loss of life and injuries. Narrow roads within the informal settlement area make it difficult to access the fire hazard location area and evacuate the affected people. Therefore, resettlement is very important for these people.

Increase rate of criminal activities

Lower-income people are gradually migrating towards the urban areas. Thus, the unemployment problem is increasing day by day. Due to lack of employment facility, the informal dwellers get involved in criminal activities (Khan 2010). The criminal activity rate is quite high in these informal settlement areas. So, general local people do not feel safe around informal settlement areas. To establish proper enforced law, resettlement and scope of employment should be increased.

Climate change effect

Bangladesh is highly threatened by the impact of climate change. Different actions have been taken to reduce the impact of climate change, but the poor informal dwellers are always overlooked (Banks et al. 2011). In the above section, the urban hazards such as flooding, stormwater flooding, fire hazards etc. have been described. But these urban hazards are the impact of climate change. Due to climate change heat island effect noticeable in urban areas. In some recent studies, it is proved that the temperature has raised a lot over the past 10 years (Rabbani, M.G. 2009). The study also shows that the poor informal people suffer the most due to this sudden rise of temperature. Deterioration of health such as fever, lack of proper supply of electricity and water are some of the sufferings (Khan 2010).

Health and hygiene

Water, sanitation, and hygiene is the basic requirement to lead a healthy life. Unfortunately, the informal dwellers are far away from this basic right. These poor people are deprived of proper health facilities and proper waste management facilities. Pandemics and other contagious diseases spread like fire in informal areas. UNICEF is working and supporting different agencies to serve health benefits to these urban informal dwellers (Ahmed 2014) agencies WAB is working for a long term with a partnership with WSUP. WSUP also gets donation from the world bank to improve sanitation and hygiene for urban informal dwellers (Ahmed

2014). In Bangladesh, local NGO named Dushtha Shaystha Kendra (DSK) are undergoing unique projects such as rainwater harvesting and others, for the urban informal settlers (Rojas-Ortuste & Mahmud 2015). WAB also works as a partner with DWASA and DCC in Dhaka city, Bangladesh to provide pure water supply, tube wells, sanitary latrines and improved drainage system to improve the hygiene within the informal settlement areas (Ahmed 2014).

4. Online Survey Questionnaire

The online survey questionnaire consists of three parts. Part one is the survey result from the local inhabitants, part two of the online survey questionnaire consists of experts' opinions and the third part is based on formal arranged via zoom and informal interview collected from different media interviews and newspaper articles. The results from this online survey questionnaire presented in this section.

4.1.1. Local inhabitants' opinion

This interview survey was formulated, and people from all over the place of Dhaka city and different professions of people had participated. In Figure 5 showing the study area is a huge piece of area. Proposal for a thematic masterplan design sketch on the study area will create a huge impact not only on the inhabitants of that particular area but also on the inhabitants of the Dhaka City as a whole. Though the online survey most importantly requires the opinion of the local inhabitants specifically the informal dwellers within the study area. As the survey was remotely performed and it was not possible to perform online survey on the informal dwellers, so that online survey was conducted on the local inhabitants of all over Dhaka city.

As the interviews were conducted remotely it was not possible to reach to the informal local dwellers to learn their point of view. Mostly all the inhabitants are aware of the present condition of the study area and somehow affected with the situation. Even the informal dwellers are somehow involved in earning their livelihoods in the surrounding neighbourhood by working as their maid, driver, caretaker. Some also work in garments factories and small retail shops (Figure 15). They play a very important role to improve the economic state not only the Dhaka city or the surrounding area but also serve for the whole country (Sohail 2007). So, the local inhabitants are aware of the overall scenario and share a relative opinion through online survey questionnaire.

This portion of online survey require readjustment further if this proposal implemented in future. As it is mentioned earlier that this is a visionary masterplan program sketch, this proposal requires something as a base to start with. An online survey questionnaire had been conducted and in total around 54 local inhabitants all over Dhaka city had participated in the survey. The Table 4 showing the characteristics of the Dhaka city local participants in an online survey questionnaire. Democratic opinion including informal dweller's opinion in accordance with Patrick Gedde's theories is required for further investigation.

Table 4: Overview of the Dhaka city local inhabitant's characteristics, the data of this table is collected and created by the author.

Demographic variables	Option	Percentage
Gender	Female	52%
	Male	48%

Age	>18 18-29 30-49 50-60 <	4% 44.4% 38.9% 12.7%
Country of origin	Bangladesh Other	100% 0%
Employment	Housewife Working Student Retired Unemployed	7.5% 75.8% 4% 12.7% 0%
Educational background	High school University degree	4% 96%

According to the online survey questionnaire almost 65% of local people in overall Dhaka city are affected somehow by the stormwater flooding issue. The following pie chart (Figure 16) reflects the percentage of people who are affected and non-affected by stormwater flooding in the whole city of Dhaka. However, these responses cannot be said to be accurate for the informal dwellers.

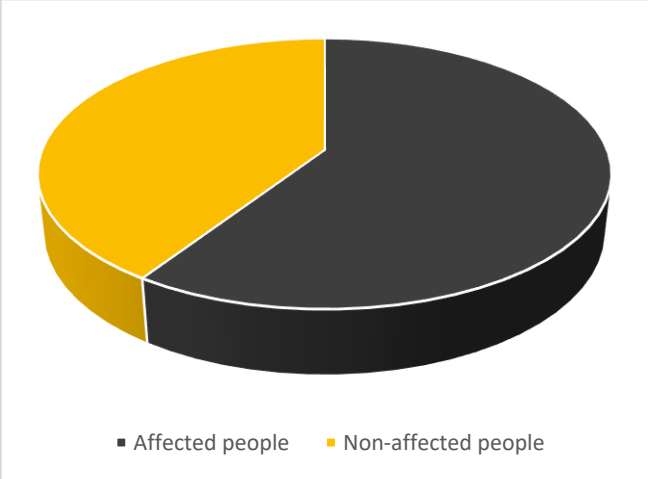


Figure 16: This pie chart reflects what percentage of people are affected and non-affected by stormwater flooding, the data is collected from the online survey questionnaire with the local inhabitants and the pie chart is created by the author.

Almost all the local inhabitants mentioned that due to stormwater flooding they face disturbance in daily life, damage to property (13%), and livestock (5%), deterioration of health conditions (20%), pollution (25%), traffic jam (35%) etc. Some also faced the accidental loss of the human life of their dear ones (2%). These are the social issues that they face regularly due to stormwater flooding. The following chart reflects (Figure 17) what types of problems the local inhabitants face due to stormwater flooding.

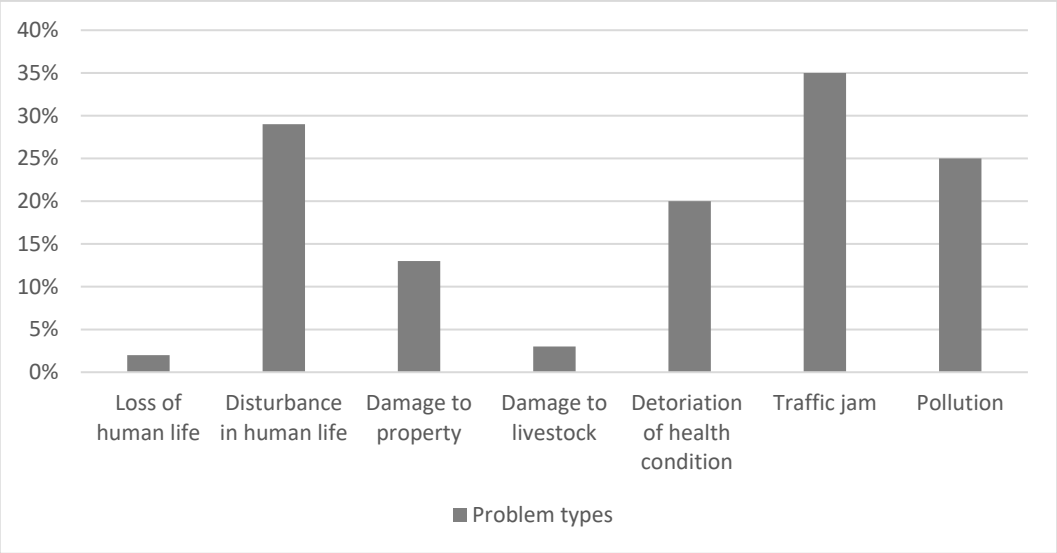


Figure 17: This chart reflects what types of problems local residents face due to stormwater flooding, the data is collected from the online survey questionnaire with the local inhabitants and the graph is created by the author.

They were asked according to them what the main reasons for stormwater flooding in their area? In response, they answered landfilling (40%), unplanned population increase (35%), mismanagement of waste materials (25%), unplanned urbanization (40%), inadequate drainage (47%), lack of awareness (20%) is the main reason for stormwater flooding. The chart below (Figure 18) reflects the survey result in percentage.

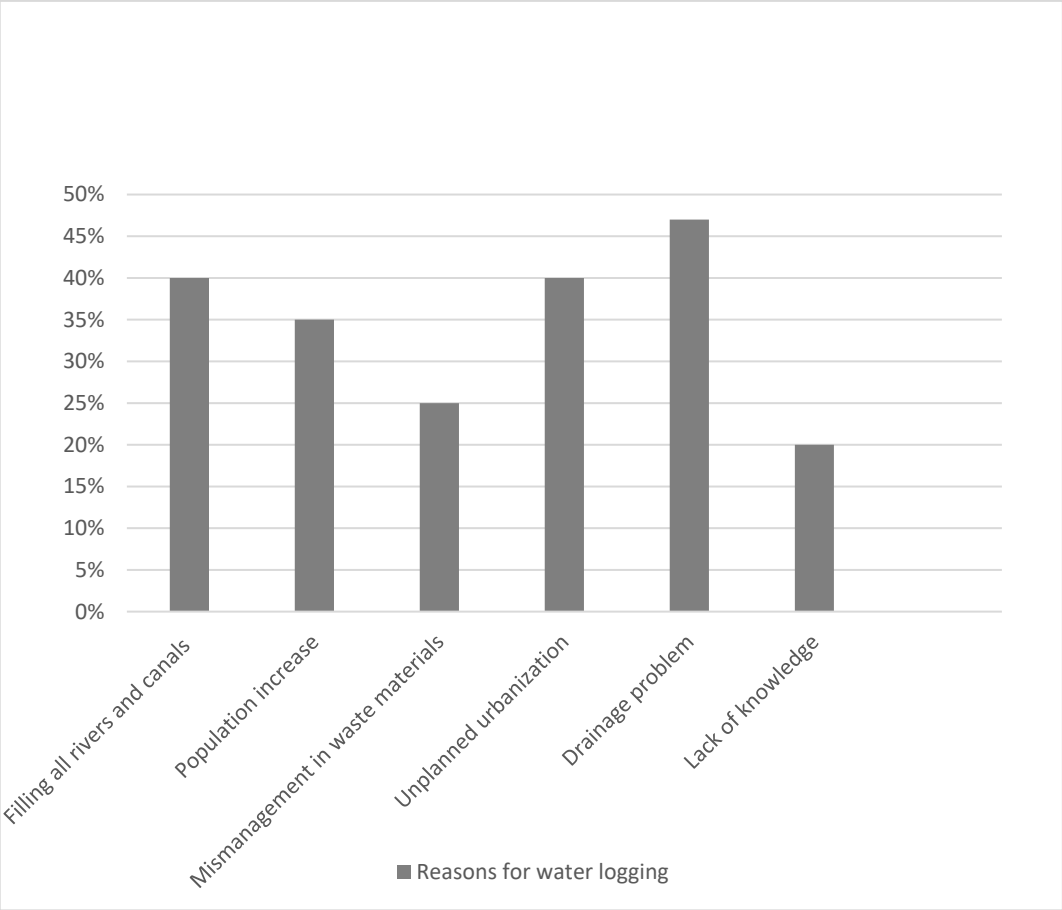


Figure 18: This chart reflects according to them what are the main reasons for stormwater flooding in their area, the data is collected from the online survey questionnaire with the local inhabitants and the graph is created by the author.

Most the people are hopeful that this waterflooding condition can be solved if roads are well-designed for drainage of water and sewerage, waste management, creating a proper channel for stormwater discharge etc. Some think that by reviving water bodies and wetlands, stormwater flooding conditions can be improved. Some also mentioned that proper monitoring, cleaning, and imposing law might also help to improve the present condition. Some also disagree with this they think that it is impossible to solve waterflooding in Dhaka city. To eliminate the problem of waterflooding there should be an absolute ban on plastic and needs to provide enough dustbin because trash and plastics often choke drains. Growing more and more plants can also help to solve the problem of storm water flooding and improve urban ecology. Some also mentioned that the responsible govt. employees are corrupted because the situation is getting worse.

4.1.2. Expert opinions

In total 10 experts from different fields from different government and private organizations had responded to this online survey questionnaire. This part of the interview questionary was aimed to gather the opinion on improving urban ecology, causes and effects of stormwater management and addressing social issues. The

participants were chosen based on their experience and expertise in different fields from different renowned govt. and private organizations.

Urban ecology is an important aspect of increasing greenery in the city. Experts and biologists have suggested that it is difficult to bring back urban greenery rather than think differently to increase urban ecology and greenery. The first step is to protect the existing one. According to their response street tree of 70%, the green roof of 100%, utilize negative space of 70%, courtyards 60%, elevated and climbers of 50%, aquatic plants of 80%, protect the existing greenery and water body of 90% reflected in percentage in the following chart (Figure 19), what steps can be taken to increase urban greenery and how we can provide habitat for other species to balance the urban ecology.

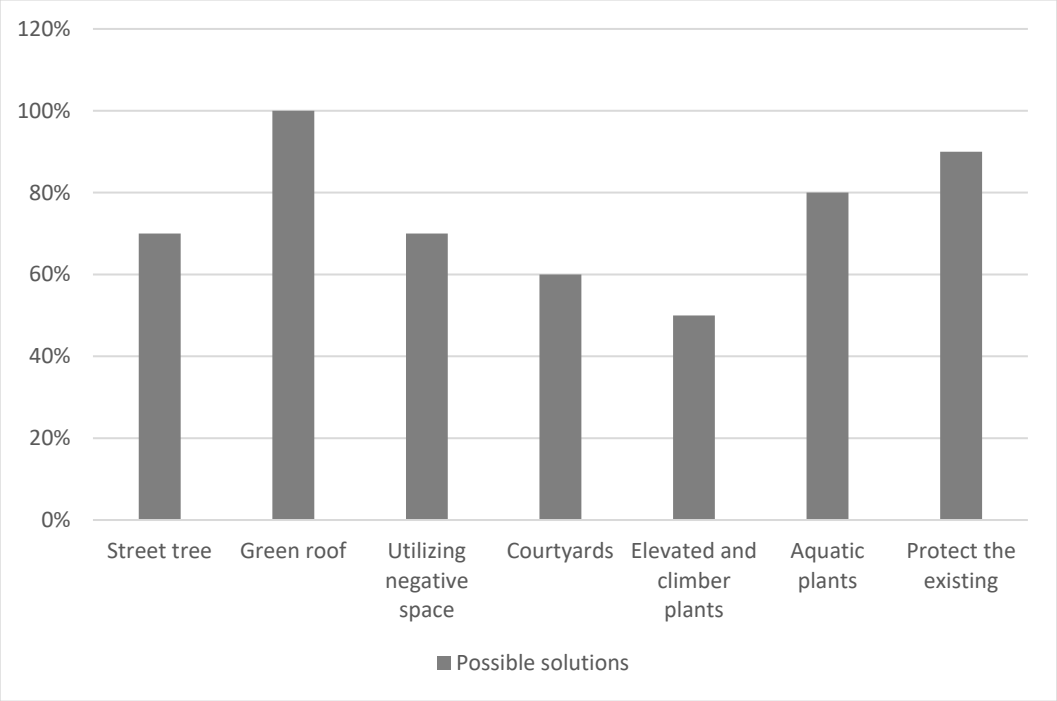


Figure 19: The chart reflects how ecological balance and greenery can be achieved according to experts, the data is collected from the online survey questionnaire with the experts and the graph is created by the author.

The disagreement of opinion occurs while asking if rain-beds or rain gardens can be a solution for stormwater flooding in the Bangladeshi context? The following pie chart (Figure 20) reflects that 40% agreed and 60% disagreed. The basic reason for disagreement is due to lack of space, costly construction infrastructure and maintenance.

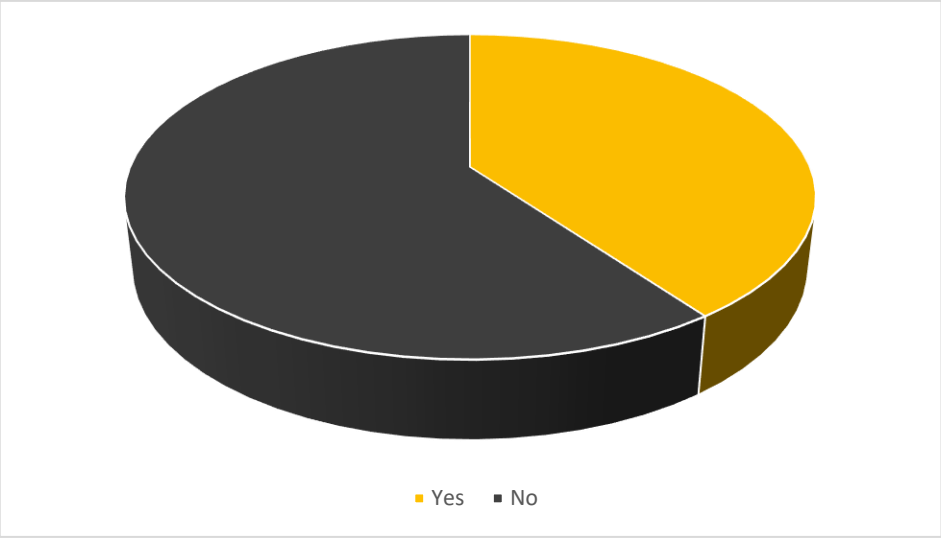


Figure 20: This pie chart reflects what percentage of people are agreed on rain bed or rain garden the expert survey, the data is collected from the online survey questionnaire with the experts and the pie chart is created by the author.

Some experts have common reflections on one issue, and some have different opinions regarding another. All agreed the city requires a proper new design solution towards the drainage system. Population increase (50%), filling all rivers and canals (70%), mismanagement of waste (50%), unplanned urbanization (80%), lack of knowledge (30%) is the main reason for stormwater flooding (Figure 21). They also suggested that raising awareness and increasing knowledge of general people to protect greenery around them by building trust and respect in them. According to them, it is important to arrange a regular inspection, maintenance and cleaning of existing sewers, drainage lines, box culverts, catch pits and manholes prior to the rainy season. They also suggested the re-excavation of canals and lakes every year. One of the experts proposed the installation of temporary pumping stations on the embankment surrounding the city where required with mobile electrical substations. They also suggested proper road planning, increasing wetlands by allowing multi-storeyed buildings of more occupancy keeping open space increasing infiltration. The following chart reflects what are the main reasons for stormwater flooding according to the expert.

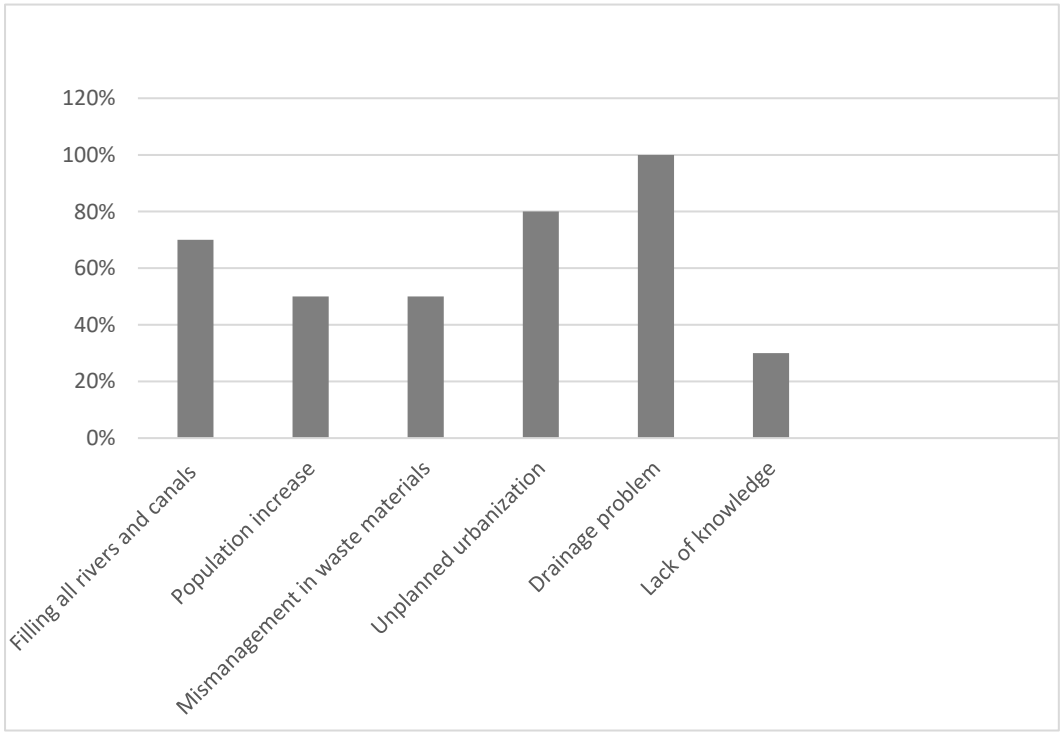


Figure 21: This chart reflects what are the main reasons for stormwater flooding according to the expert survey, the data is collected from the online survey questionnaire with the experts and the graph is created by the author.

Regarding the social aspect, they were also asked if the informal dwellers should be evicted, or they should be resettled properly. Some agreed with the re-settlement idea, but some also disagreed. Some experts suggested that it is a fact that the class difference is quite prominent in the city of Dhaka and it cannot be denied that not only for an economic purpose but also for other social purposes we need the lower-income people. They deserve to have proper resettlement. Opposing this idea some experts mentioned that we should not think emotionally rather than logically about what is important for a better future. According to them if different sorts of job opportunities are increased in other parts of the country there is no need to gather a crowd and create extra pressure on the capital city. The following pie chart (Figure 22) reflects that almost 65% of experts responded that they should have a proper sustainable area for living.

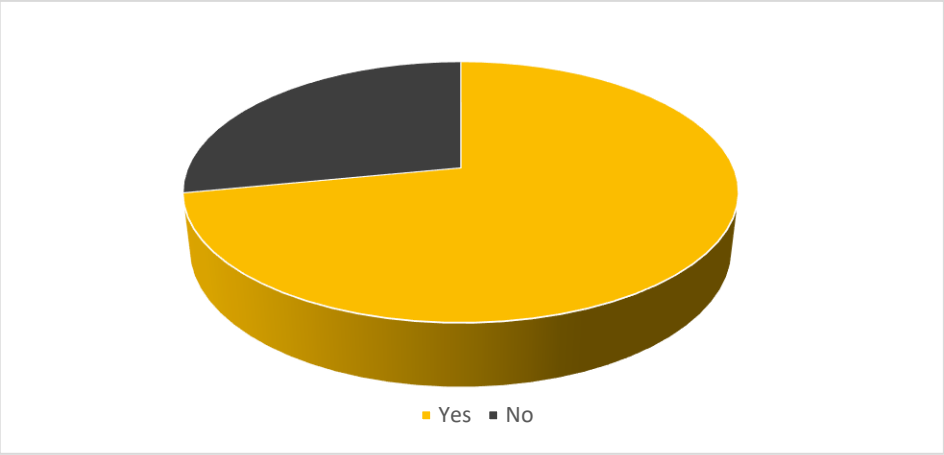


Figure 22: This pie chart reflects what percentage of people agreed and disagreed on the resettlements of the informal settlements on the expert survey, the data is collected from the online survey questionnaire with the experts and the pie chart is created by the author.

4.1.3. Informal interviews

Informal and unstructured interviews and communications have the flexibility to pursue qualitative research processes. These social interactions are important for collecting participant's observation and data collection. These informal conversations are sometimes termed "informal interviewing" or "unstructured interviewing" and "ethnographic interviewing" (Swain & Spire 2020). In this thesis, they are termed as informal interviews. Informal interviews from the newspaper articles, news media have also been collected. Another way of communicating with the experts and informal interviews have also been conducted. These informal talks was important in evaluating my findings as a whole and do the SWOT analyse and conceptualize providing sustainable solutions and guidelines.

Not as many trees are planted on the streets and pedestrian areas in Dhaka city. Though it is very important to plant trees for the pedestrian walkers to provide shade. Rabiul Islam who is a young architect, landscape designer and environmentalist suggested that trees with high tolerance level and water absorbed plants should be selected for lower maintenance and control stormwater flooding on streets. From his own working experience, he also suggested that instead of plants with growing branches vertical growing plants should be used to avoid obstacles and for lower maintenance. He also suggested that evergreen plants should be introduced to provide shelter for other species (Datta & Ahmen 2018).

In an informal interview personally arranged with Mustaque Quadry who an architect and a naturist mentioned that it is difficult to bring greenery back into the city again because it is an already a built-up city. So, what can be done is to design in a planned way in other parts of the city. The first thing is to do is to allocate a defined space for trees only. The negative spaces can be utilized by plantation. Utilizing trees for plastic decoration has no function to serve in improving urban ecology. Green roofs, vegetable gardens can be designed in buildings. The trees should be selected carefully for roof garden special as we have seasonal storm from April to May which is called "Kalboishikhi jhor" might cause hazards. Vertical climbers can be used as a fence and in overbridges and flyovers. Aquatic

plants can be increased on the water bodies to improve the ecological balance within the city. Then the catchment areas should be increased to hold the excess water during the flooding period and rainy season. He also mentioned that the protection of the existing greenery and water body is very at this moment to reduce the stormwater flooding condition in Dhaka city.

Architect Iqbal Habib also agreed with Mustaque Quadry in protecting the existing greenery and water body. Iqbal Habib is an architect and joint secretary of BAPA (Bangladesh Poribesh Andolon), he mentioned the canals are very important to hold the stormwater as well as to develop a loop network system for waterways. He also suggested the construction of a vertical structural element for a foundation rather than slopes beside the canals to increase water catchment and also provide designed walkways to protect from stormwater flooding (Alam 2016).

5. GIS analysis

The SWOT analysis of the study area is to a great deal based on the GIS analysis. The GIS analysis is formulated based on the aspects named below:

- Land use
- Green and open spaces
- Informal settlements
- Loss of wetlands and waterbody
- Flood analysis

5.1.1. Land use

It is important to understand the existing condition of the city and its land use and land cover. GIS helps to perform this analysis to understand the land use & land cover of a particular area how it used to be and how it changed gradually over time.

The map showing the land use and land cover in Dhaka city. Dhaka city is continuously changing. The comparison of two maps in the year 2006 and 2016 can easily identify how much the city has changed. Loss of agricultural lands, bare lands is visible. The increase in the construction area, urban fabric and industrial development are prominent in these maps (Figure 24). The pie chart below (Figure 23) shorts reflects the land use and land cover changes in percentage.

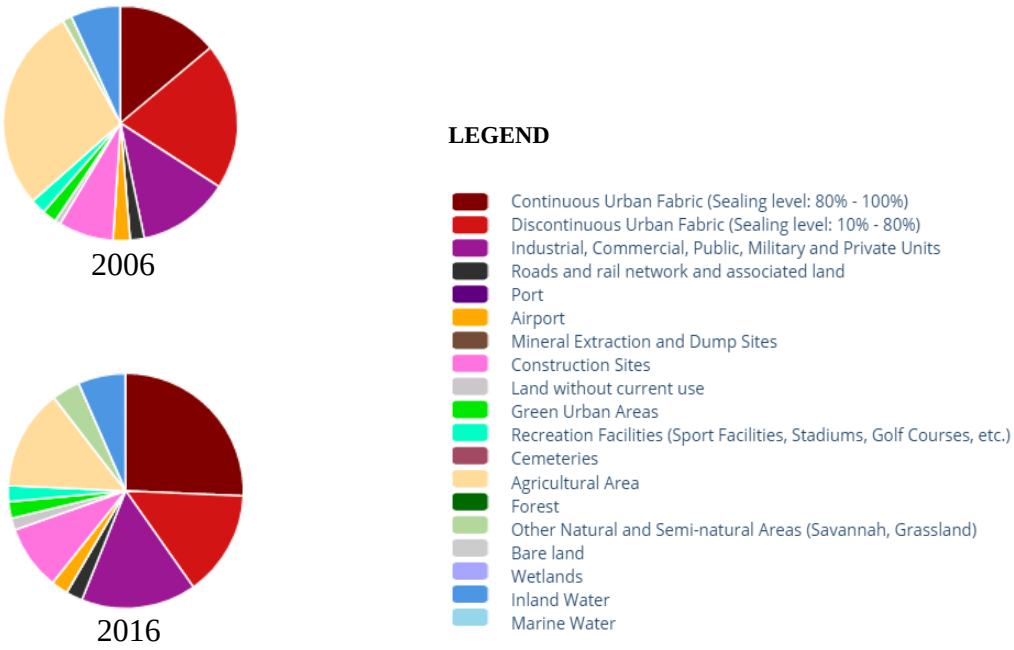


Figure 23: Land cover classes – the percentage of total area, the pie chart is created by the author.

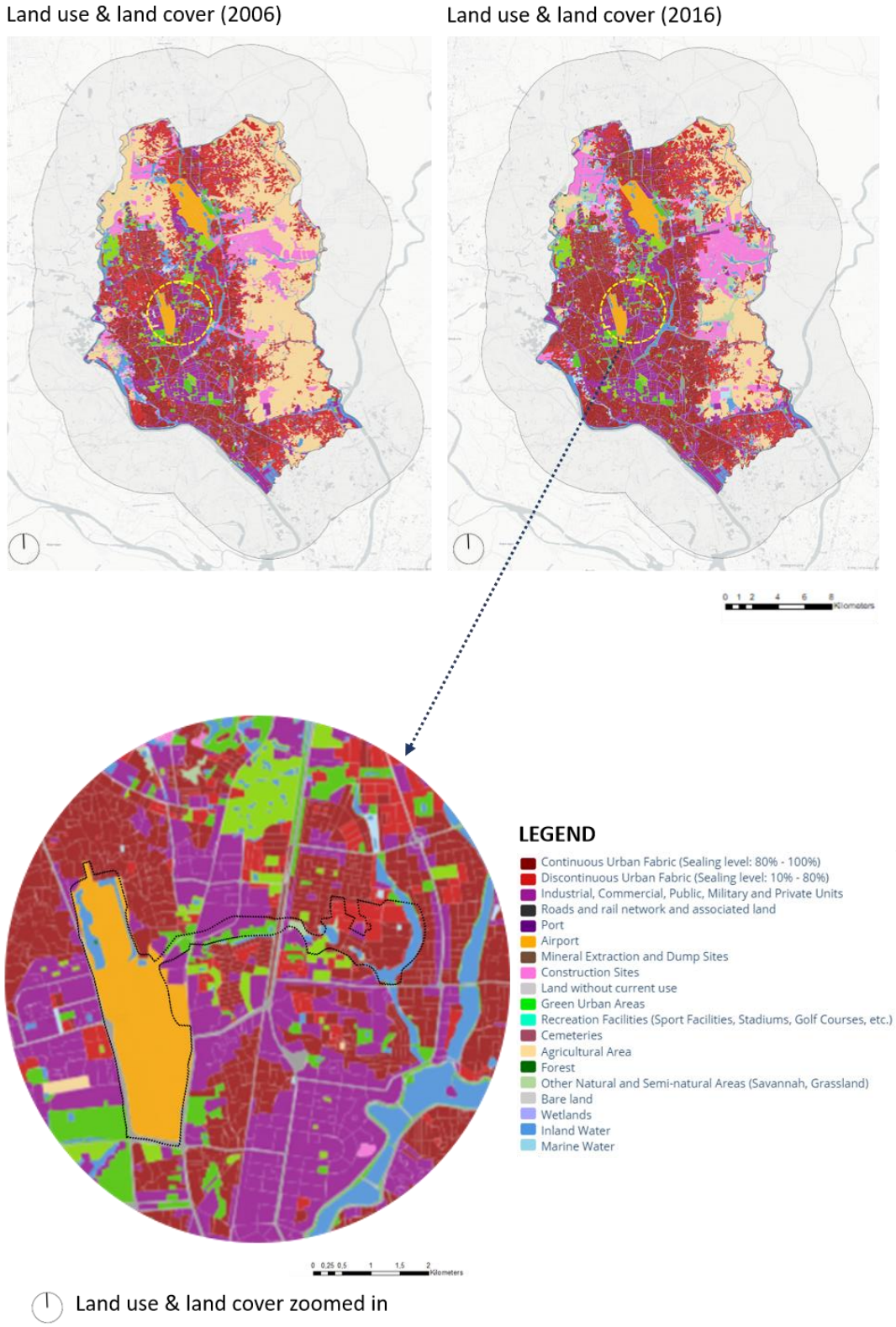


Figure 24: Land use and land cover map in zoom in for the study area, the map is produced by the author.

5.1.1. Green and open areas

This GIS analysis was formulated to identify green and open spaces. Urban open green spaces are important to identify to propose recreational areas. In a broader sense to resolve environmental issues urban open green spaces are very important to identify and classify. The map below (Figure 25)reflects the green and open spaces of the study area in Dhaka city. To reduce the bad impact on the environment, provide walking paths, recreational facilities and protect the habitats from destruction this GIS analysis had been formulated.

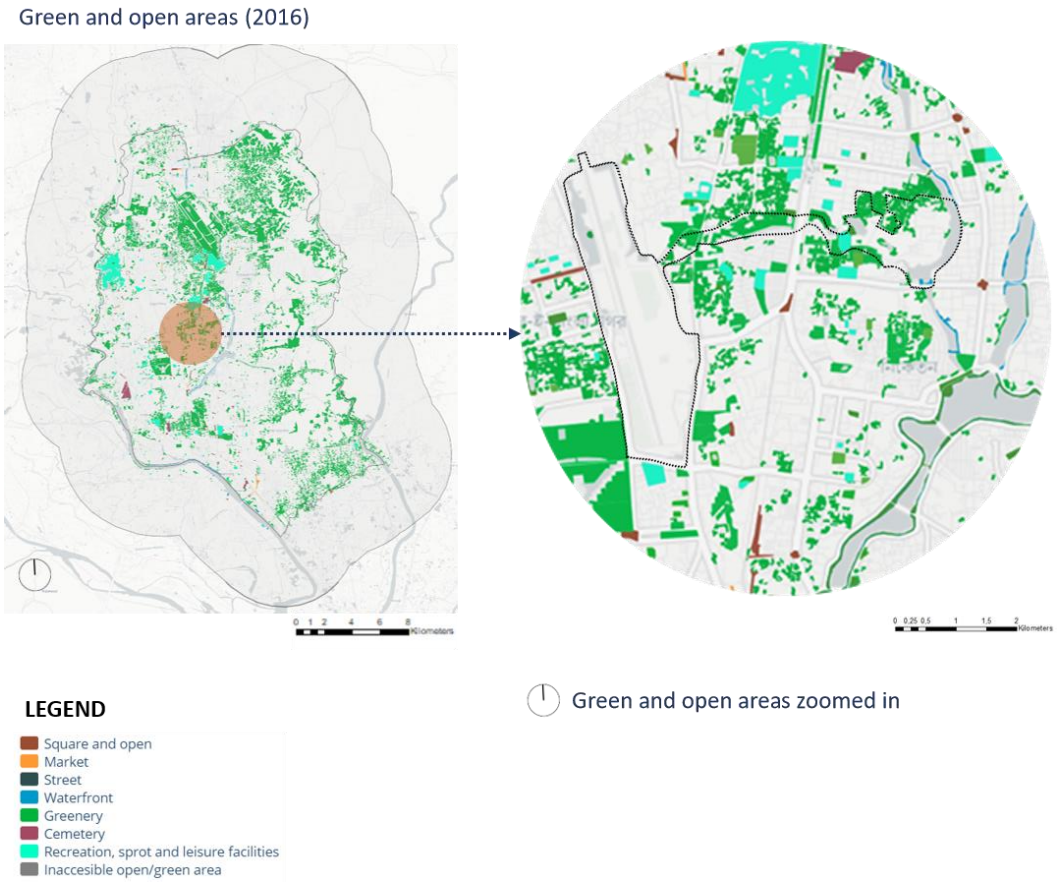


Figure 25: Green and open spaces map and map for the study area zoomed-in, the map is produced by the author.

5.1.2. Informal settlements

A lot of people migrate towards Dhaka city every year. They find their accommodations in the informal settlement areas. It was important to trace where the areas of the informal settlements are growing and locate them correctly.

The map below (Figure 26) helped to identify the traces of the informal settlements in Dhaka city during the year 2017. The zoomed-in map reflects the study area with the informal settlements which is known as “Karail slum”.

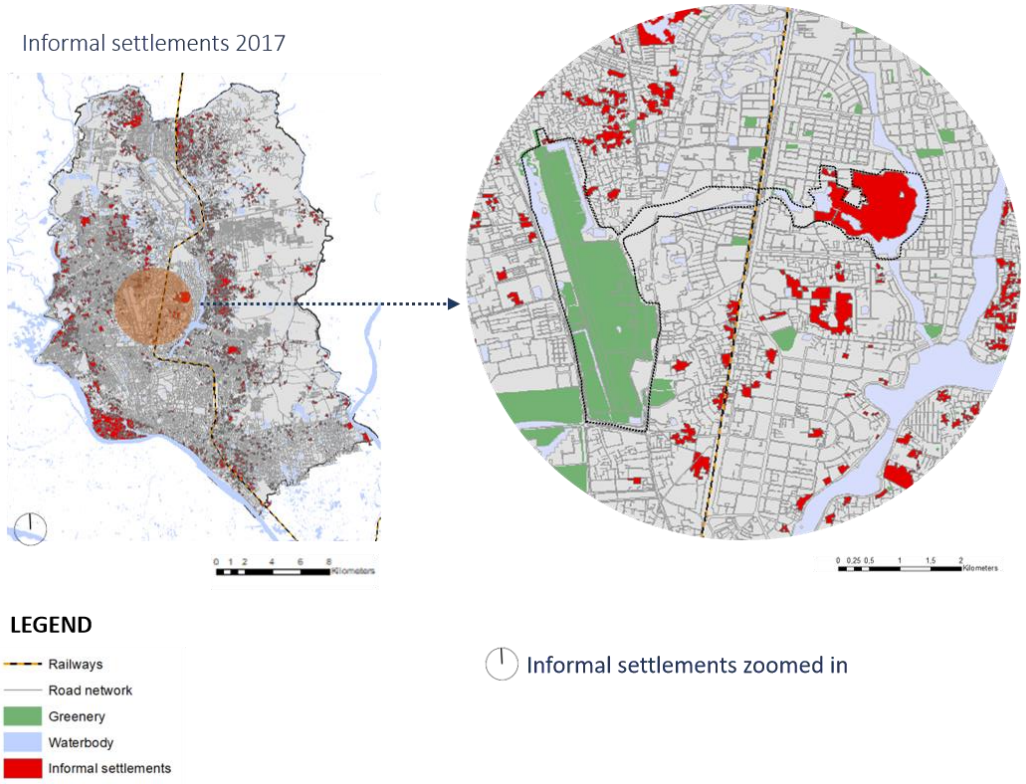


Figure 26: Informal settlements for overall Dhaka city and map of the study area zoomed-in, the map is produced by the author.

The informal settlement area is almost 100 acre. A huge part of people live in this area around 59,516 inhabitants and almost 18,067 households are accommodated in this part (Hasan & Mollah 2017). In (Figure 27, Figure 28) showing the existing land-use map and the existing road network in the zoomed-in maps of the Karail slum area.

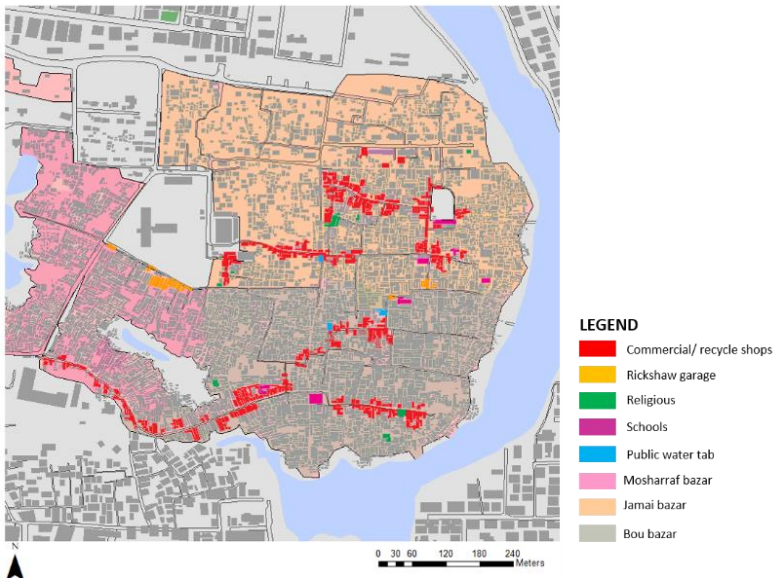


Figure 27: Land use map for informal settlers in Karail slum area, the map is produced by the author.

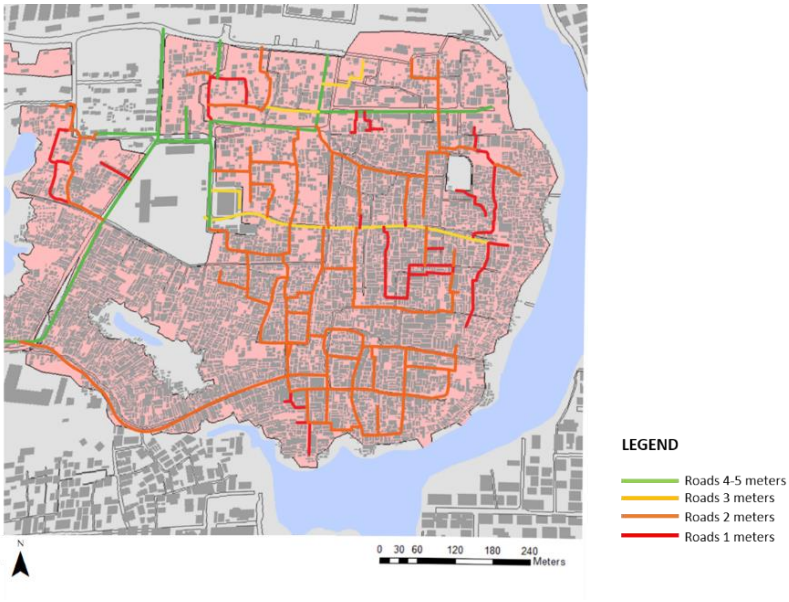


Figure 28: Road width and road network map in the informal settlement area, the map is produced by the author.

5.1.1. Loss of wetlands and waterbodies

Due to unplanned developments, population increase, landfilling the wetlands and water bodies had been decreasing day by day in Dhaka city. The map below (Figure 29) shows the comparison between the two maps. The first one was in 1998 and the other one in 2009. The loss of wetlands and water bodies is quite prominent. The connectivity is completely lost in certain parts. The zoom-in map reflects the loss of connectivity in the study area.

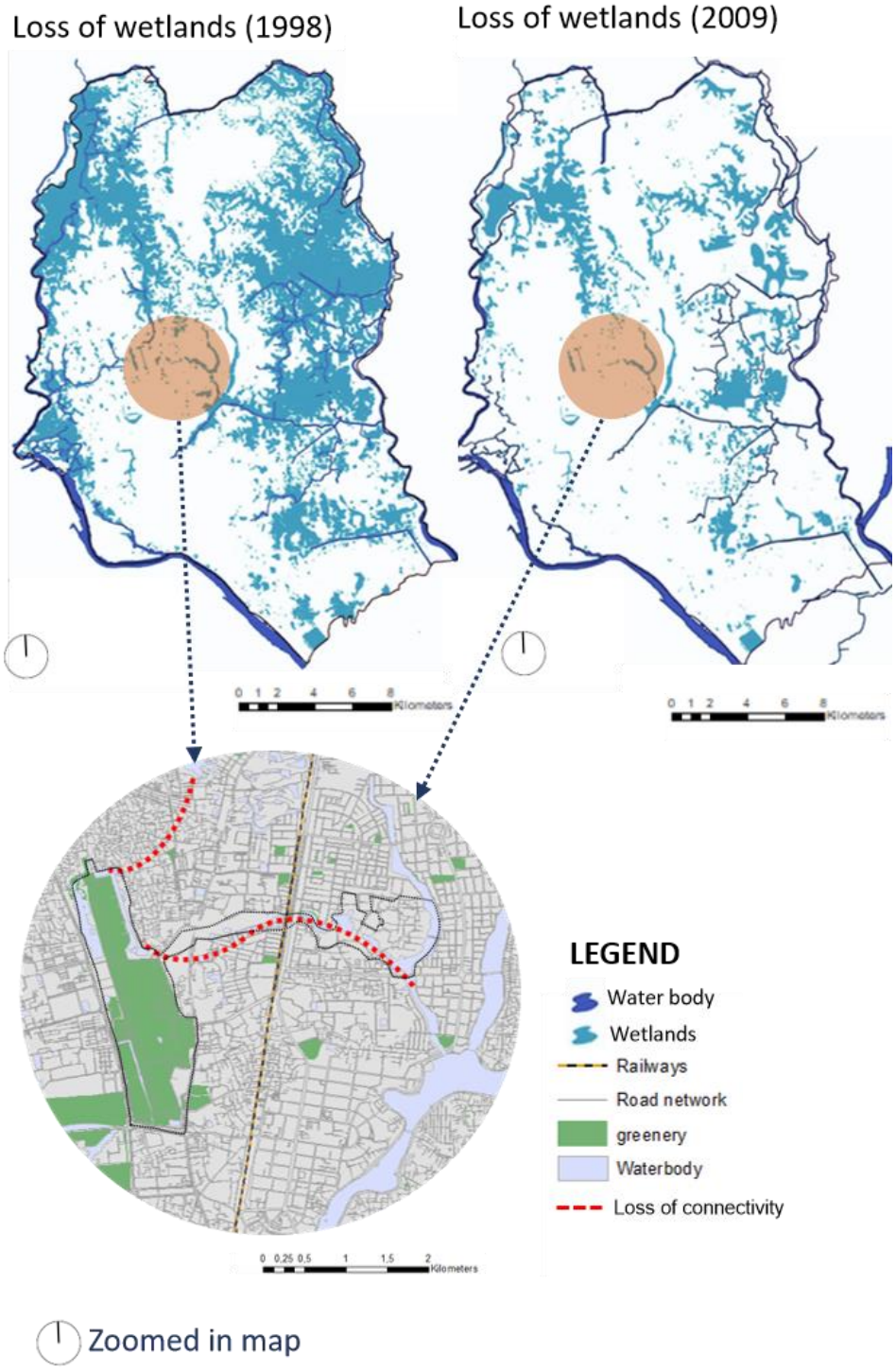


Figure 29: Map showing loss of water body and wetlands in Dhaka city and map of the study area zoomed-in, the map is produced by the author.

5.1.2. Flood analysis

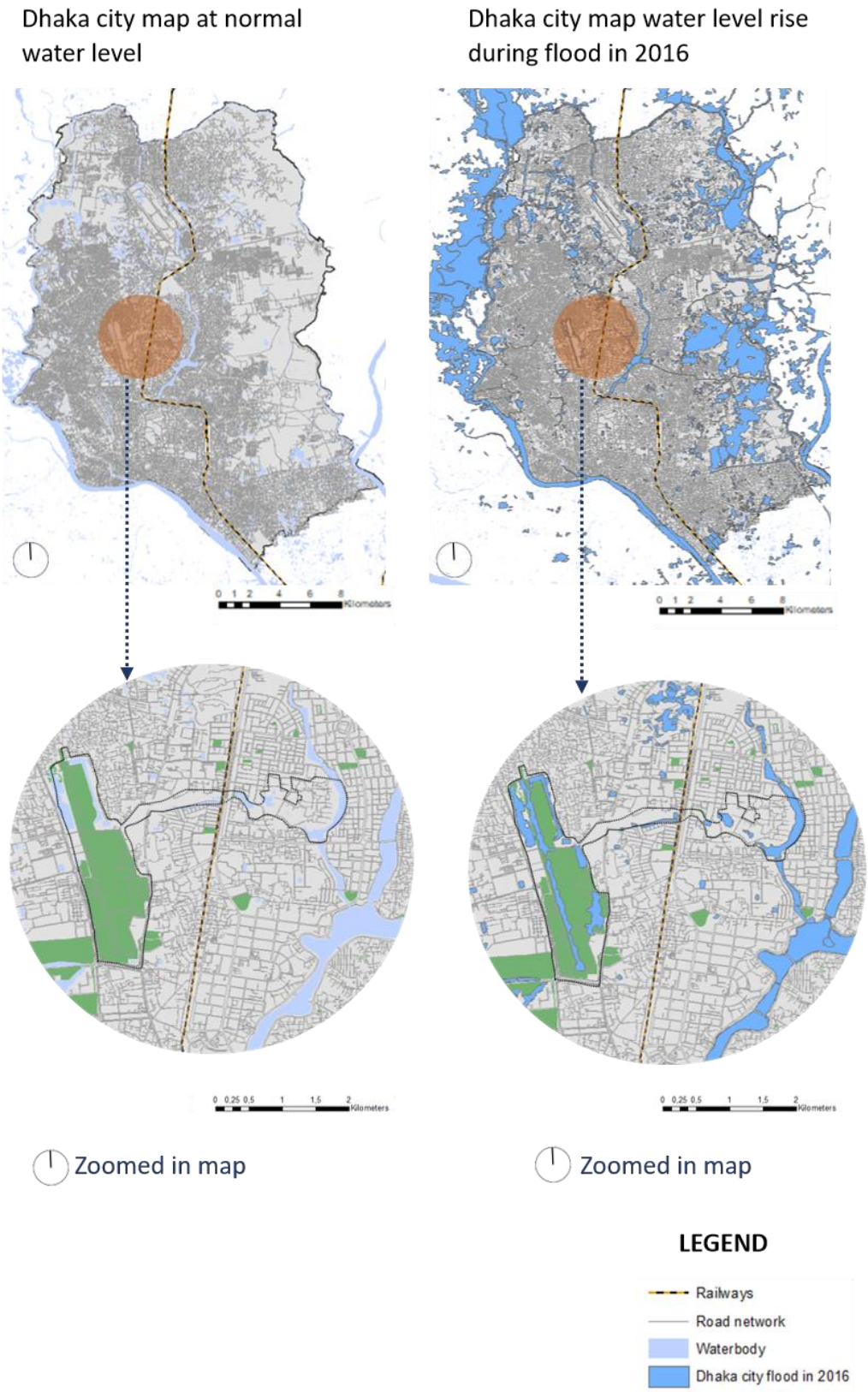


Figure 30: Comparison of water level during flooding time in Dhaka city and zoomed-in maps, the map is produced by the author.

Unplanned developments and the population is increasing day by day. As it was mentioned earlier that due to this increasing condition of population and unplanned urban developments landfilling of wetlands and water bodies had been decreasing day by day. Greenery is lost from Dhaka city.

Due to the deduction of water catchment areas frequent flooding has increased in recent years. The map above (Figure 30) reflects the comparison within the normal water level and the increased water level in 2016 in Dhaka city. in the zoom-in maps, the increase of water level and the comparison is easily determined.

6. Role models around the world

Different projects from North America, Europe and Asia had been considered in this section which address the three thematic aspects in Dhaka city of this thesis i.e., urban ecology, stormwater management, and social issues.

This part of the methodology of the thesis considered various relevant ways to get knowledge and inspiration from other successful projects. Most of these projects are implemented and some are conceptual or strategic plans. But all projects try to solve the same problematic issues that this thesis is trying to solve. These projects chosen as role models have many positive aspects that this thesis took inspirations from. Some of the design challenges, limitations and previous drawbacks gave ideas to handle the upcoming design challenges in the context of Dhaka city. The study of role models provide background to better guidelines for the designed the masterplan program-sketch both by their positive aspects and their limitations, challenges, and drawbacks.

The following Table 5 summarise project names and how they complement this thesis in terms of the main three thematic aspects, positive aspect, limitations, or design challenges.

Table 5: Different projects with short summary & how it complements this thesis, the table is created by the author.

Role Models	Project Type	Complementing main aspects	Positive Aspects	Limitations / Design Challenges
North America				
➢ **The Big U Project**	Real project (Winner of a project competition)	✓ Increase greenery and diversity. ✓ Manage stormwater and flooding. ✓ Consider social and economic aspect.	➢ Reduce the consequences of climate change. ➢ Measures for managing stormwater flooding. ➢ Measures to prevent flooding. ➢ Underground canal system. ➢ Create a barrier between the raise of water level. ➢ Achieve sustainability. in an artistic way. ➢ Diversity within the spaces.	➢ Funding gap. ➢ Funding gap has also created challenges to level up public expectations. ➢ Lack of feasibility. ➢ Lack of risk analysis of technical issues related to vulnerability, energy needs, infrastructure conditions etc. (Grannis 2016)

			➢ Establish social and economic relationship.	
Europe				
➢ **All London Green Grid framework**	Comprehensive planning	✓ Increase greenery, diversity & improve urban ecology ✓ Manage stormwater and flooding ✓ Consider social and economic aspect	➢ Establish greenery connection to promote greenery and diversity ➢ Benefit humans and wildlife ➢ Maintain the ecological balance and environment to improve the quality of living ➢ Access to open nature ➢ Productive landscape ➢ Promote recreational and leisure facilities ➢ Encourage people for physical activity ➢ Reduce the effect of stormwater and flooding	➢ Integration of the Green Grid into planning ➢ Certain barrier in the flow of greenery ➢ Long term design process ➢ Continuous changes in policy and framework for further improvement.
➢ **Reopening waterways in Oslo**	Real project	✓ Increase biodiversity ✓ Reduce flooding risk ✓ Consider social	➢ Take flood control measures ➢ Provide recreational facilities ➢ Provide ecosystem services ➢ Provide habitat for wildlife	➢ Water quality problems are not fully solved ➢ Issues related to stormwater management and chemical pollution of sediments ➢ Future restoration of urban rivers and lakes requires broader catchment and retention areas (European Environment Agency. 2016)
➢ **Raingarden to manage stormwater on street in Stockholm, Sweden**	Real project	✓ Increase greenery, diversity & improve urban ecology ✓ Manage stormwater ✓ Consider social aspect	➢ Helps to manage stormwater ➢ Provide social and visual value ➢ Playful environment to the streetscape ➢ Lead a healthy living, and enjoy the greenery	➢ Design challenges are cost efficiency and management.
➢ **Raingarden to manage stormwater on street in**	Proposal waiting for implementation	✓ Increase greenery, diversity & improve urban ecology	➢ Improve the social quality of living ➢ Well-designed streetscape	_____

Växjö, Sweden		✓ Manage stormwater ✓ Consider social aspect	➢ Improve street ecology ➢ Sustainable use of stormwater	
Asia				
➢ **Climate change adaptation in Ho Chi Minh City (HCMC), Vietnam**	Strategic Planning	✓ Increase greenery ✓ Manage flooding ✓ Consider social and economic aspect	➢ Formally arranged street commercial facilities. ➢ Informal markets beside laneways Recreational facilities	➢ Major design challenges comes in terms of infrastructure development, public transport, flood prevention and the provision of other public services due to its ongoing rapid growth. ➢ Existing policies and strategic documents require revision to meet new challenges. ➢ Design requires evacuation routes during hazards and construct drainage channels. ➢ Lack of decision making governance and distribution of proper finance ➢ Gap between the approach of the local community and government regarding land acquisition and slum resettlement ➢ Require workshops and training for raising awareness (Connecting Delta Cities 2013)
➢ **Saigon informal resettlement housing in Vietnam**	Conceptual project	✓ Increase greenery and diversity ***X*** Manage stormwater and flooding ✓ Consider social and economic aspect	➢ Provide quality of living ➢ Take measures for proper flood protection ➢ Take measures for proper stormwater flooding ➢ Strategies to improve the urban blue and green network	➢ Accommodate future population growth. ➢ Maintenance ➢ Proper implementation

The following sections will shortly reflect and discuss the basic information on these role models which has inspired the author.

6.1. North America: The BIG U project

In the year 2012 “Hurricane Sandy” hit the east coast of the US. Thousands of people lost their lives and lost their homes. Roads and subways were underwater. Lower Manhattan was affected the most (Grannis 2016). The New York City council took necessary measures to prevent the necessary flooding. In the year of 2014, the state of New York launched a competition to protect Manhattan. This competition was won by Danish-American Architectural firm Bjarke Ingels Group (BIG) with BIG U (Howarth 2018).

Figure 31: The Big U project in Manhattan, New York, USA (Howarth 2018).

The Big U proposal aimed to protect Lower Manhattan from floods, stormwater flooding and reduce the consequences of climate change. The project consists of the construction of a 16 km long green barrier raised above the sea level in the southern tip of Manhattan (Howarth 2018). An underground canal system is also planned to carry and collect the exessive stormwater flood water towards the sea (Figure 31).

The design approach of BIG U to the project for Manhatten is based on a basic principle not to create a barrier between the raise of water level and the city instead the aim was to integrate them together in such a way so that they can form a relationship to tackle the obstacles in different situations. Another aspect was to achieve sustainablity in an artistic way. The diversity within the spaces created a link to enrich the environmental balance and establish social and economical relationship within the city (Grannis 2016).

6.2. Europe: All London Green Grid framework

A design policy or a framework is established to promote greenery and diversity in London to benefit humans and wildlife. All London Green Grid (ALGG) aims to fill up the blanks where the urban greenery and opens spaces lack the connections. These frameworks in Figure 32, Figure 33 altogether works to maintain the ecological balance and environment to improve the quality of living for a better future.

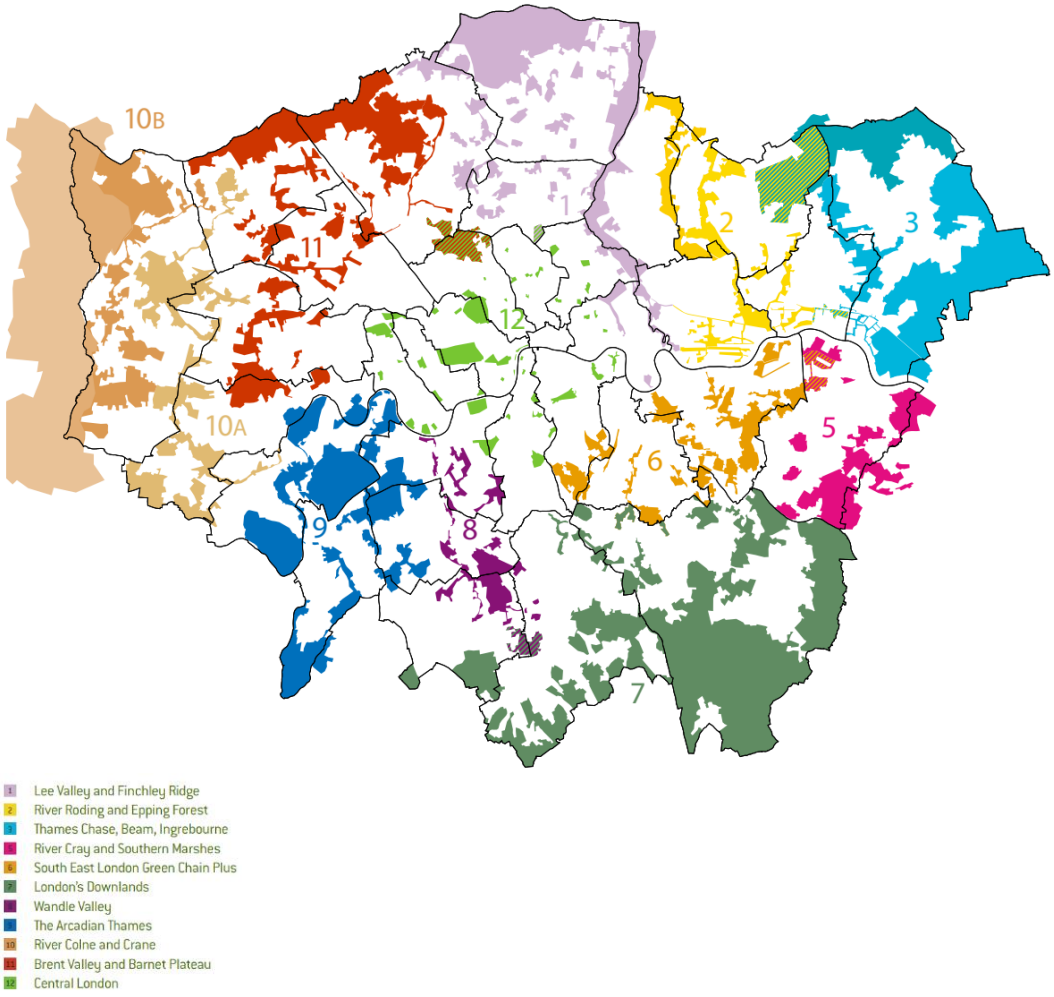


Figure 32: The frameworks that cover the ALGG areas (Harrow Green Grid 2012).

The impact of climate change in London is huge such as frequent floodings, droughts, urban heat island effect. The rise of temperature during summer, causes extreme heat waves, droughts, and extreme rainstorms. Increase of sea level, frequent flooding from tidal, surface water drainage is the common problems. The existing drainage system, flood protection barrier and green infrastructure network required to expand and redesign to recreate a new strategic network of green and blue infrastructure to reduce the effect of stormwater flooding and flood risk (Mayor of London 2013).

Figure 33: All London green grid landscape and open space planning (Mayor of London 2013).

The main aims and objectives of this framework is shown in following Figure 34 (Harrow Green Grid 2012). They are:

- Access to open spaces
- Access to nature
- Managing flood risk
- Making connections
- Distinctive destinations
- Healthy communities
- Productive landscape
- Skills and training

Figure 34: The main aims and objectives of ALGG (Harrow Green Grid 2012).

The green and blue structure will combinedly help to absorb the excess water, lower down the temperature and improve the environment quality. Specifying spaces for flora and fauna will help to develop urban ecology. It will also promote recreational and leisure facilities. Improved network system will also encourage people for walking, running, and cycling. Improving landscape hierarchy and heritage will also support the local economy.

6.3. Europe: Reopening waterways in Oslo

The city of Oslo is shaped by its urban waterways. There are 10 main waterways in the built-up areas including its rivers and streams (*Oslo Reopening Waterways* 2017). These waterways showing in Figure 35, provide opportunities for flood control measures, recreational facilities, ecosystem services, provide habitat for wildlife etc (European Environment Agency. 2016).

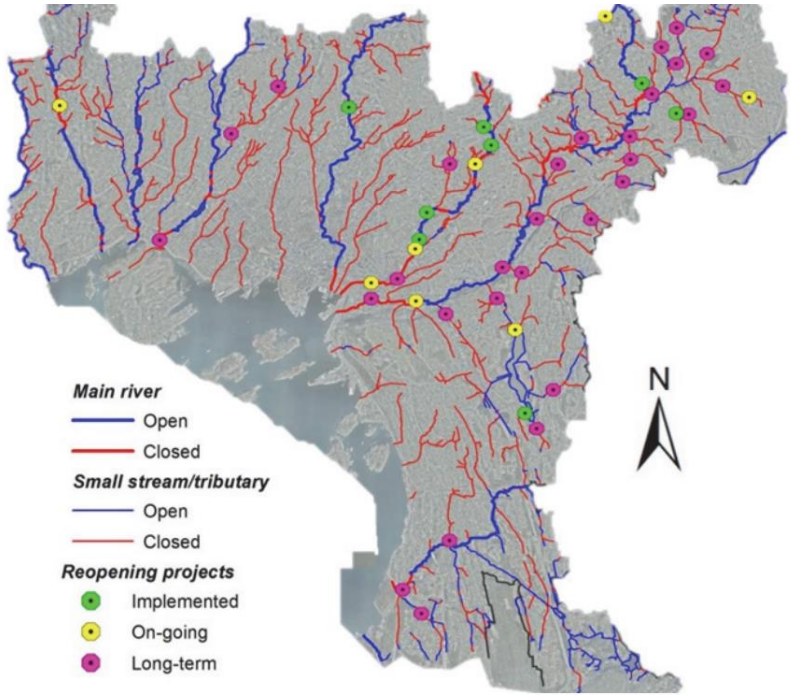


*Figure 35: Oslo plan for reopening waterways (*Oslo Reopening Waterways *2017).*

Due to climate change, extreme increase in rainfall caused flooding. To manage this flooding issue Oslo decided to open these waterways again. This reopening project aimed to keep it as natural as possible. The use of native plants and aquatic plants helped to develop sustainable solutions. The ecosystem service improved within the city. The natural cleaning system has improved to control pollution (Figure 36) (European Environment Agency. 2016). The main aim (*Oslo Reopening Waterways* 2017) of reopening these waterways are -

- Reduce the flood risk
- Increase biodiversity
- Improve water quality
- Benefit public health
- Add recreational values

Figure 36: Streetscape and raingarden in Jaktgatan/ Lövängsgatan, Norra Djurgårdsstaden, Stockholm, Sweden (Reopening waterways 2015).

6.4. Europe: Raingarden to manage stormwater on street in Stockholm, Sweden

Jaktgatan and Lövängsgatan main road of 25 meters contain 6.5 meters of the asymmetric green path. This green path helps to manage stormwater. It also helps to contribute to cars to drive safely. Different types of trees, shrubs and tall perennials help to benefit biodiversity, improve ecological values as well as provide social and visual value (LILA 2021). Wooden platforms and seating located on the green path added a playful environment to the streetscape. This playful environment encouraged the people to walk, lead a healthy living, and enjoy the greenery (Figure 37).

Figure 37: Streetscape and raingarden in Jaktgatan/ Lövängsgatan, Norra Djurgårdsstaden, Stockholm, Sweden (LILA 2021).

6.5. Europe: Raingarden to manage stormwater on street in Växjö, Sweden

Improving the social quality of a well-designed streetscape will promote street ecological functions, sustainable use of stormwater. The sunny side of the street in Växjö, shops & squares close to the street, green areas with child-friendly & social gathering spaces, walkable slow-flowing, unbroken flow for pedestrians across the fast-moving street is very efficient for commuting. Experts from different fields and specific tree selection also improved the ecology. It also provides shelter for insects and other habitats. Different vegetation, flower plants, perennials also help to catch surface runoff and stormwater from the street and pedestrian (Figure 38). These altogether created an urban playful environment (AFRY 2021).

Figure 38: Streetscape in Växjö (AFRY 2021).

6.6. Asia: Climate change adaptation in Ho Chi Minh City (HCMC), Vietnam

The Ho Chi Minh City (HCMC) is located in Vietnam at the edge of the Saigon river delta and Dong the Nai river. HCMC city has a huge diversity in nature starting from the north dominated by cultivating rural landscape to the south with mangrove forest, rivers, and canals.

The built-up area of HCMC has grown almost double within the last decade. The city also expanded towards the flood risk zone along the coastal side. One-third of the city is already situated in the flood risk zone. If urbanization keeps growing like this without taking proper measures, then two-third of the city will suffer the effect of flooding regularly (Dutch water sector 2013). Figure 39 showing how climate change has affected the city most. They are as follows:

- Raise of temperature
- Raise of sea level
- Decreased sedimentation
- Irregular river discharge
- Increases precipitation peaks
- Heat island effect
- Inadequate drainage to tackle the frequent flooding
- Increases storm surges

These are the reasons to take proper measures or strategies (Connecting Delta Cities 2013).

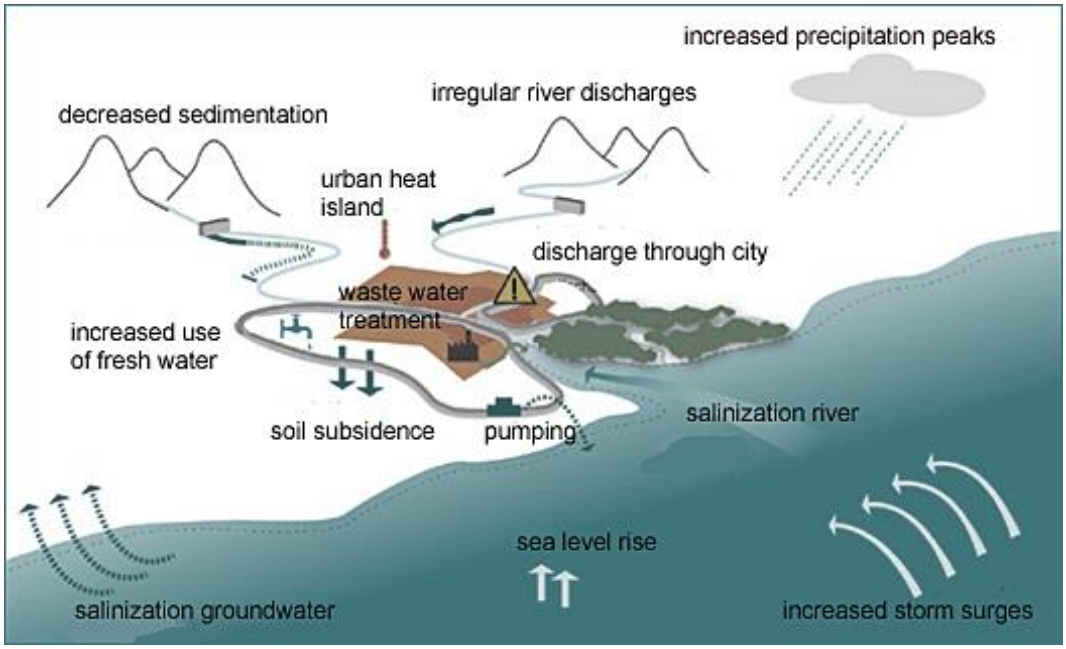


Figure 39: Climate change impact for Ho Chi Minh City (Dutch water sector 2013).

To reduce these climate change impacts HCMC has formulated a climate change adaptation strategy in 2013 (Dutch water sector 2013). The strategies as follows:

1. Design strategies to accommodate the increased population and quality of living.
2. Take proper flood protection measures at different levels.
3. Increase water catchment and drainage capacity to avoid local flooding due to stormwater flooding.
4. Take measures to reduce the salinization problem.
5. Propose and create a different creative solution to reuse groundwater.
6. Create a breathing space to reduce the urban heat island effect and make strategies to improve the urban blue and green network.

Climate change adaptation in socio-economic development is the central aim of HCMC. The project aims to solve the overall socio-economic condition along-side planning properly in developing sector wise planning including land use, transportation, water management, waste management, health, agriculture etc.(Linh & Quan 2019).

Due to lack of minimum integration efforts the project faces huge design challenges at the time of implementation. This project also faces problem in decision making, governance, distribution of proper finance (Linh & Quan 2019). Limited capacity to execute large scale project is one of the reasons behind these limitations.

The project also fails to estimate proper growth of population and immigrants. The expansion of city and the project planning fails to match the reality. Thus, the project faces design challenges in land acquisition and resettlement.

The local inhabitants were not comfortable to hand over their lands (Linh & Quan 2019). They were more interested in improving their own houses with community facilities and open public spaces with the help of funding and other financial support, but this approach is disregarded by the government. Government wanted to evict them and invest more in real estate development to attract the foreigners (Seo et al. 2021). Due to lack of public participation and co-operation, lack of communication with the local stakeholders, HCMC made several efforts, for instance, a new division on land compensation, resettlement compensation etc (Linh & Quan 2019). This reflects the gap between the approach of the local community and government regarding slum development. The ownership of land due to different income level, dividing the community mainly into two groups. To solve this issue both the housing rights for the slum dwellers and the comprehensive urban development is required (Seo et al. 2021).

6.7. Asia: Saigon informal resettlement housing in Vietnam

The informal settlement project is around 2.4 hectares and located in Ho Chi Minh City, Vietnam. This informal settlement area is surrounded by canals and highways (Ton Vu 2011). The urban planners and designers tried to redesign the informal area and also tried to benefit the economic lifestyle of the informal dwellers as well.

To benefit the informal dwellers economically mixed-used design proposal is formulated. Commercial and residential mixed-use design is proposed to boost up the economic condition of the informal dwellers (Figure 40). This design proposal three main activity zones –

1. Formally arranged street commercial facilities.
2. Informal markets beside laneways
3. Recreational facilities.

The proposed houses are designed in such a way that they are flexible and expandable due to high population density and economic affordability. Common open spaces are designed for common purposes. The main aim of the project is to enrich cultural values and benefit the lower-income people economically.

Figure 40: Resettlement of informal housing in Ho Chi Minh City, Vietnam (Ton Vu 2011).

7. Result: Findings, Guidelines and Masterplan Program-sketch

This chapter will represent the main findings of the study area, guidelines and the final designed masterplan program-sketch based. Based on the collected data, analysing and findings the guidelines are developed for the visionary masterplan program-sketch for the study area. The masterplan suggests a sustainable conceptually designed program-sketch by integrating green and blue structure considering the main three thematic aspects of this thesis paper i.e., urban ecology, solving the stormwater flooding issue during the rainy season & considering social & economic well-being for the informal dwellers to the overall living condition of Dhaka city.

Literate review, background analysis, role models with different parts of the world and different context worked as a base in formulating the guidelines and the final masterplan program-sketch. The analysis from the online survey questionnaire in Dhaka city helped to understand local people's and expert's opinions. This survey helped the local people to share their experience of the sufferings during stormwater flooding. Their suggestions and demands helped to reduce the effects of stormwater flooding and increase greenery motivations to formulate the result. The analysis from GIS helped to understand the existing condition and surrounding of the city. It later helped to formulate the SWOT analysis of the study area later in this section.

7.1. Main findings of the study area

Unplanned development, population increase are the main reasons for the loss of urban ecology and stormwater flooding are the two aspects of this thesis paper. From the background analysis, literature review and GIS analysis this thesis came to know that one of the main reasons for population increase is the migration of rural people every year in search of work and other better opportunities. They start living in the informal settlement area. The study area consists of around 59,516 inhabitants and almost 18,067 households (Hasan & Mollah 2017). In every area, the number is increasing. The diagram in Figure 41, shortly reflects the reason for the increased population in Dhaka city. That is why the third aspect of the aims and objectives derived to improving social and economic conditions living for the informal dwellers through the guidelines and designed masterplan proposal.

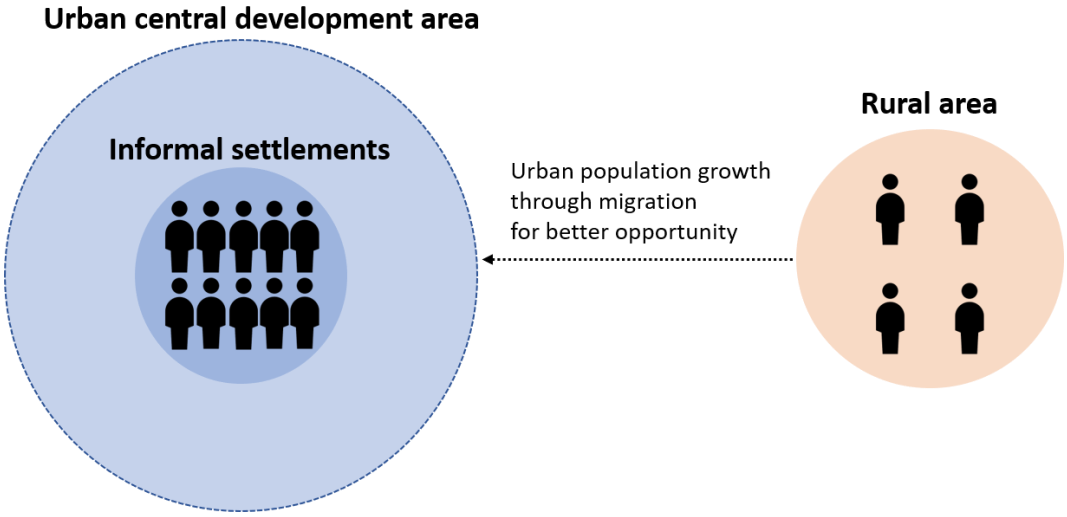
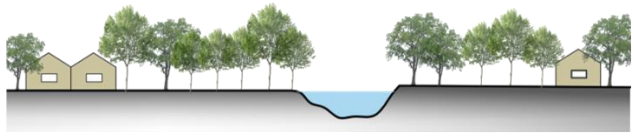
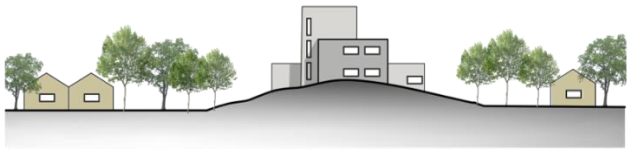


Figure 41: Diagram reflects the reason for the increased population in Dhaka city, the diagram is produced by the author.

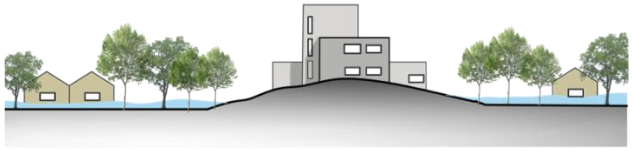
Through the analysis, this thesis came up with two different interpretations or theories for the loss of greenery and stormwater flooding in the study area. The basic theory the author came up with through analysis is that the study area is the central area in Dhaka city. The land of the study area is slightly levelled up from the surrounding land area. The first theory is the basic reason for this levelled up due to landfilling and levelled up of lands for urban construction causes flooding in lower parts due to lack of water catchment area (Figure 42).



Natural setting within waterbody, tree and greenery



Landfilling and levelled up of lands for urban constructions



Due to landfilling and levelled up of lands for urban construction causes flood in other lower parts due to lack of water catchment

Figure 42: Section showing unplanned urbanization and stormwater flooding, the sections are produced by the author.

The second theory is though some parts are levelled up, some parts are not that much levelled up due to landfill and unplanned development of the raise of the waterbody, water level rises during excessive rainfall (Figure 43).

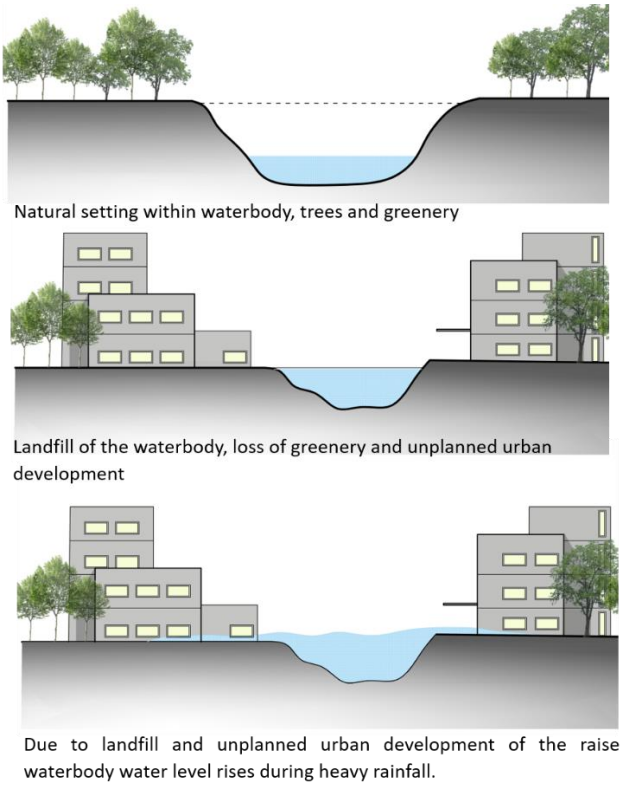


Figure 43: Section showing loss of greenery and waterbody one of the main causes of loss of urban ecology and stormwater flooding, the sections are produced by the author.

Both these two theories can be noticed within the selected study area. There is a scope for providing solutions to this problematic theory. The study area previously had a connected waterbody and a lot of greenery (Figure 3, Figure 4). The connectivity was lost due to population increase and unplanned development. From the GIS analysis and the background analysis, the trace of connectivity is still there and the scope to reconnect the greenery and water body is still possible (Figure 25, Figure 29 & Figure 30), which made the author select this study area. All the three basic aspects of the thesis aims & objectives and proposed research questions will be hopefully answered in this result section.

Another reason for selecting this area is the huge piece of land of the old airport in the Tejgaon area. This airport is no longer functional. Sometimes this area is used for training purposes by BAF. Various competition projects are arranged at various times by re-known organizations to utilize this huge space to make the area more functional with enough public accessibility. Thus, a huge piece of land can be utilised to increase greenery. Public access and activity will serve several purposes and also complement the aims and objectives of the thesis.

Figure 6 reflects the site surroundings of the study area. Due to the surrounding settlements of the informal dwellers, the opportunity arises to work for

resettlements and provide the scope for fulfilling all the three aspects of the thesis through proposing overall guidelines and the masterplan program-sketch.

7.2. SWOT analysis

The performed methodology in the thesis lead to a SWOT analysis. The physical environment of the study area is analysed considering strength, weakness, opportunity, and threat. This SWOT analysis was used to formulate the basic guidelines and to design a masterplan for the overall blue and green structure to achieve the aims and objectives of this thesis paper. These four categories of SWOT analysis of the study area are specified below in Table 6.

Table 6: SWOT analysis of the study area, the table is produced by the author.

Strength	Weakness
	➢ Narrow and unplanned roads in the informal settlement areas
➢ Existing street?network condition	➢ Unplanned informal settlements
➢ Existing surrounding condition specially waterbody and greenery	➢ Poor living environment
➢ Manpower (workforce)	➢ Lack of education level awareness within the informal dwellers
➢ Possibility for further development	➢ Settlements at the edge of the lake
➢ Utilize the big chunk of open land for peoples physical, psycological and social wellbeing	➢ No recreational facilities
➢ Existing community facilities	➢ Water pollution and lack of proper waste management
	➢ Stormwater flooding
	➢ Inadequate drainage capacity

Opportunities	Threats
➢ Possiblities to recreate waterbody connectivity	➢ Funding issues

➢ Possibility to provide solutions for manage stormwater	➢ Political issues
➢ Possibility to increase greenery within the city	➢ Corruptions
➢ Possibility to improve urban ecology and biodiversity	➢ Unplanned population increase
➢ Possibilities for biodiversity by providing habitat for species	➢ Lack of management and maintenance
➢ Possibilities for improving the living condition for the informal settlers	➢ Lack of knowledge and awareness
➢ Possibilities for improving the social and economic aspect	➢ Crime, illegal toll, unsafety
➢ Possibilities for introducing sustainable municipal technical infrastructure	
➢ Possibilities to slow down climate change	
➢ Possibilities for creating recreational facilities	

This SWOT analysis is formulated based on the literature reviews, online survey questionnaire and GIS analysis.

7.3. Guidelines

The guidelines are inspired by the Fredrick law Olmsted's concept and Patrick Geddes theory. Main findings and analysis from performing the methodology also act as a base in forming the guidelines. These guidelines in this section are based on the three thematic aspects on which the main aim and objectives of this thesis paper are based. One thematic aspect is for developing urban ecology and greenery, the second strategy thematic aspect is for stormwater management and the last thematic aspect is for formulated to achieve the social and economic benefit through proposing the overall green and blue structure. This overall green and blue structure will help to lead to a better quality of life and a better more civilized future.

The guidelines are explained with symbols that represents the three aspects of the masterplan program-sketch; urban ecology and greenery, stormwater management and social economic development.

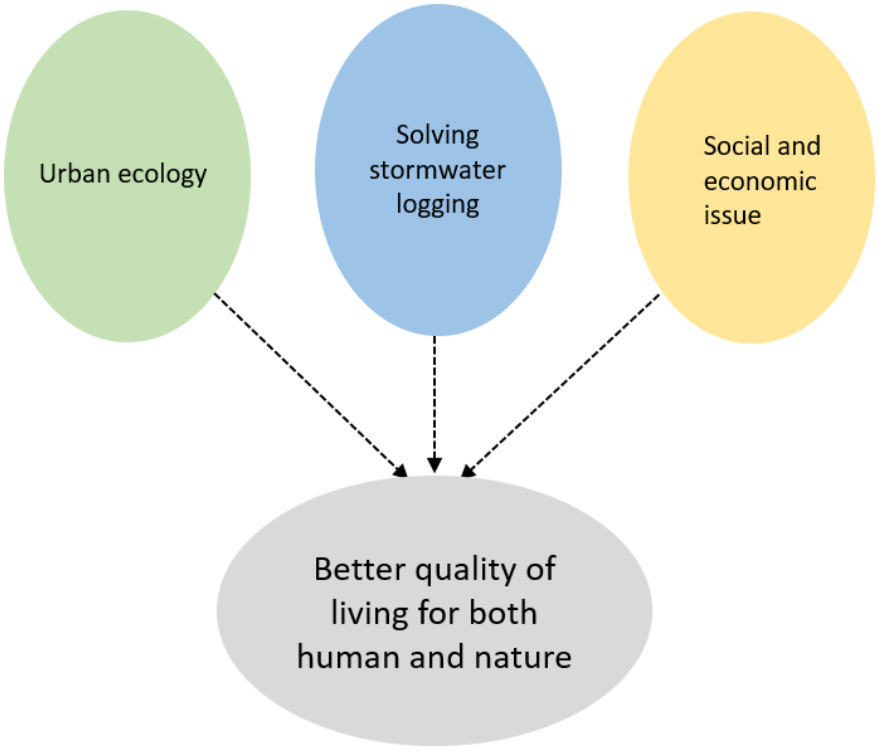


Figure 44: The diagram reflects the basic three thematic aspects of the aim and objective of this thesis paper; the diagram is produced by the author.

The diagram in Figure 44 reflects the basic three thematic aspects on this thesis paper have concentrated and the base of these guidelines are formed upon on the main findings. Here the green colour stands for urban ecology and greenery, the blue colour stands for stormwater flooding and the yellow colour stands for improving social and economic aspect.

7.3.1. Guidelines for improving urban ecology and greenery

As mentioned in the introduction section the capital city Dhaka was planned properly with greenery and parks during the Mughal period (Mukti 2006). But over a short time period, most of the greenery was lost, and the urban ecology is disrupted by many unfortunate reasons. Utilizing this huge land area in the old airport is considered as a centre point in Dhaka city to re-establish the greenery.

The guidelines reflect the seven 'S' concept by Fredrick Law Olmsted and Patrick Geddes theories. The diagram in Figure 47 show how the formulated guidelines expected to provide various positive aspects and fit into Olmsted's seven 'S' concepts.

To re-establish the greenery and improve urban ecology certain guidelines must be adopted (Figure 45) they are discussed in the following subsections below.

Figure 45: Guideline symbols for improving urban ecology and greenery. The illustration is produced by the author.

Protect the existing

Many greeneries have been lost from the city due to lack of knowledge and unplanned development. From the GIS analysis, the missing links of water bodies were identified. This thesis proposal is to re-establishing the lost connectivity of greenery and waterbody in the thesis project area. The existing waterbody in Banani lake and the open land of the old airport must be reconnected. This step can become the first step towards redeveloping the connectivity of nature in the whole city of Dhaka. Following this planning strategy further development and re-establish the connectivity in other parts can happen as well. This strategy will result in an improved urban ecology and increased urban greenery. During the online survey questionnaire, 90% of the experts they also suggested that protecting the existing water bodies and greenery can start solving the issue. This strategy is also inspired by one of the role models from London, Europe. Their strategies inspired this thesis to formulate protection for the existing green infrastructure.

Parks along the canal side

Abandoned land like the old airport combined with additional water bodies, canals and lakes can become the fundamental asset to create recreational parks and public areas including design for scenic beauty. Combined it will create an overall green and blue structure to benefit the ecology of the city. It will mitigate the rise in temperature and reduce the urban heat island effect. From the literature review chapter, this thesis paper tried to address the possible benefits that can be achieved through the greenery. An interconnected network of green and blue structures along with the parks and water body will provide the opportunity to establish an eco-friendly environment. This green and blue structural network will promote wildlife and function as an ecological corridor. This will add recreational value for people's wellbeing.

Increase greenery on roads and pedestrian paths

Due lack of open space in Dhaka city roads and pedestrian paths can be utilized and designed for more greenery. From the media interview Rabiul Islam who is a young architect, landscape designer and environmentalist suggested that

planting trees are important for the pedestrian walkers to provide shades. Trees with high tolerance level and water absorbed plants should be selected for lower maintenance and control over stormwater flooding on streets. He also suggested that evergreen plants should be introduced to provide shelter for other species (Datta & Ahmen 2018). During the online survey questionnaire, 70% of the experts also suggested street trees. Trees with high tolerance level, water absorbing plants and evergreen plants lists are attached in the Appendix A, Table A1 section. Role models from Stockholm and Växjö from Sweden also inspired how roads and pedestrian paths can be designed to achieve more greenery that holds and clean stormwater.

Roof garden

The community has a demand and a desire to establish better connectectivity for nature. But unfortunately, the city only has less than 14.5% (Byomkesh et al. 2012) of greenery according to a study of 2012. Lack of space made it very difficult to create open lands for parks and other plantations. During the online survey questionnaire all the experts also suggested green roofs. In an informal interview with Mustaque Quadry, he did suggest that green roofs can be an alternative solution for increasing greenery. But in that case, proper tree selection is one major thing that should be considered as we have seasonal storm from April to May which is called "Kalboishikhi jhor" might cause hazards. From the online survey questionnaire, all the experts also agreed that introducing roof gardens can be one of the solutions to increase greenery in the city.

Introduce vertical gardening and climbers

Vertical gardening, climbers can be the strategy to increase greenery in the city. It will benefit urban ecology. During the online survey questionnaire 50% of the experts also suggested vertical gardening and climbers. In the zoom interview, Mustaque Quadry suggested that new ways of guidelines and designs should be introduced such as vertical gardening and climbers due to lack of space for planting trees. According to him, vertical climbers can be used as a fence and on bridges and flyovers. Rabiul Islam suggested from his own working experience that instead of plants with growing branches vertical growing plants should be used to avoid obstacles and for lower maintenance (Datta & Ahmen 2018).

Utilize negative spaces

Due to the rapid growth of urbanization and lack of holistic planning many unused impediments or negative spaces are created. These negative spaces can be utilized through plantation not only to improve ecology or greenery but also to add aesthetic value. During the online survey questionnaire, 70% of the experts agreed on utilizing negative spaces. In the zoom interview Mustaque Quadry suggested that the first thing is to do is to allocate a defined space for trees only. The negative spaces can be utilized for plantation. Utilizing trees for plastic or other decorations should though be forbidden since it has no function to serve for improving urban ecology.

Introduce aquatic plants

Aquatic plants are not often found in big cities like Dhaka. Aquatic plants can be beneficial to develop urban ecology. During the online survey questionnaire, 80% of the experts also suggested aquatic plants for better urban ecology. Mustaque Quadry also suggested that aquatic plants in the water bodies could improve the ecological balance within the city.

Proper tree selection

The literature review showed the importance to identify appropriate tree selections and the importance for aesthetics. In Dhaka city, the space provided for tree plantation is not enough. Right trees are not placed in the right place. This topic was discussed in the literature chapter. Mustaque Quadry shared his work experience and supported the important of tree selection for biological function and aesthetic appearance. The tree inventory was done during the literature review and is attached in the Appendix A section under Table A1. The guidelines can be of great support to choose to improve greenery with native plants and also exotic plants that benefit urban ecology.

Parks for delaying and infiltration

The green infrastructural network can be designed for delaying and infiltration of stormwater. The integratation of green structure and treeplantation with stormwater planning is a very important systemic approach to manage urban areas. It will contribute to physiological, social, and economic wellbeing. The literature review, clearly shows that greeneries improve the environmental quality and aesthetics in urban environments.

Raise awareness

The creation of environmental awareness among the common people is necessary and encourages them to take part in taking care of the environment. In the online survey questionnaire, almost 20% of local inhabitants and 30% of experts agreed the lack of knowledge is one of the reasons for ecological disbalance. Environmental protection can be achieved by taking necessary measures to make people aware of the consequences of environmental degradation. Awareness can be raised using symbolic language complemented with texts through advertisements, newspaper articles, campaigns, drama etc. seminars and workshops can also be arranged to raise awareness.

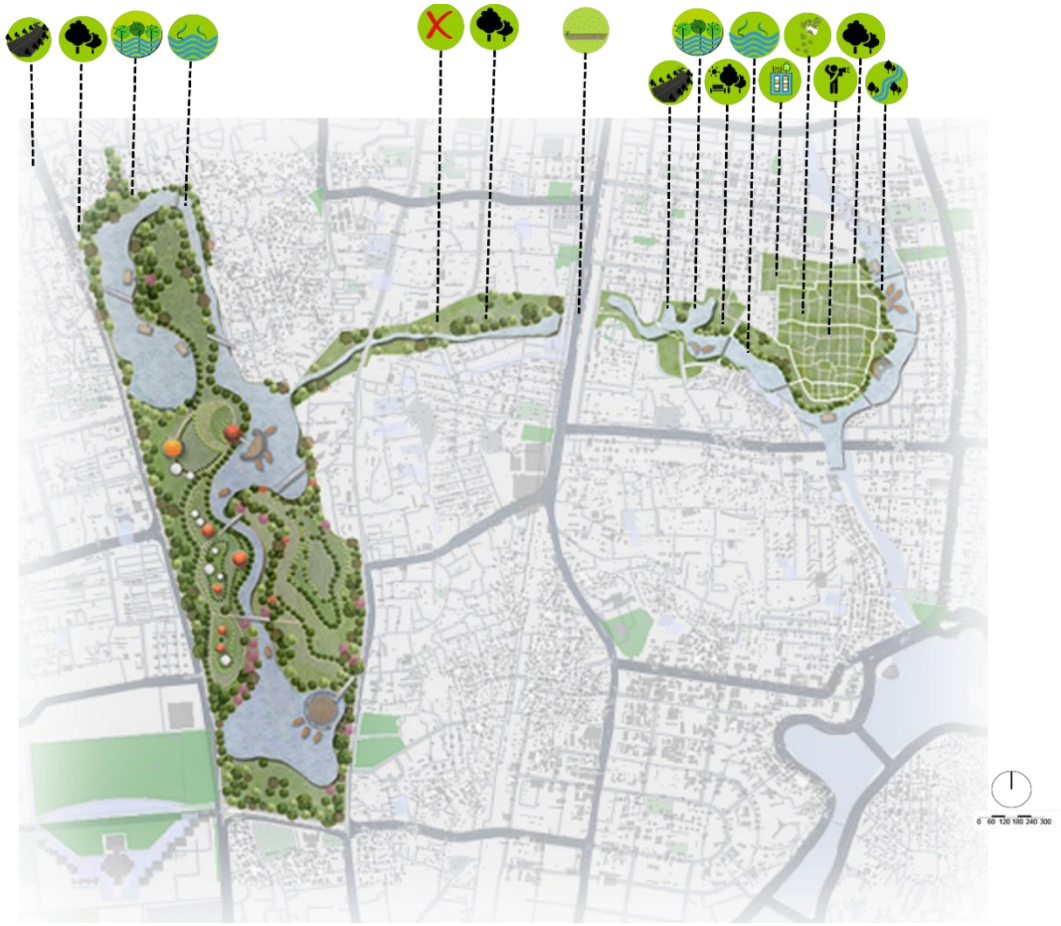


Figure 46: Overall guidelines for improving urban ecology and greenery, the legend of this map is described in Figure 45. The illustration is produced by the author.

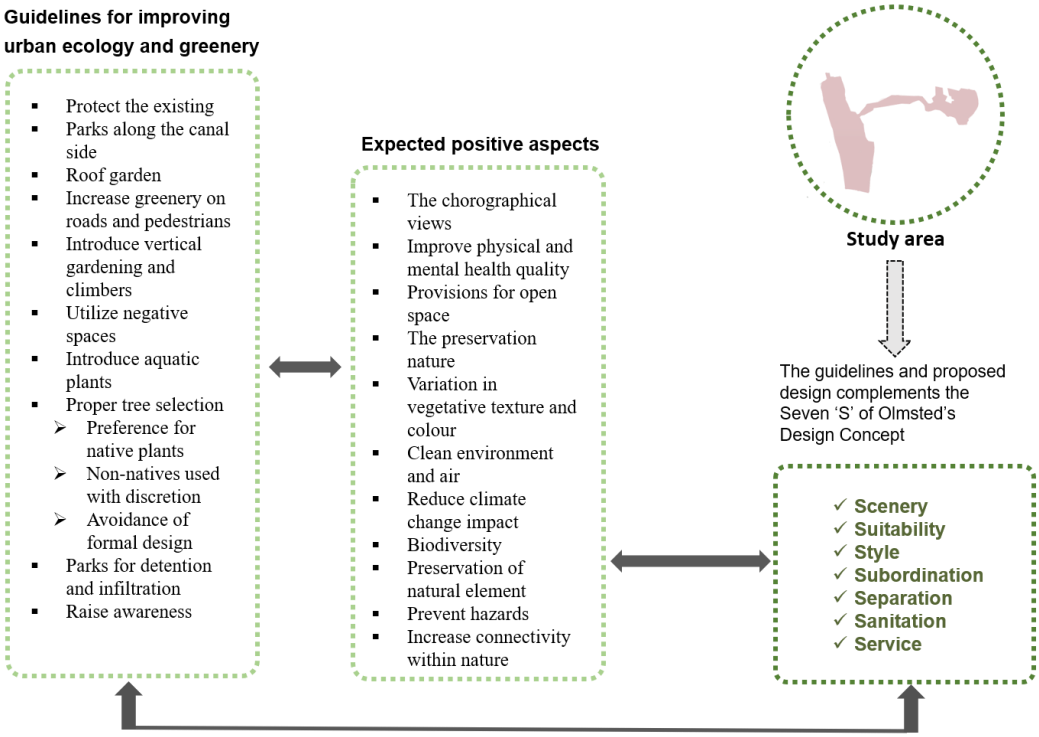


Figure 47: The positive impacts through guidelines and how it complements the Fredrick Law Olmsted's the seven 'S' concept, the diagram is produced by the author.

7.3.2. Guidelines for stormwater management

A proper flood control plan is required as Dhaka city is frequently affected by flooding. Such detailed plans are missing in DAP (Detail Area Planning) provided by RAJUK as was mentioned in the method section. To plan flood control detailed plans is required to reduce the sufferings for local inhabitants the thesis paper came to know through online survey questionnaire. To manage stormwater this thesis paper tried to formulate certain guidelines (Figure 48) to develop a blue network so that it helps to provide a proper drainage system, clean surface water to reuse water. These guidelines are discussed in the following subsections.

Figure 48: Guideline symbols for stormwater management, the illustration is produced by the author.

Network for stormwater collection

The green and blue infrastructure will serve the main drainage system of the city. In some parts rainfall will be directly collected in the lakes and canals and the rest will be collected in a separate sewerage systems and then released to the canals.

Iqbal Habib is an architect and joint secretary of BAPA, in a media interview, he mentioned the canals are very important to hold the stormwater as well as to develop a loop network system for waterways. He also suggested construction of vertical structural elements as foundations rather than slopes beside the canals to increase water catchment and also provide designed walkways to protect from stormwater flooding (Alam 2016).

Storage for stormwater

Sometimes excessive rainfall overlaps with the water level of different water bodies. At this point, the drainage system is not capable of discharging the stormwater properly, that is why the detention area can be constructed to hold the excess amount of stormwater. The stormwater can be stored in the detention areas until the water level comes to a normal level. Thus, the water catchment area can be raised in designated areas which are at the risk of flooding. Stormwater channels also are introduced to create paths to flow the excess stormwater. Many of the answers from local inhabitants to open-ended survey questions suggested stormwater channels to flow the excess stormwater.

In some cases local residents can use a rainwater harvesting system, so that they can hold the excess rainwater and can use it when it is required during the dry seasons.

Permeable surfaces can transmit the excess rainwater to the ground. Rain garden and rain-beds can be introducing to manage the excess stormwater (Figure 49).

Role models from Stockholm and Växjö from Sweden inspired by design solutions for greenery in roads, streets and pedestrian pathways to treat stormwater. The online survey questionnaire with the experts in Bangladesh though disagreed to use rain gardens or rain-beds as a solution for stormwater management. Almost 40% agreed and 60% disagreed to rain gardens. The basic reason for disagreement is due to lack of space, costly construction for infrastructure and costs for maintenance.

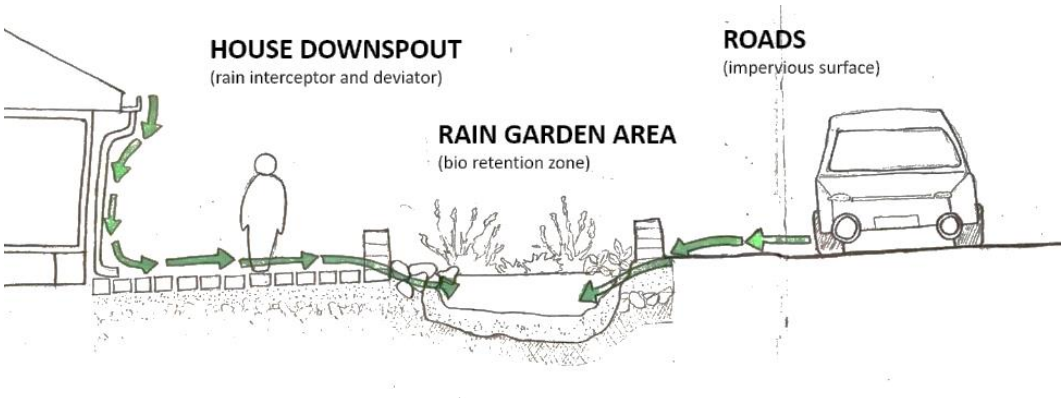


Figure 49: The rain garden functionality to store stormwater, the sketch is produced by the author.

Recover the existing water bodies and discourage landfilling

The existing water bodies are the main actors to maintain the drainage system of a city. so, the main aim should be to protect the existing water bodies to maintain stormwater flooding. From the literature review, nowadays the water bodies are in very poor condition due to unplanned development. That is why these water bodies are neglected and they become dumping places for the waste material. Land grabbers and informal settlements are growing very fast beside the water bodies. From the GIS analysis the increased water level was identified during flooding. According to the experts 70% and 40% of local inhabitants agreed that landfilling is the main reason behind the flooding. The increase in land price will encourage the land grabber to fill up the canals. Protection of water bodies will help to maintain an effective drainage system and benefit the citizens to lead a safer and healthier life.

Reopen the old canals

The GIS analysis showed that many canals and lakes are lost from the city. They have been transformed into culverts and underground water lines. By reopening these old canals and lakes will help to reconnect the water lines to reduce stormwater flooding. This strategy is inspired by the role model of Oslo. These waterways provide new opportunities for flood control measures, recreational facilities, ecosystem services, better providings for wildlife habitats, biodiverstity etc.

Create detention and infiltration areas

The detention or catchment areas are usually dry and can be flooded when needed. They can store water until it is necessary and then get back to their dry state by letting the water go. These detention areas ensure the natural drainage system of the city and help to reduce the effect of stormwater flooding. The old airport can be utilized for several detention areas.

When the detention areas are dry the infiltration areas can be flooded when needed. But detention and infiltration areas are not the same as the infiltration is not directly connected to the drainage system. The stored water cannot be transmitted to the drainage pipes as they are infiltrated into the ground. It helps to protect the groundwater level (Alam 2016).

Redesign and Maintenance

From studying different documents during performing research methodology the municipality authority DWASA must build a proper drainage network which is currently missing. Documents such as the DAP plan produced by RAJUK also lack a proper drainage network. The existing infrastructure should be enlarged to reach the capacity to facilitate the public need. During the online survey questionnaire, all the experts and almost 25% of local inhabitants agreed that the city needs a proper drainage system

A treatment plant should be constructed to treat the surface stormwater. It is necessary to plan, implement and check the process constantly. One of the main obstacles is waste management. A significant portion of waste remain on the streets and creates obstacles towards the inlets to flow stormwater smoothly (Imdadul Islam, 2020). The inlet should be cleaned properly. During the online

survey questionnaire, almost 50% of experts and almost 47% of local inhabitants agreed the mismanagements of waste materials are the reason for stormwater management. Role models from North America the Big U project and the project from Vietnam, Asia became the inspiration to formulate this strategy.

The Figure 50 below showing the overall guideline symbols for stormwater management.

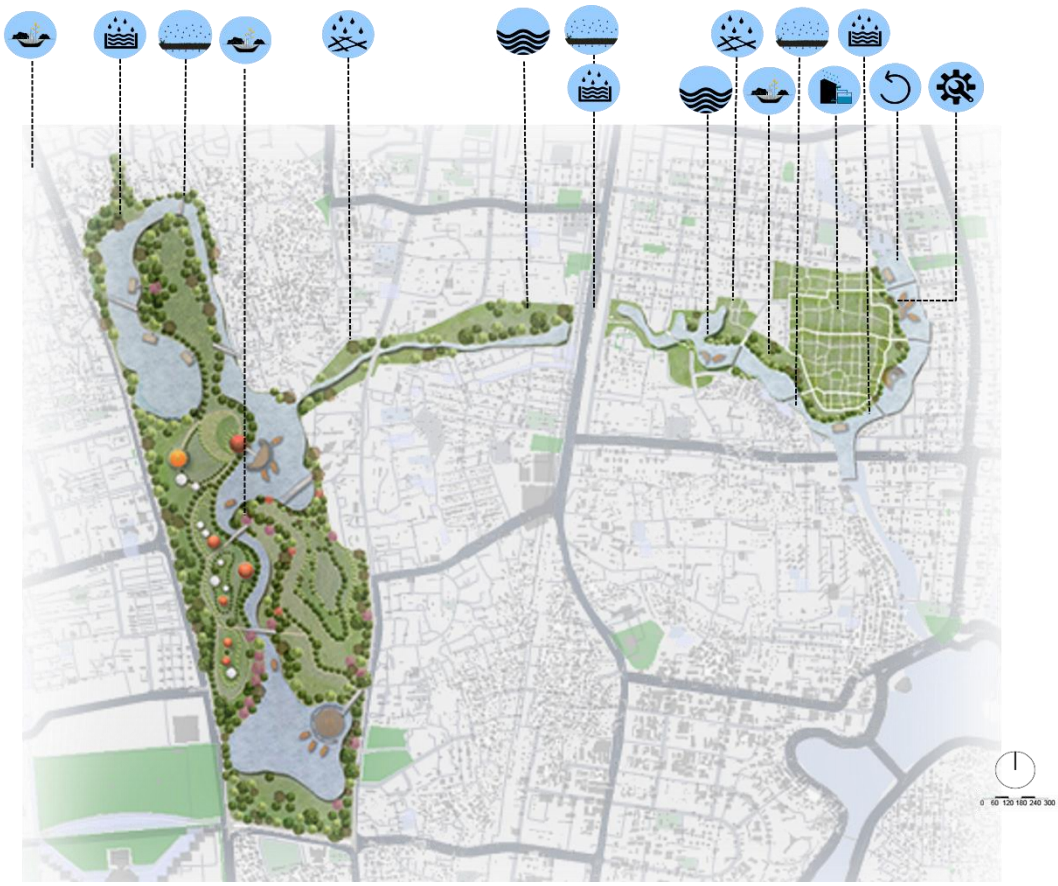


Figure 50: Overall guidelines for stormwater management, the legend with symbols of this map is described in the figure 49. The illustration is produced by the author.

The guidelines are formulated based on the methodology of this thesis. These guidelines also fits into the seven 'S' concept by Fredrick Law Olmsted. The diagram in Figure 51, reflects how the formulated guidelines expected to provide various positive aspects and achieve Olmsted's seven 'S' concept.

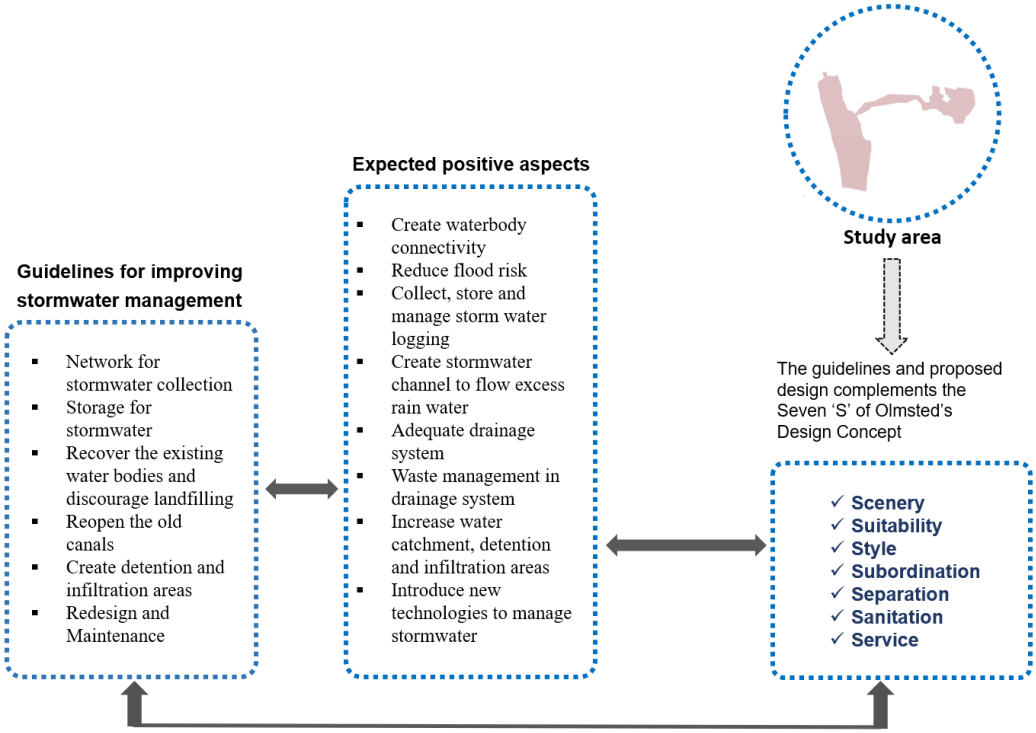


Figure 51: Guidelines for improving stormwater flooding and how the positives impacts can be achieved and complement The Fredrick Law Olmsted's the seven 'S' concept the diagram is produced by the author.

7.3.3. Social and economic guidelines

The fundamental principal of town planning by Patrick Geddes is based on "place, work and people" (Talukder 2015). This concept inspired me to consider the socio-economic condition of the study as a thematic aspect in my thesis. These guidelines (Figure 52) based on this thematic aspect are addressed in the figure and discussed widely in the following subsections below.

Figure 52: Social and economic guideline symbols, the illustration is produced by the author.

The Figure 53 below showing the social and economic guidelines.

Figure 53: Overall social and economic guidelines, the legend of this map is described in figure 52. The illustration is produced by the author.

The guidelines are formulated based on the methodology in this thesis. These guidelines also fit in the seven ‘S’ concept by Fredrick Law Olmsted. The diagram in Figure 54, reflects how the formulated guidelines expected to provide various positive aspects and achieve Olmsted’s seven ‘S’ concept.

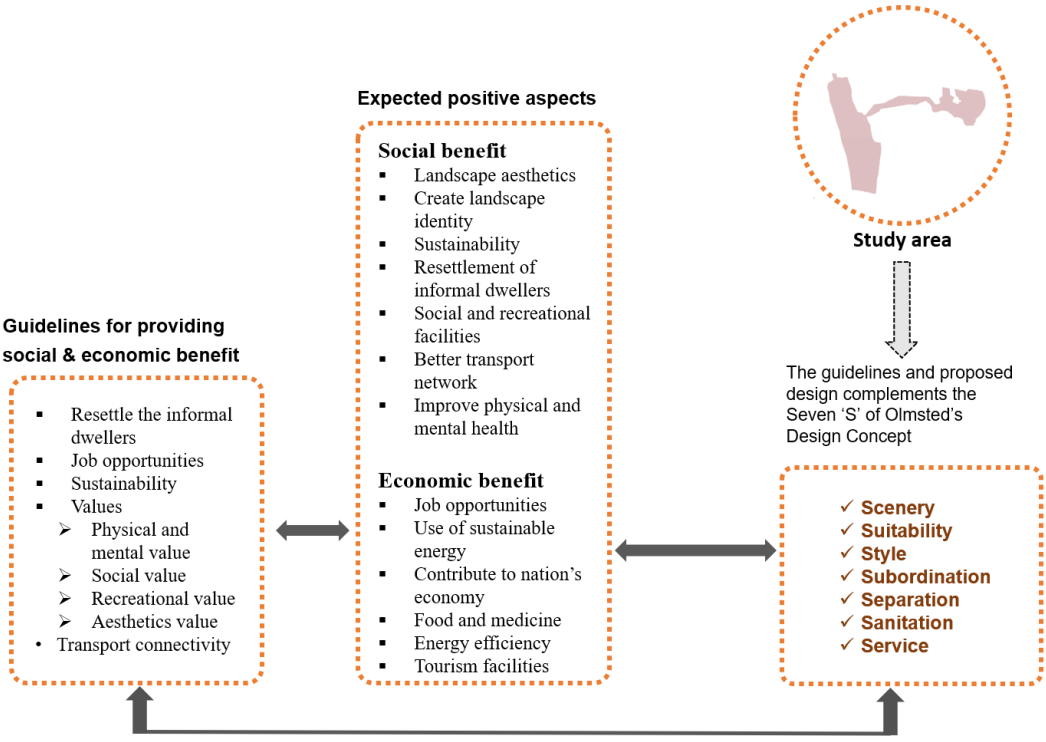


Figure 54: Guidelines for providing social and economic benefits and how the positives impacts can be achieved and complement The Fredrick Law Olmsted's the seven 'S' concept, the diagram is produced by the author.

Social benefit: Resettlements for the informal dwellers

One of the major guidelines to benefit the society is to provide proper resettlement for the informal dwellers. Utilizing the existing infrastructure properly for roads and drainage network according to Patrick Geddes contribute to keep place identity. The basic rules are strategized to design the house for them such as:

- Utilizing the existing infrastructure properly for roads and drainage networks.
- Multi-storied well-structured houses to accommodate the future migrated rural people as the number of informal dwellers are increasing day by day.
- Mixed-use housings can be provided as from the GIS analysis we know that there are many commercial buildings, rickshaw garages, pharmacies and other retail and grocery shops. These can be accommodated on the ground floor in certain parts.
- All the houses should have natural ventilation.
- Courtyards can also help with natural air and light flow. It will also help to add greenery as well.
- Maximum houses should have a view towards the lake. Staggered houses will help to let each house a lake view. Green roofs and climbers should be used not only for aesthetics but also for adding ecological values.

The Figure 55 below shortly show the guideline symbols for benefiting the informal dwellers regarding the social aspects.

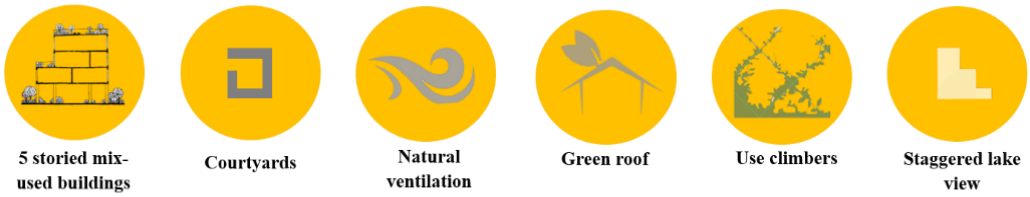


Figure 55: Guideline symbols for benefiting the informal dwellers respecting the social aspect, the illustration is produced by the author.

Economic benefit: Job opportunities

One of the major guidelines to benefit economically is to ensure jobs for the poor informal dwellers. Town planning principal by Patrick Geddes is based on "place, work and people" (Talukder 2015). The transition within place and people is a continuous process. Climate and geographical settings influence a lot in shaping an individual lifestyle. On the other hand, individual's act at the same time is also shape the place through economic process.

From the background analysis as we know that many rural people migrate to urban areas for jobs and better opportunities. Besides household caretakers or rickshaw pulling they can work in a properly designed food or tea stalls and can also provide job scopes for them. Proposing mixed-use buildings in Karail slum area will make it possible for dwellers to have their own or rented grocery stores to earn their livelihood (Sohail 2007).

The existing waterbody or lakes can provide them to the scope of work fishing or aquaculture. By cultivating fishes and selling them in marketplaces will help them to improve their economic status.

The city of Dhaka is full of life. The city celebrates seasonal fairs and cultural fairs throughout the seasons such as Baishakhi fair (Bangla new year fair), falgun festivals (Spring fair), pitha utshob (cake festival), botany fair etc. These seasonal festivals can be arranged throughout the year in the Tejgaon old airport area to make that space functional with public accessibility. The Figure 56 below shortly reflects the guidelines to achieve economic benefit.

Figure 56: Guidelines to achieve the economic benefit, the illustration is produced by the author.

Sustainability

Guidelines for various sustainability measures are proposed such as waste management, recycling of waste materials, reuse water and cleaning the surface water etc. The Figure 57 below shortly reflects the sustainable guidelines.

Figure 57: Sustainable guidelines, the illustration is produced by the author.

Waste should be collected and moved to the waste stations which should be located nearby the neighborhood. While online survey questionnaire with the local inhabitants, many of them suggested having enough dustbins because trash and plastics often choke the drains. Managing waste materials in this way will benefit the environment by reducing air pollution, water pollution, reduce bad odors, waste spillovers etc. Separating is needed for type-wise trashes from the bins and then collecting them to the central waste stations. These waste stations should serve the existing size of the population and have access to transport of the waste.

Biogas-plants and recycled plants can also be introduced. Trashes can be categorized and collected in separate bins so that they can be recycled and reused. Organic trashes can be separately collected in biogas-plants to produce energy for gas and electricity.

For healthy living safe water must be ensured to keep the citizens free from water contaminated diseases. The literature review showed that informal dwellers are deprived of basic rights of clean water. Due to lack of pure water supply, many informal dwellers must use polluted water from the Banani lake. It is necessary to preserve and purify the water collected from different sources and supply clean water. The existing water bodies such as lakes, canals, rivers in Dhaka city should be preserved. Proper water management and purification should be ensured before supply of drinking water.

Specific values

The base for adding some specific values derived from the literature review (Figure 58). Green and blue infrastructure along the Banani lake and the redesigned old airport converted into a huge park. This would be of great recreational value and promote people's mental and physical health. Parks encourage people to physical activities. The park areas would also become important meeting places for people's social gathering and add aesthetics as well as ecological values to the city.

Figure 58: Guideline symbols for adding specific values, the illustration is produced by the author.

Easy accessibility

Ensuring easy accessibility and efficient traffic systems is essential for serving administrative, commercial, and financial purposes for the city. All the citizens should have equal access so that everyone enjoys maximum benefits from city life. The literature review was the main base for formulating the guidelines (Figure 59). The proposal is to keep the existing road network rather than completely altering the street structure according to Patrick Geddes theories. The roads are proposed to be widen enough for easy vehicular accessibility specially during fire hazards (Ahmed & Johnson 2014) . These existing road networks are developed by the users' stage by stage according to their need. It also helps to hold the memory and character of this area. According to Patrick Geddes the importance of nurturing the reflection of past one of the essential elements of human evolution. This perspective identifies a social process, and forms of belonging, practices, experiences (Garau et al. 2016).

Measures such as encouraging people to use bicycles or walk on foot are pedestrian and cycle paths along the parks. Thus, environmental pollution can be reduced. Additionally, these habits will let people exercise daily. This will also help to reduce traffic congestion on roads. Walking and cycling is more suitable for short-distance travel and helps to save a lot of time. Proper traffic laws, lanes and speed limits should be imposed and maintained strictly to decrease disturbance from traffic.

Water taxi can be introduced as a new culture for transportation. Water taxis would have separate paths and lanes without any conflicts with other road vehicles. It will be cheap to travel and less time-consuming. It will also provide a possibility for poor people to find job opportunities.

Designing new bridges over the Banani lake and overpasses for pedestrian walkers will provide easy accessibility. Local inhabitants from the nearby neighbourhood can easily travel. All the parks should have an easy transport system and accessibility along the lake. Water taxis should have proper designed places to stop. Open accessibility will encourage more pedestrians and cyclists.

Proper designed crossings will need to be provided for the pedestrians and cyclists. The parks should be designed as close to the residential areas as possible to encourage people to benefit from their nearest greenery.

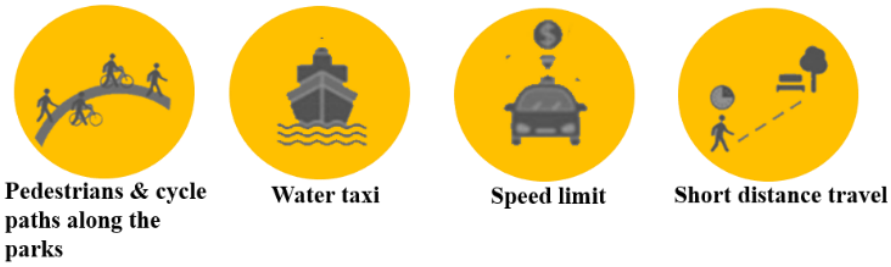


Figure 59: Guidelines for easy accessibility, the illustration is produced by the author.

7.4. Final designed masterplan program-sketch

The following illustration in Figure 61, reflects the overall visionary masterplan by integrating the green and blue structure respecting the three thematic aspects of this thesis. Re-establishing the connectivity with greenery and waterbody to improving greenery and ecology. Proposal for planting more native plants, green roofs, aquatic plants, climbers will add increased greenery and seasonal colour and textures. Opening underground drainage system to of a surface stormwater channel that increase water catchment and water detention areas to manage stormwater flooding. Informal settlements with rainwater harvesting, rain garden and streets with rain beds to manage both urban ecology and stormwater flooding in the study area. The resettlements of the Karail study area is done to serve the social and economic benefit, by keeping its own character of built blocks and street structure.

Fredrick Law Olmsted's design concept the seven 'S' concept of Olmsted (Figure 60 have inspired the proposal in Figure 60.

Scenery - Frederick Law Olmsted always tried to avoid hard-edges and formally designed planting and used instead curved forms. The proposal of this thesis uses curved lines in the landscape design especially in waterbody design. Curved pathways within the parks and no obstacles or boundaries in order to give the viewer a sense of openness and connectivity with nature and greenery (Figure 79). The houses for informal resettlements are mostly rectangular but the author tried staggered house types and courtyards so that each house has views and at least have their garden and greenery. The author also tried to ensure the lake view beside lakeside housing (Figure 68).

Suitability – Each environment has it's own identity and character. Frederick Law Olmsted always utilised both advantages and disadvantages in the landscape to create favourable results. This thesis tried keep the existing qualities in the character of the study area. For example is the existing road network is kept as it is. Changes are added to maintain the naturalness and character of the site to benefit ecology and promote sustainability. The traces of water flow and raise of water level during heavy rainfall are identified and recreated to enrich the water connectivity and manage stormwater.

Style - Frederick Law Olmsted used to have two specific styles mainly "Pastoral style" and "Picturesque style". This thesis use both styles to some extent. The "Pastoral style" helps to create a sense of regained spirit through scattered trees, open green spaces, and water bodies. The "Picturesque style" is also used to create a mysterious environment by effect of light and shadow (Figure 80). This effect can be created through the designed structures (Figure 69) and the interplay of light and shadow under the trees.

Subordination - According to Frederick Law Olmsted, any barrier or disturbance in achieving the desired goal should be eliminated or subordinated (Nicholson 2004). The author tried to design the landscape as a unified composition. The old airport is today considered as an obstacle and a barrier which the thesis proposal change by design that achieve goals for the three thematic aspects of this thesis.

Separation - Olmsted tried to separate spaces according to their uses. The thesis proposal develop zone-wise and phase-wise development so that user can fully enjoy the landscape and possible conflicts can be avoided (Figure 65), (Figure 72) (Figure 77).

Sanitation - One of the important aspects that Olmsted focused on the impact on health and sanitation due to landscape. Water, sanitation, and hygiene is the basic requirement to lead a healthy life. The author tried to provide these basic rights to the informal dwellers. WAB also works as a partner with DWASA and DCC in Dhaka city, Bangladesh to provide pure water supply, tube wells, sanitary latrines and improved drainage system to improve the hygiene within the informal settlement areas (Ahmed 2014). Olmsted's other consideration was providing a proper adequate drainage system and other engineering considerations to promote the physical and mental well-being of the people (Nicholson 2004). Engineering considerations such as calculations of water catchment areas, underground drainage in phase two development, design of rain beds in phase three development etc. are proposed to be further discussed in the phase-wise development.

Service – Olmsted always paid attention to utility services to ensure social and psychological needs. Urban green spaces play an important role in improving the quality of living of urban dwellers. This thesis proposal enrich the study area with greenery to provide basic infrastructure for a better quality of living. Better connectivity, sustainable way of energy use, a proper drainage important for the thesis proposal. Utility services with greenery provide the dwellers with recreative escaping place from their busy and dull regular life. Greenery reduces a certain degree of stress, depression and improves our mental health. A sense of peace and calmness also increases productivity and enriches the mind with creativity. It also encourages people to go outside for exercise. Open spaces and greenery provide more possibilities to communicate and interact. Thus, urban greenery also encourages social gathering, interaction and improved neighbourhood well-being. Parks, amphitheatre, boating and fishing deck to perform cultural art and festivals encourages community gathering and social interaction.

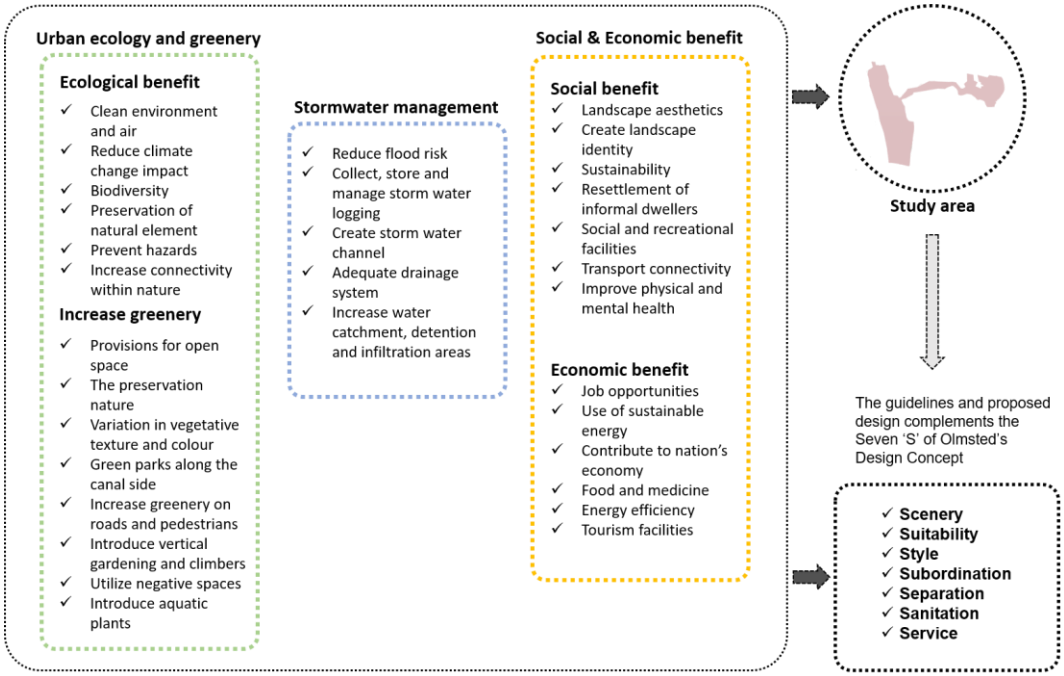


Figure 60: The three thematic aspects of the thesis and how they provide benefit to the study area & complement the Fredrick Law Olmsted's seven 'S' concept.

This proposed designed overall green and blue infrastructure network is based on the formulated research methodology. All three thematic aspects of this thesis paper are tried to justify the seven 'S' concept by Fredrick Law Olmsted. The diagram in Figure 60, reflects how all the three thematic aspects respect Olmsted's seven 'S' concept.

Figure 61: Overall integrated thematic masterplan program-sketch. The illustration summarize the integration of green and blue infra structure, stormwater treatment and social improvements. Illustration produced by the author.

7.5. Phase wise development

The overall masterplan program-sketch suggests to be implemented in three phases. Each of these phases is discussed in the following subsections.

7.5.1. Phase 01

The first phase (Figure 62) will mainly concentrate on the resettlement of the informal dwellers, recreate the existing water connectivity to manage stormwater flooding and design parks and patches of green spaces to improve greenery and urban ecology (Figure 68).

The dwellers of the 'Karail slum' area should be evacuated and provide temporary shelter in the 'Old airport' area during the construction period. The development of resettling the informal dwellers is a long-term process. The stages of slum/ informal development are discussed in depth with references (Sori 2012) in the literature review section. This temporary shifting can be stated as a stage of pre-settlement. Then the three stages of developing informal settlement i.e. the beginning or establishment, the expansion and occupancy and lastly, the absorption, stated in the literature review chapter, gradually begins.

This phase will concentrate mainly on the road networks and the housings for the informal dwellers. The Figure 62 below is pointing at the phase one portion of development within the overall design masterplan program-sketch of green and blue structure.

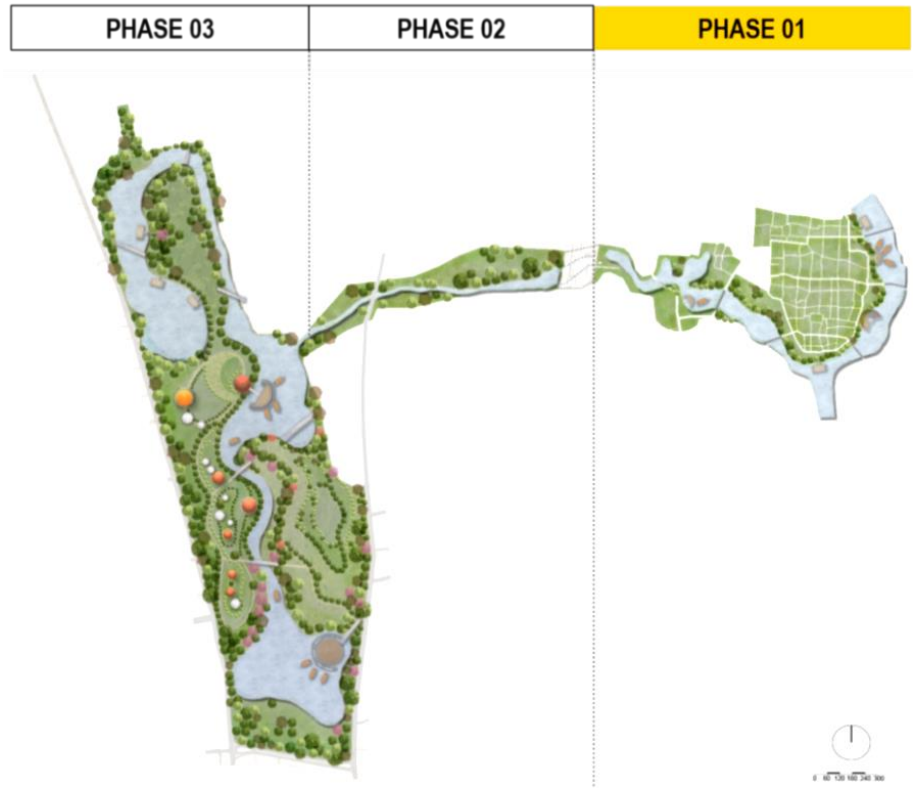


Figure 62: Overall masterplan program-sketch for green and blue structure with subdivision of the three phases and the yellow bar indicates the phase one development section, the illustration is produced by the author.

Phase one of the proposal contain a developed a concept of the flow of greenery from personal garden to neighbourhood garden to public parks. This concept was inspired by one of the role models i.e London Green Grid Framework. Figure 63 below illustrates the concept of the flow of greenery with a three- dimensional visualization.

Figure 63: The concept of the flow of greenery with a three- dimensional visualization inspired from London Green Grid Framewor. The illustration is produced by the author.

The road network will be redeveloped during implementation phase one. The general road network of the city follows a grid pattern of the road network, but this thesis proposal will keep and develop the existing road network structure. As these road networks are developed by the users' stage by stage according to their need. Usually, these kinds of gradually developed infrastructures are quite long-lasting. It will also help to hold the memory and character of this area, in which the local dwellers recognise the area immediately which makes it easier to develop social sustainability. This concept derived from the concept from Patrick Geddes (Geddes 1915). Quote:

"We have to realise and keep in view the spirit and individuality of our city, its personality and character, and to enhance and express this, if we would not further efface or repress it."

Figure 64: The proposed road network for the informal settlement area keeps existing structure. The illustration is produced by the author.

The blue line in the image in Figure 64 reflects the proposed road width of 5 meters, the orange line reflects the 3 meters of proposed road width, and the red line reflects 8 meters of proposed road width for easy vehicular accessibility. The 3 meters roads will be built with gravels or other permeable materials so that they can transmit the excess water to the ground easily. Vehicular accessibility is very important during fire hazard situations. From the literature review, this thesis came to know that during fire hazards it becomes, difficult to access at the incident location due to the narrow width of roads. The three meters road will be usually used by the rickshaws and CNGs as in this part the local dwellers do not own personal cars. In the time of emergency, other motor vehicles are rarely allowed. To transport from one place to another the motor vehicles will use 5- and 8-meter roads.

Phase one of this site area is divided into seven zones they are residential housing zone, mixed-use housing zone for the local informal dwellers, religious zone such as mosque, educational zones such as school, biogas-plant or recycle zone for sustainability, green zone such as public parks and blue zone providing recreational facilities such as amphitheatre for performance art and festivals, fishing and swimming decks, water taxi for transport and recreational purpose. The Figure 65, below showing the zoning of the phase one site area and a three-dimensional view of types of housings.

Figure 65: Proposed zoning map with section lines and housing types for the informal settlements, the illustration is produced by the author.

The Figure 66 below shows the three types of proposed housings with height restrictions. The first type is staggered houses with lake views with a maximum height of three-storied. The second type is proposed with courtyards and the third

type is proposed mixed-use housings with courtyards. During interviews with locals and experts suggested courtyards, green roofs and climbers should be introduced in new design proposals. These housings will also have a rainwater harvesting system and rain gardens to manage the stormwater and and hold the excess amount of water during excessive rainfall (Figure 49).

Figure 66: Different house types with height restrictions with applying the provided guidelines, the illustration is produced by the author.

The Figure 67 below shows the section for proposed commercial or mixed-use housing. The GIS analysis and the role models from Vietnam inspired and act as a base to propose mixed-use housings.

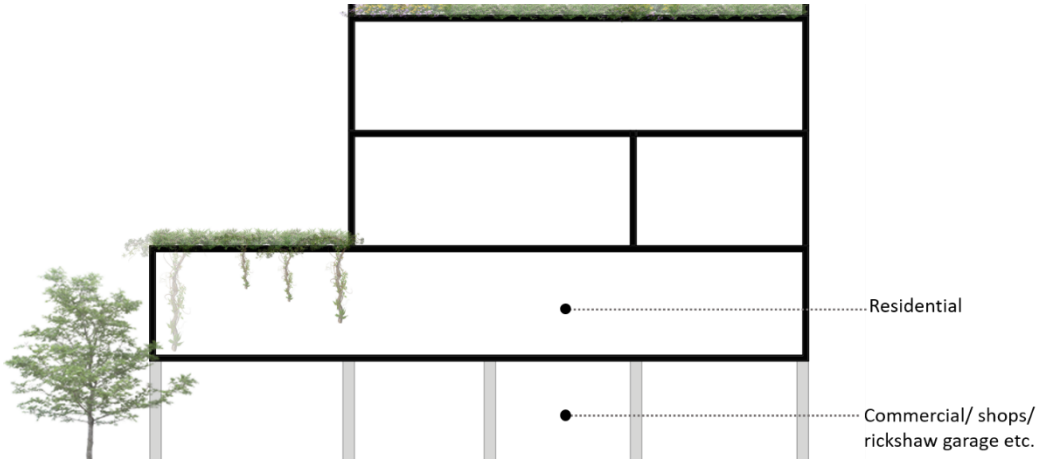


Figure 67: Conceptual sketches for mixed-used buildings for the informal dwellers, the illustration is produced by the author.

These mixed-use housing will facilitate grocery shops, pharmacies, rickshaw garages etc. these will help the local informal inhabitants to offer job opportunities. Other job opportunities such as cultivating vegetables in their gardens and roof gardens. These produce fruits and vegetables they can sell and earn their livelihood. Teas or small food stalls beside the park areas, water taxis, fishing and aquaculture will also facilitate the local informal inhabitant's job opportunities.

Figure 68: Redesigned informal settlement area and the proposed green and blue infrastructure beside Banani lake, the 3D visualization is produced by the author.

The 3D illustration in Figure 68 reflecting the overall masterplan for the informal settlement area by integrating the green and blue infrastructure and the newly proposed settlements for the informal dwellers. The green belt along the blue infrastructure will act as a park, and meeting ground for the neighbourhood people. The staggered green roof houses will also get the lake view.
The amphitheatre (Figure 69) beside the lake will also provide a opportunities for events and different cultural performances at special occasions. It will also add an aesthetic value to the landscape.

Figure 69: Proposed amphitheatreby Banani Lake for performing arts which add recreational value in the project area. The 3D illustration is produced by the author.

Phase one will also include promoting of specific tree selections to achieve urban ecology effects. The following section in Figure 71, reflects what specific trees can be selected to improve urban ecology. The tree inventory is attached in the Appendix A section.

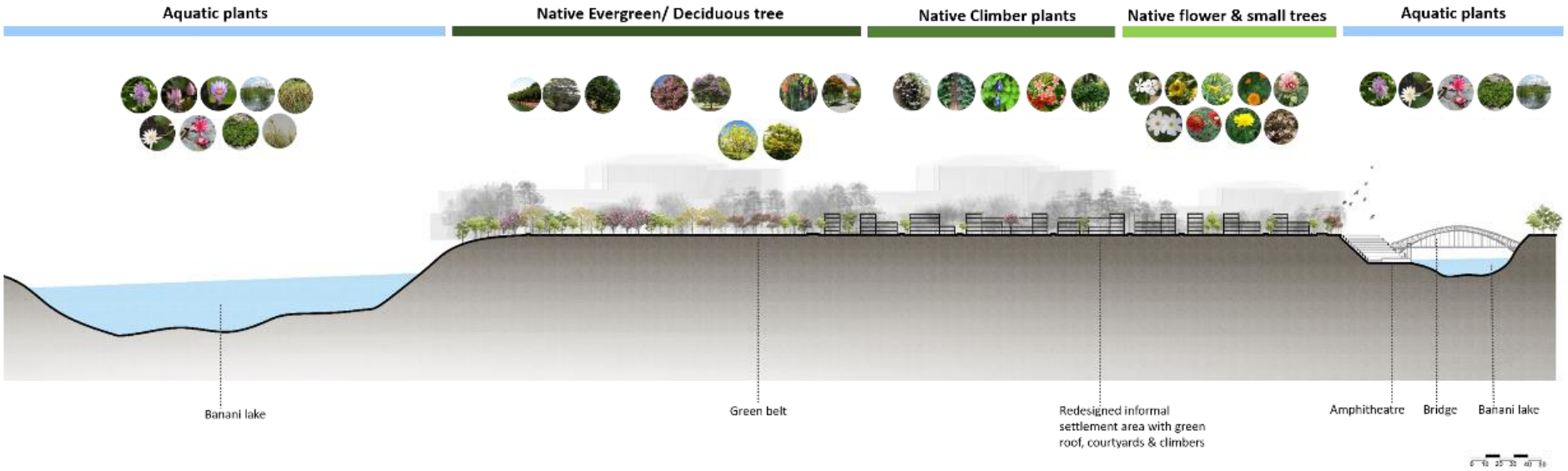


Figure 70: Section of phase one through the redesigned informal settlement area and Banani lake, showing a proposal for specific tree selection, the section is produced by the author.

7.5.2. Phase 02

The second phase (Figure 71) will mainly concentrate on establishing the connectivity with the existing waterbody of 'Banani lake'. Re-establishing the connectivity will be achieved through underground drainage and creating the stormwater channel. This phase will mainly concentrate on urban ecology and stormwater management these basic two aspects of the thesis aims and objectives. The figure below is pointing at the phase second portion of development within the overall design masterplan program-sketch of green and blue structure.

Figure 71: Overall masterplan program-sketch for green and blue structure with subdivision of the three phases and the yellow bar indicates the phase two development section, the illustration is produced by the author.

This phase will re-establish the connectivity of the green and blue structure. It will also create a green corridor along the stormwater channel. The proposal for underground drainage is inspired by the role model of the Big U project in North America. To manage excess water this underground drainage will act as a detention or catchment area which is mentioned in the guidelines section. These detention or catchment areas are usually dry and can store water until it is necessary and then get back to their dry state by letting the water go. They will ensure the natural drainage system and help to reduce the effect of stormwater flooding (Figure 72).

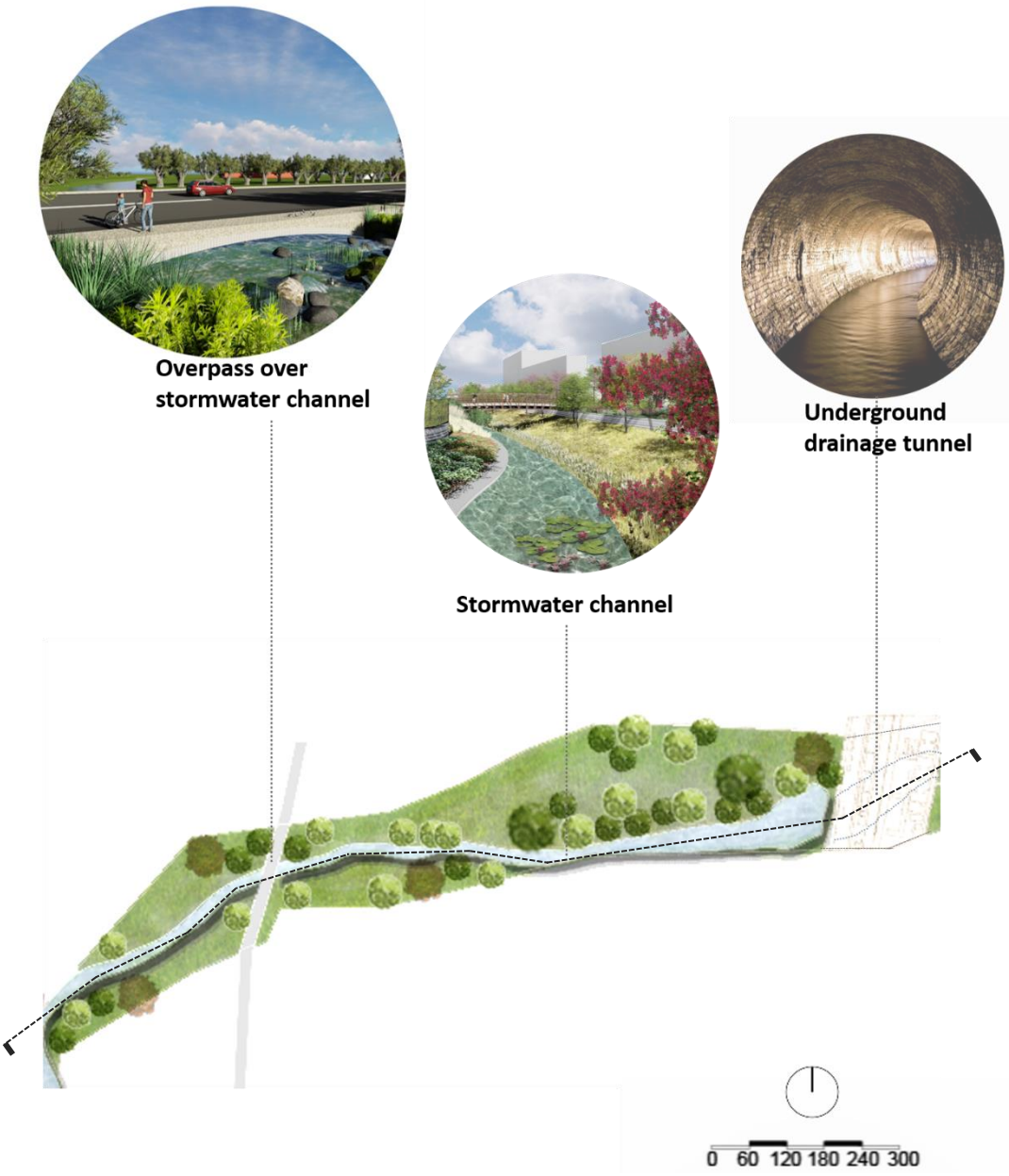


Figure 72: The proposals for phase two development with a section line which includes storm-water channel, underground drainage tunnel, overpasses, and bridges, the illustration is produced by the author.

The green corridor along the stormwater channel will act as a small park for the nearby neighbourhood. This will provide scope for a small gathering and meeting ground (Figure 73).

Figure 73: Conceptual illustration for the stormwater channel within the neighbourhood. The 3D illustration is produced by the author.

The plantation is an important part of phase 02 with specific tree selection to achieve urban ecology (Figure 74) according to tree inventory in the Appendix A. Phase 02 is thought to be parallel to monitoring the guidelines of phase 01 and shift the informal dwellers back to their permanent settlement areas. The over-passes and connected bridges over the 'Banani Lake' to enrich the connectivity is important in pase 02 (Figure 75).

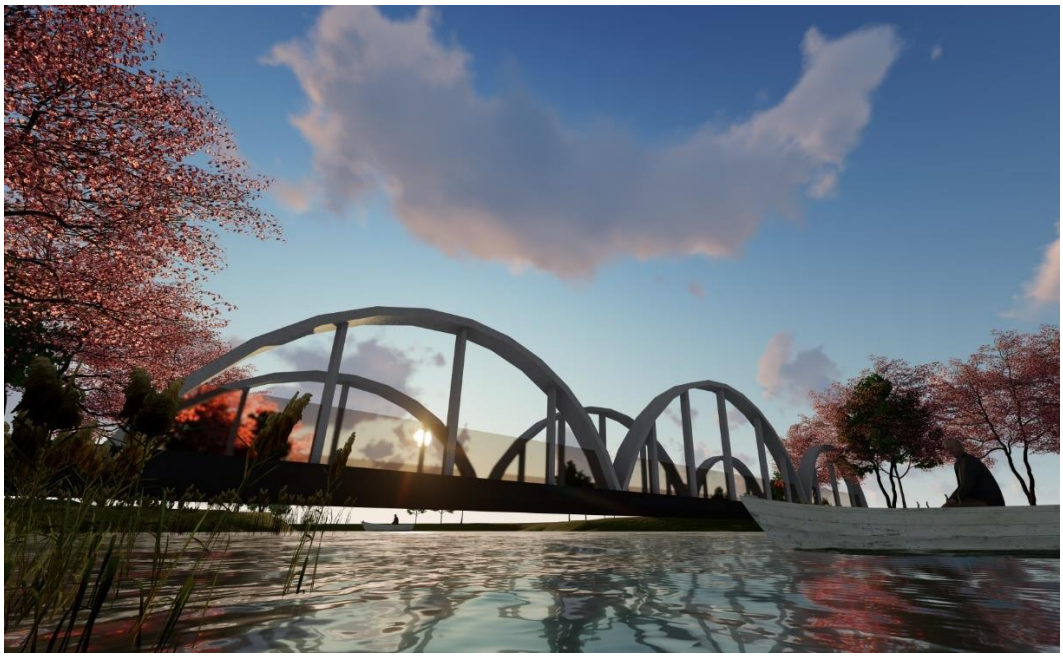


Figure 74: Connected bridges over the 'Banani Lake' to enrich the connectivity and add aesthetic value, the 3D illustration is produced by the author.

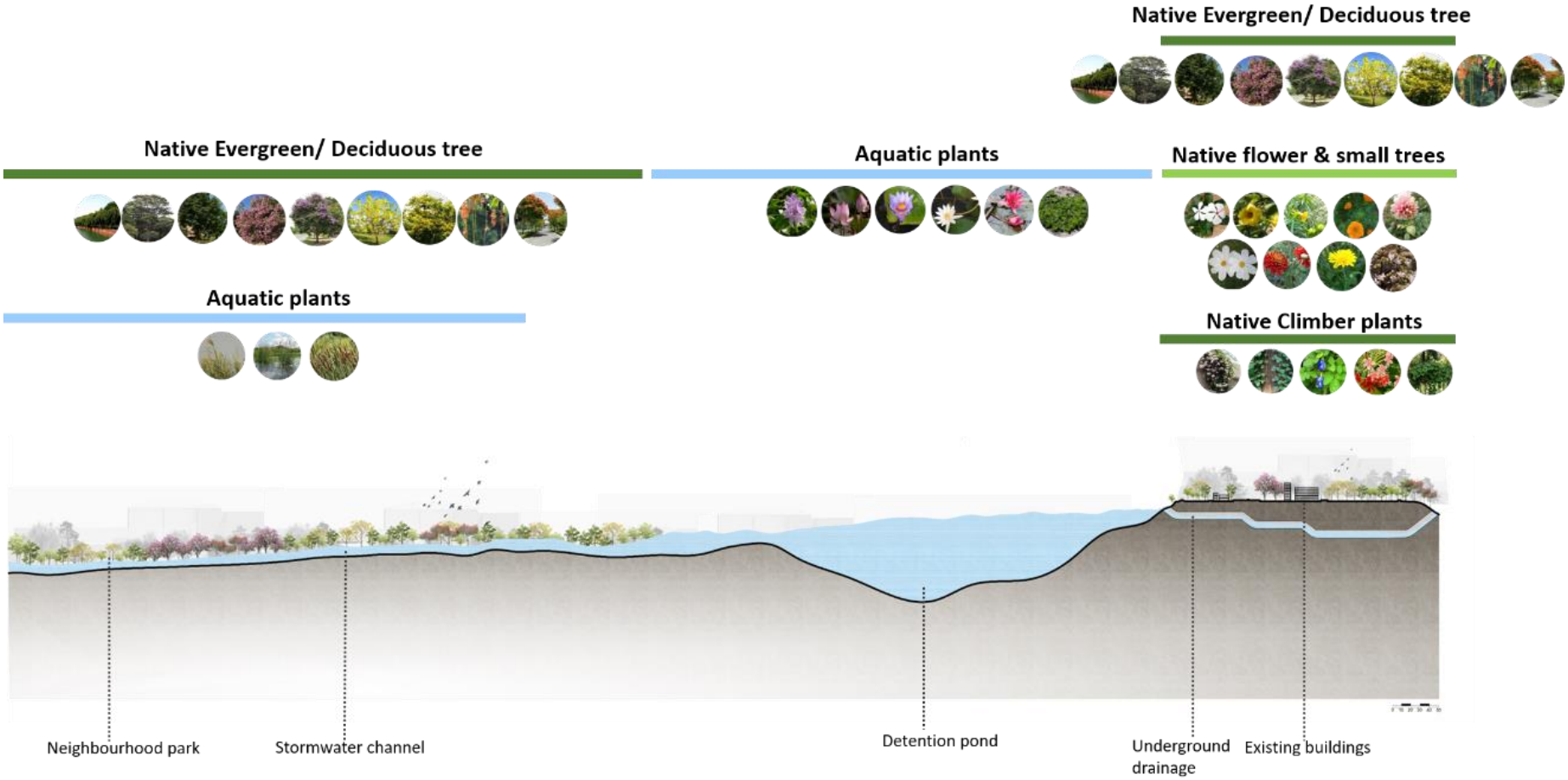


Figure 75: Plan of phase two showing a proposal for specific tree selections, the section is produced by the author.

7.5.3. Phase 03

The phase three (Figure 76) will concentrate on all the three thematic aspects of the thesis aims and objectives through the overall thesis proposal. The figure below is pointing at the phase three portion of development within the overall designed masterplan program-sketch of green and blue structure.

Figure 76: Overall masterplan program-sketch for green and blue structure with subdivision of the three phases and the yellow bar indicates the phase three development section. The illustration is produced by the author.

Parallel to phase 03 development maintenance in phase 01 and phase 02 should be ensured to follow proper guidelines. The overall connectivity with greenery and waterbody should be ensured to gain the maximum effect. The following Figure 77 and 79 show the zoning and uses for phase 03 development. This part of the site area should be designed artistically and aesthetically using the tree index attached to the Appendix A. The use of listed trees will help in improving ecology and greenery. The flower festivals can be arranged to bring the seasonal colours to Dhaka city. During an interview with Mustaque Quadry he insisted that the native plants such as Lagerstroemia speciosa (জারুল), Bauhinia variegate (রক্তকাঞ্চন), Spathodea campanulate (রুদ্রপলাশ), Delonix regia (কৃষ্ণচূড়া), Cassia fistula (সোনাইল) etc. should be used.

Figure 77: Phase three zoning with section lines, the illustration is produced by the author.

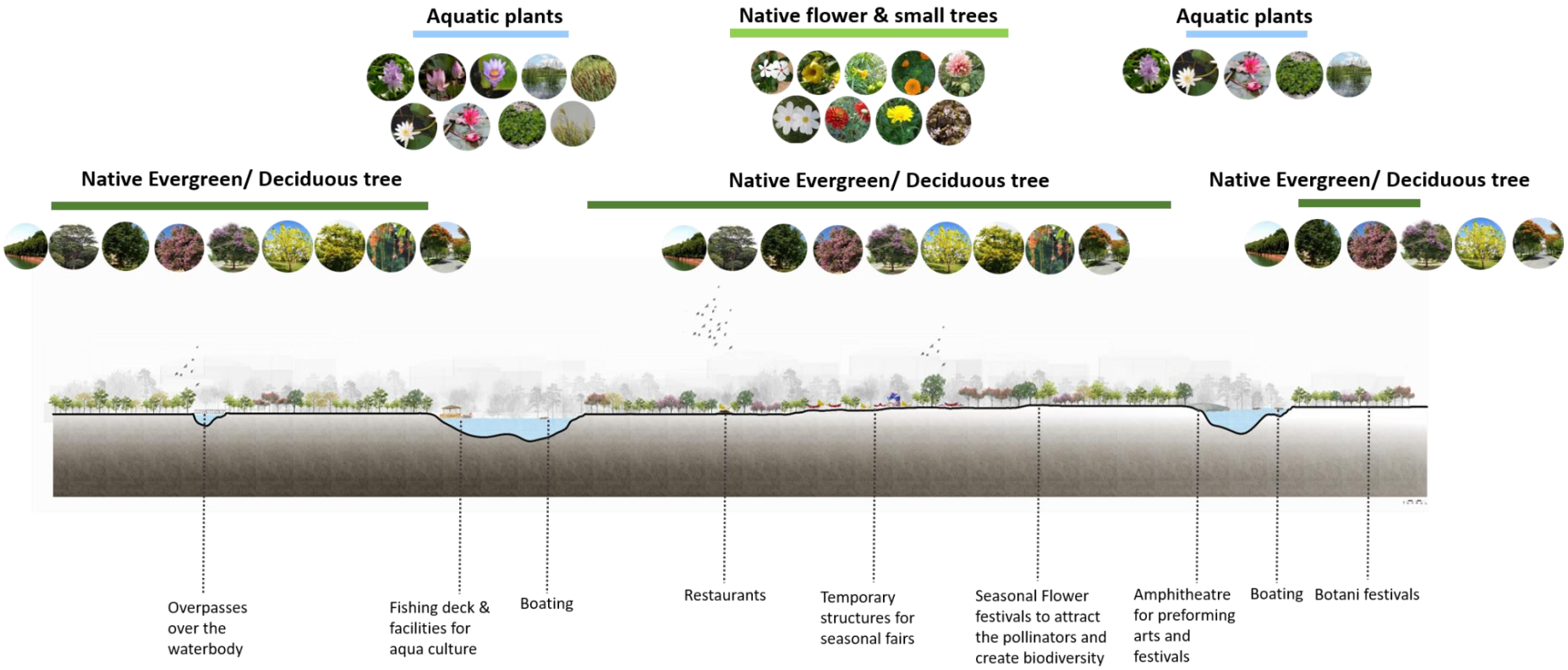


Figure 78: Phase three section through the green-blue infrastructure and specific tree selections from the tree inventory attached in the Appendix A section, the section is produced by the author.

The design should emphasize the different seasons. The seasonal colours during the summer and spring are special and differs from colourful flower trees and small trees that add colours during winter. Colourful flowering all year round will attract pollinators and other habitats and help to develop biodiversity. The pavement beside the waterbody will be built with gravels or other permeable materials so that it can transmit the excess water to the ground easily (Figure 79).

Figure 79: The 3d illustration shows the parks area with exercise facilities and the temporary structures for holding different seasonal fairs and festivals for recreation, social gathering and economic benefit, the 3D illustration is produced by the author.

Dhaka city is full of culture and traditions. Temporary stalls can be constructed to use throughout the year during arrangements of these seasonal festivals (Figure 79). Festivals such as flower festival, botany fair, cake festivals (pitha uthshob), book fair, food festival, Bangla new year festival (Pohela Boishakh mela), spring festival (falgun mela) etc. These festivals and fairs will keep the city life cheerful and lively (Figure 80). The new park can become a meeting ground for different age group people and provide an income source for many people. Throughout the year small fish and vegetable shops, retail shops or even small restaurants and tea stalls can provide jab scopes for people. People usually gather around the small tea stalls and small restaurants every day after returning from work and start chatting on various topics over a cup of tea. This will help not only to improve social interaction within the people but also to improve the economic living condition of especially for people with lower incomes in Dhaka city.

Figure 80: The 3d visualization emphasizes the floating deck for boating and celebrating the traditional fanush festival, the 3D illustration is produced by the author.

In the GIS analysis knowledge was produced which show that during the flooding season the water overflows the site area of phase 03. The water body is considered in the design by using the water overflow. The overflow will slowly infiltrate in the catchment area which is mentioned in the guidelines section. The water will be stored and utilized during dry seasons. The catchment areas will ensure the natural drainage system and reduce the effect of stormwater flooding. The water bodies can be designed for fishing and aquaculture (Figure 81) and thus provide a source of income for many people and add recreational value as well.

Figure 81: The 3d visualization showing the fishing and swimming deck, the 3D illustration is produced by the author.

From personal experience and newspaper articles this thesis paper came to know that stormwater flooding is quite common on the 'Begum Rokeya Road' beside the study area. To manage this stormwater flooding on streets rain beds can be introduced as there is enough room for adding them. During the online survey questionnaire the 40% of experts did not agree to construct rain-beds as they are very costly and requires maintenance. The examples from Stockholm and Växjö, Sweden inspired the author to propose rain-beds beside the streets to increase greenery and manage stormwater flooding. The following Figure 82, show the details for the rain-beds in the pedestrian areas which can be constructed beside the 'Begum Rokeya Road' as there is enough room for designing rain-beds.

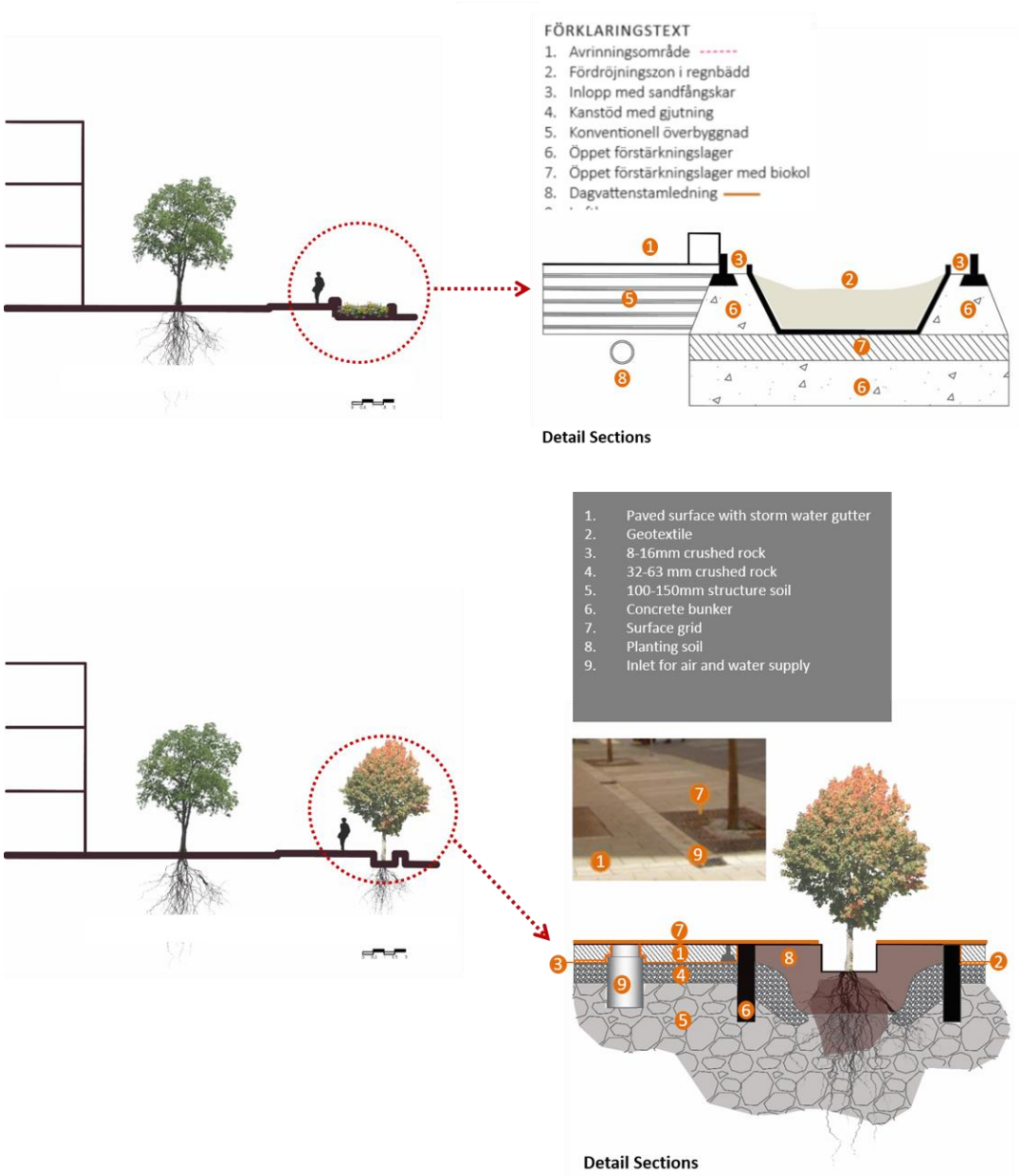


Figure 82: Detail section of rain-beds beside the streets to improve greenery and manage stormwater. The sections and the details are produced by the author.

8. Discussion

The thesis work with a combination of three thematic aspects; urban ecology, stormwater management and improved living conditions for inhabitants in Dhaka strengthened my motives and ideas for certain parts of my proposal. Each thematic aspect gave reasons to the other ones to have a certain form or a certain allowed usage. Three themes required to work with both form and function in several aspects all the time. The masterplan process by utilizing the thematic aspects can be a tool to address complex urban problems on an overall level. The combined concept for the thesis is derived from Frederick Law Olmsted's philosophy. Urban ecology, stormwater management, social and economic benefit all these thematic aspects altogether will help to provide a better quality of living. The further implementation of masterplan program-sketch and guidelines also focused on the nature and human wellbeing and how to achieve sustainability.

The historical changes in greenery, wetlands, water bodies are identified and analysed in Dhaka city. The missing connectivity within the water bodies causes stormwater flooding within Dhaka city. Identifying the existing greenery, open areas, waterbody protection can help to develop urban greenery and urban ecology through GIS analysis. Projects from around the world considering improving urban ecology, stormwater management helped to provide solutions and guidelines for the masterplan program-sketch. Literature review, data analysis, collecting maps and photographs from both primary and secondary sources is collected and analysed. The online survey questionnaire for both local inhabitants and experts of different fields were conducted. Informal interviews, and interviews from newspaper articles, media interviews are also considered. Overall, their point of views and suggestions helped to shape the guidelines and structure the thematic masterplan

8.1. Strength of the proposal

This thesis work started off with interest on stormwater and flooding. The stormwater issues cannot be addressed without studies of how the green structure interact with the water flows. Since the green infrastructure has a great impact of people's health and wellbeing wanted to include that aspect to my thesis. The thesis work learned me that sustainable urban design must combine thematic aspects in order to solve complex problem situations. This thematic masterplan processes used three themes as a tool to address complex urban problems on an overall level.

At the end of the 19th century Fredrick Law Olmsted work with park systems including water engineering and social uses for wellbeing that was new times to town planning. I have applied the philosophy of Fredrick Law Olmsted's and his theory that park systems can provide health and wellbeing to the inhabitants. The Fredrick Law Olmsted philosophy with Seven 'S' concept (Nicholson 2004) helped me to conceptualize guidelines and design the final masterplan program-sketch that promote sustainability, enrich ecological and aesthetics values as well as social and economic values.

Two factors that seem to have had consequences of flooding is firstly that or the land of the study area is slightly levelled up from the surrounding land area. Secondly landfilling of waterbodies for unplanned developments the water level rises in certain places during excessive rainfall. Due to the levelling up of lands and landfilling for urban construction flooding of lower parts occur. There are possibilities for providing solutions to this problem by working with new of water catchment areas.

The study area previously had a connected waterbody and a lot of greenery. The connectivity was lost due to population increase and unplanned development. The trace of connectivity is still there and the possibility to reconnect the greenery and water body is still there which is shown in the integrated green and blue program-sketch. Creating public accessibility and activity in the huge open land of the old Tejgaon airport will serve several purposes and aims and objectives of this thesis. The project with connecting waterbodies and the resettlement of Karail can provide job opportunities to the informal dwellers.

The proposal helped not only to increase the connectivity but also provide the possibilities to protect the existing natural values. Overall green and blue structure helped to increase urban greenery and improved urban ecology. The list of trees which is mentioned in the literature review chapter helps to select specific trees. They are categorized into four groups such as big trees, flowers and bushes, aquatic plants and climbers. Listed trees are mostly native but some exotic plants which have now become a part of the ecology and benefit the urban ecology by providing shelter for other habitats. The proposal also focused on increasing habitats and other pollinators and to increase biodiversity within the city. The green spaces will also add to recreational values, health values, social values, environmental values and aesthetic values as well.

Recreating connectivity within waterbody and greenery increase the water catchment area to hold the excess water during heavy rainfall and flooding seasons. Proposal for the proper drainage system to manage the drainage system and flow the excess stormwater are stormwater channels, underground drainage channels to flow the excess water, specific tree selections, plantation, rain beds, rain gardens, green roofs, rainwater harvesting etc.that all together help to manage the overflow stormwater.

The study area includes Karail with many informal dwellers. The quality of living of these informal dwellers is very poor. They are deprived of their basic rights for example to clean drinking water. The proposal includes providing temporary settlements for the informal dwellers until the phase 01 development is completed. Shifting a huge amount of people difficult task to perform. The shifting of people is justified through literature review, as a process of stage wise development and upgrading of the informal settlements of Karail. The proposal also

considered the possibilities of further development to provide shelter to the increasing number of informal dwellers.

The thesis has used all valuable existing structures, especially building and road networks. In some parts a new road is proposed within the existing network to increase transport connectivity by proposing bridges over the water bodies and overpasses with a view of greenery and waterbody. Introducing water taxis also increase connectivity and accessibility and is a source of job opportunities.

The dwellers in informal settlements are deprived of job opportunities. An masterplan can lead to job opportunities according to Patrick Geddes theory (Talukder 2015). A masterplan can contain possibilities of for example aquaculture with opportunities of selling fishes and other food product from farming on seasonal festivals etc..

Through providing job opportunities and maintaining the enforced law within the overall proposal will safety and security be better ensured. Which will help to reduce criminal and unlawful activities and create a liveable safe environment (Khan 2010). People's interaction with nature, creating openness, human interactions offer a sense of safety. The overall proposal address the social and economic aspects and how they can be improved.

The proposal introduce new and modern technologies and solutions inspired by other countries. Role models from North America, Europe and Asia had been considered to get knowledge and inspiration from other successful projects. The role models show how to overcome design challenges and limitations as well so that the previous mistakes can be avoided. The thesis results have been put in comparison to the described role models to evaluate possible goals to achieve by an implementation of the thesis proposal (Table 5). Proposals for proper waste management, recycling, bio plants for sustainable development will become a role model to apply in other parts of Dhaka city.

The goals with the proposal are to improve urban ecology, manage the excess flow of stormwater, and improve the social and economic condition of living. These three altogether can lead towards better living quality. The results cannot fully be evaluated until the masterplan has been further developed and implemented.

8.2. Design challenges

There were many design challenges in gathering the background and design a proposal for this thesis. The main challenge within the chosen area is the divided discussion about the future uses of the Tejgaon airport. The old airport in the Tejgaon area is the huge piece of land. Sometimes this area is used as an air force training ground for flying fighter plane and parade training. Prime Minister Sheikh Hasina confirmed that recently there is no plan to shut down the Tejgaon old airport as it belongs to Bangladesh Air Force (BAF) (The Daily Star 2021). But soon there may be a possibility to construct something else for the future betterment of Dhaka city to reduce the climate change impact. For that reason, various competition projects are arranged at various times by re-known organizations such as BUET, Urban Oasis etc. to utilize this huge space with enough public accessibility (Holmes 2015). Although, this is an ongoing debate with the

government and the BAF whether there should be constructed other projects with public accessibility rather than a training ground.

The urban planning and landscape planning legislation in Bangladesh is outdated (Mridha et al. 2009). The policy for urbanization lacks fundamental rules and regulations and that is why the rules are not capable enough to face the recent challenges. The holistic urbanization policies lack proper governance, skill and coordination. (Mridha et al. 2009).

One of the major design challenges is to differentiate between the two types of water flooding. One is due to river flooding and the other one is due to extreme rainfall. Sometimes in some cases, it was difficult to pinpoint exactly as sometimes both types of water flooding get merged.

Another limitation of this thesis paper is there is a limited number of study materials and literature related to stormwater flooding and the drainage system within Dhaka city. The limitations of collecting data regarding previous drainage systems to compare with the existing one. It would have helped to address the issues with inadequate drainage capacity in particular areas. In some cases, lack of inadequate data made the thesis force to depend on other secondary sources such as maps, images, and photographs to understand the overall situation.

During formulating the online survey questionnaire with local people there are certain drawbacks. As the interviews were conducted remotely it was not possible to reach the informal local dwellers to learn their point of view. The survey was conducted all over Dhaka city to grasp the overall scenario. However, these responses cannot be said to be truly representative for the local people in the study area. This portion of online survey require readjustment further for future implementation. Democratic opinion including informal dweller's opinion is required for further investigation. This will further help to avoid the opinion gap within the planner and informal dwellers. further investigation for research purpose will help to overcome the design constrains similar to the role model in Ho Chi Minh City (HCMC), Vietnam which is mentioned in chapter six.

In certain cases, while conducting the survey with the local inhabitants, they did not answer properly or answered irrelevant things. These answers were not used in the thesis. During performing the informal interviews method, a certain barrier came across the path. Some experts were not very comfortable answering certain questions as their comment and suggestion might go against the higher authority officers. Some also mentioned that the responsible authorities' irresponsible behaviour, corruption and lack of knowledge have created this present condition of this city. A next step of the thesis proposal should be to have further discussions with the authorities.

During the GIS analysis, the availability of shapefiles and layer files of Dhaka city is one of the main obstacles to perform this thesis study. If an open source of all types of shapefiles and layer files would have been accessible it would have helped to this thesis. Experts who are working with GIS have the availability of the shapefiles and layer files. But they were not interested to help or cooperate by sharing any data. This was one of the drawbacks of this research analysis.

The overall proposal requires a team member of different expertise fields to solve different technical issues. The proposal is made from an architectural and landscape design perspective. Different input from different expertise fields would have been helpful to provide a better proposal even at a program level.

This thesis was formulated remotely. The result might have been slightly different if this the research methodology process had been performed directly on-site. The communication with different responsible authorities would have been easier to collect data in better face to face communication and performed interviews.

The COVID-19 pandemic situation is completely ignored throughout this thesis paper. Besides this masterplan program-sketch is not proven it's efficiency yet. This thematic masterplan is only at a program sketch level. To achieve enough background on urban ecology, manage stormwater flooding and socio-economic well-being for a master plan is a long process with many different experts involved. A drawback and design challenge of a single person thesis project of the kind that I have worked with is that needed specialists are not yet involved in the project other than the ones I have interviewed.

8.3. Implication and further development

This thesis proposal is a documented outline which the thesis topic defines the issues that this thesis addressed and explained why the topic requires further research. It identified the problem and provided solution with three thematical approaches to that problem. The collected data, analysis and proposal can be helpful for further research and planning process. In the process of future development this thesis can become one of the steppingstones by utilizing the strength of the proposal and for further research the design limitations must be overcome

This thesis requires multi-disciplinary professionals to work as a team. Working parallelly with multi-disciplinary professionals prevent the project being viewed from only one angle. Each discipline has certain requirements and aspects to focus on. When a multidisciplinary team is formed, it allows to collaborative supports from a wide range of experts. This thesis could not parallelly work with multi-disciplinary professionals. But for further implication and development working with multi-disciplinary professionals is required. The benefit of having multi-discipline professionals on a same project can help to avoid problems in the later design stages. A multidisciplinary team offers to set specific goals in terms of daily, weekly, monthly, and yearly goals for themselves. This allows the team to engage with the goals, holding themselves and achieve desired outcome within a specific timeframe.

The project implementation and further development require funding. The funding is usually provided by Asian banks or some other foreign companies who are interested in developing urban green and blue structures. Sometimes the government also plans a specific budget for developing such proposals through different governmental organizations. In such cases, the necessity of monitoring arises to plan budget and funding money to reduce corruption. The phase-wise development also requires monitoring so that all the phases can be completed within the time frame.

NHA has undertaken a few land development projects to provide housing for the poor and lower income people (Sinthia 2013). Due to the corruption in the various governmental sectors, they only serve the higher-level people. Sometimes, when the projects are completed, many low-income people sell their houses to the

rich and powerful people. These poor people are often deprived of their rights and return to the slum areas again (Islam 1996). Governments have taken initiations with The UNICEF to fund Slum Improvement Project (SIP). They are implemented by The Local Government Engineering Department (LGED) to develop slum infrastructure. It is very pitiful that but they do not serve any housing project for poor people (Sinthia 2013). The NGOs like: BRAC, ASA, DSK, BRISK, RIC, Bureau Bangladesh, Glory, and SHAKTI etc work for the poor people. Other NGOs which are funded by the foreign countries work for improving the slum environment to benefit the poor, women empowerment, consider the hygiene issues such as water and sanitation, provide basic healthcare facilities etc. (Mridha et al. 2009).

Possibilities of further development should be ensured to provide shelter for the increasing number of migrated rural people to accommodate in the newly proposed 'Karail' area. The same kind of projects can be developed to reconnect the water bodies and greenery. The kind of solution that is presented in this thesis can also act as a role model for developing in other parts of the city.

The project requires working with a group of experts who have specialized knowledge in relevant fields. This co-operation in a team of experts is essential to solve the technical issues and to ensure the project promote quality of living.

8.4. Recommendation

To improve the quality of living in urban areas urban greenery, stormwater management and improving the social and economic condition is required. These are the basic three thematical aspects of this master's thesis paper.

After development and implementation of this overall program-sketch further maintenance according to recommendations must follow. Proper maintenance should be ensured to gain the maximum result output. If the proposed green and blue infrastructure is taken over by unnecessary unplanned developments or if the informal dwellers keep developing whatever they want, then all the efforts will be in vain. In other words, the whole masterplan will be declared as a failure.

Raising awareness is one of the goals with the guidelines which is also proposed for maintenance. General people should know the negative sides of climate change causes and effects. Positive sides of maintaining the environmental quality should though be explained. Creating awareness among the common people is necessary and encourages them to take part in taking care of the environment. Awareness can be raised through advertisements, newspaper articles, campaigns, drama etc. seminars and workshops can also be arranged to raise awareness. In some cases, self-awareness plays an important role in maintaining the overall environmental quality. As an individual, it is everyone's responsibility to maintain the environmental quality. It is not only the responsibility of the government to manage and solve this issue. By imposing laws there can be control to some extent but without taking responsibility as an individual and without self-awareness it is impossible to maintain the effect of climate change such as urban ecology and stormwater flooding. This thesis includes a language of symbols for facilitating the communication with the inhabitants of Dhaka. Everyone can be motivated to follow proper guidelines and recommendations since they will improve the social

and economic condition of living and ensure a quality of living for a better civilized future.

9. Conclusion

This thesis investigated three different thematic aspects i.e., urban ecology and greenery, stormwater flooding and social and economic conditions. The study area for this thesis have been the former airport Tejgaon, the informal settlement area in Karail and Banani Lake within Dhaka city. The capital city of Bangladesh Dhaka is a densely populated fast developing city. The chronological changes due to rapid growth of urbanization have made the green and blue structures replaced with the built-up areas and hard surfaces. This causes imbalance in urban ecology in the city of Dhaka affects storm water flooding and social wellbeing.

The aim of this thesis paper was to integrate three important thematic aspects i.e., improve qualities in the urban ecological situation, provide ideas for handling stormwater flooding and ideas to improve socio-economic aspects for inhabitants.

The result of the thesis is an integrated thematic masterplan design sketch at program level in three phases that is based on guidelines. The guidelines were produced in this thesis from a background of gathered knowledge in a complex methodology conducted parallel to sketching the plan.

The conclusion of this thesis is that I learned the importance of integrated work with thematic aspects on an overall planning level is essential to solve complex climate issues and sustainability. The integration of themes should be parallel work involving both experts, politicians, and inhabitants. The traditionally function divided “top down” planning processes must be changed into “bottom up” thematically integrated democratic planning processes.

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Acknowledgement

I express my heartful of love and gratitude towards my thesis supervisor Lena Steffner. She was very supportive throughout the process. Her enthusiasm for the project constantly encouraging me. She was always available whenever the feedback, guidelines and suggestion were required. Throughout the thesis her suggestions were always constructive and inspiring.

I would like to thank Antoienette Wärnbäck for her support and guidance during the 80% Thesis Seminar.

I would like to thank Burcu Yigit Turan for their valuable comments to improve my thesis during my examination.

I want to thank the Department of Urban and Rural Development, Swedish University of Agricultural Sciences, for throughout this LASU Master's program.

Furthermore, my grateful thanks to Architect and naturalist Mustaque Quadry who shared his knowledge and personal experiences to develop my thesis further.

I am very grateful to my friend Adiba Aziz Asha for helping me with last moment proofreading to avoid spelling and grammatical mistakes.

I wish to thank my Mom and my Dad, for their love, support, and encouragement, – without them it would not have been possible for me to come this far. I would like to thank my in laws, family and my friends for their support.

Special thanks to my husband Mir Riyanul Islam – who made the road smoother towards completing my Masters. I could not have done this without his support and inspiration.

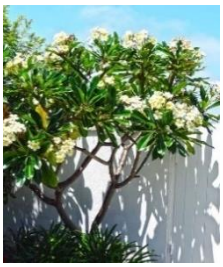
Appendix A

Table A1: Tree inventory, types and images of trees, the table is produced by the author.

Name	**Types** (Native/ Exotic)	**Types**	**Images**
দেবদারু/দেশী দেবদারু Polyalthia longifolia	Native	Deciduous Tree	
কনকচূড়া Peltophorum ptero-carpum	Native	Deciduous Tree	
গগন শিরীষ Albizia richardiana	Exotic	Deciduous Tree	

পাদাউক Pterocarpus indicus	Exotic	Deciduous Tree	
তেলশুর Hopea odorata	Native	Evergreen Tree	
কৃষ্ণচূড়া Delonix regia	Exotic	Deciduous Tree	
নাগেশ্বর Mesua ferrea	Native	Evergreen Tree	

মণিমালা Millettia peguensis	Exotic	Deciduous Tree	
বকুল Mimusops elengi	Native	Evergreen Tree	
জারুল Lagerstroemia speciosa	Native	Deciduous Tree	
রক্তকাঞ্চন Bauhinia variegata	Native	Semi-Evergreen to Deciduous Tree	

সোনাইল Cassia fistula	Native	Deciduous Tree	
উদয়পদ্ম/হিমচাঁপা Magnolia grandiflora	Exotic	Evergreen Tree	
কুরচি Holarrhena pubescens	Native	Deciduous Tree	
কাঠগোলাপ Plumeria sp.	Exotic	Deciduous Tree	

বোতলব্রাশ Callistemon viminalis	Native	Evergreen tree	
হিজল Barringtonia acutangula	Native	Water loving Ever-green tree	
বরুণ Crateva religiosa	Exotic	Water loving Decidu-ous Tree	
রুদ্রপলাশ Spathodea campanulate	Exotic	evergreen tropical tree	

কুসুম গাছ Schleichera oleosa	Native	Semi-Evergreen to Deciduous Tree	
অশ্বত্থ গাছ Ficus religiosa	Native	Semi-Evergreen to Deciduous Tree	
তেঁতুল গাছ Tamarindus indica	Exotic	Evergreen tree	
Tagetes erecta L.	Native	Bush	

Latadeji Sphagneticola triobata	Native	Bush	
Marhatitiga Spilanthes acmella	Native	Bush	
Asamlata Mikania micrantha Kunth	Native	Climber	
Daila Adahlia pinnata	Native	Bush	

Kukshim Cyanthillium cinereum	Native	Bush	
Helencha Enhydra fluctuans	Native	Bush	
Kackmach Cosmos Bipinnatus	Native	Bush	
Chandramollika Hrysanthemum morifo-lium	Native	Bush	

Calendula Calendula officinalis	Native	Bush	
Nayan tara Catharanthus roseus	Native	Bush	
Kolkeful Cascabela thevetia	Native	Small tree or Bush	
Bhat Clerodendrum viscosum	Native	Small tree	

Olokanonda Allamanda cathartica	Native	Small tree	
Konok-chapa Ochna squarrosa	Native	Small tree	
Kanthalichapa Artabotrys hexaperalus	Native	Climber	
Kochuripana Eichhornia crassipes	Native	Aquatic plants	
Padma nelumbo nucifera	Native	Aquatic plants	

Kolmi-lota Ipomoea aquatica	Native	Aquatic plants	
Boronukha Monochoria hastata	Native	Aquatic plants	
Rokto-komo Nymphaea rubra	Native	Aquatic plants	
Shapla Nymphaea pubescens	Native	Aquatic plants	
Topapana Pistia stratiote	Native	Aquatic plants	

Binna-ghash Chrysopogon zizanioides	Native	Aquatic plants	
Hogla Typha domingensis	Native	Aquatic plants	
Nolkhagra Arundo donax	Native	Aquatic plants	
Chondromala Nymphoides cristatum	Native	Aquatic plants	
Maloncho Alternanthera philoxe-roides	Native	Aquatic plants	

Shaluk Nymphaea nouchali	Native	Aquatic plants	
Guloncho Tinospora cordifolia	Native	Climber	
Onontolota Antigonon leptopu	Native	Climber	
Blue morning glory ipomoea nil	Exotic	Climber	
Amal lota Cayratia trifolia	Native	Climber	

Modhu-monjori Combretum indicum	Native	Climber	
Oporajita Clitoria ternatea	Native	Climber	
Asam lota Mikania micrantha	Native	Climber	
Ashari-lota Capparis zeylanica	Native	Climber	
Roshundi-lota Mansoa alliacea	Native	Climber	

Madhobi-lota Hiptage benghalensi	Native	Climber	
Pipul Piper longum	Native	Climber	

Appendix B

Certain questionaries have been formulated below for experts. They are as follows:

1. What is the name of the respondent?
2. What is the name of the organization?
3. What is the expertise field of the respondent?
4. According to him or her what is the main reason for water flooding in Dhaka city?
5. What measures have been taken by your organization for managing water flooding?
6. Proper urban planning, drainage system and protecting existing waterbodies and greenery what else we can do to provide solution for water flooding?
7. Rain-beds or rain gardens can be a solution for stormwater flooding in Bangladeshi context?
8. What are the specific trees you suggest managing storm water flooding on streets?
9. How can we provide habitat for other species to balance the urban ecology?
10. What do you think about the informal settlements? Should we evict them or provide proper rehabilitation?

Table B1: Responses from the experts, the table is produced by the author.

Name	**Email address**	**Expertise field**	**Organization**	**Responded date**
Brigadier General Amirul Islam	ce@dncc.gov.bd	Civil Engineering, Urban Engineering	DNCC	18.02.2021
Dr. Monowar Hossain	drmonowarhossain@gmail.com	Water resources management, flood, Drainage system Planning	Engineering Staff College Bangladesh (ESCB)	18.02.2021
Ahsan Iqbal Bhuiyan	dirz1@rajukdhaka.gov.bd ah-saniqbal65@gmail.com	Planning, Estate & Land	RAJUK	18.02.2021
A. K. M. Shahid uddin	shahidud-din8325@gmail.com	Water Supply, sewerage and stormwater	DWASA	19.02.2021

		drainage management		
Taqsem Khan	taqsem@yahoo.com	Engineering and Water Management	DWASA	20.02.2021
Md. Abdulla Hel Kafi	ahk@iwmbd.org	Hydrology	IWM	22.02.2021
Ismat Ara Pervin	iap@iwmbd.org	Hydrodynamics	IWM	22.02.2021
Md. Rafiq Azam	shatotto.pdc@gmail.com	Green Architecture	SHATOTTO architecture for green living	24.02.2021
Md Abu Hena Mostofa Kamal	ahm@iwmbd.org	Water Resources	IWM	01.03.2021
Mustaque Quadry	mustaque.quadry@gmail.com	Architect and naturist	Bishwa Sahitya Kendra, Volium zero ltd.	12.02.2021

Certain questionaries have been formulated below for the local people. They are as follows:

1. What is the name of the respondent?
2. What is the profession for the respondent?
3. In which area they live in Dhaka city?
4. Do they face water flooding in their area?
5. If yes, then what types of problems do you face during stormwater flooding?
6. According to you that is the main reason for water flooding in your area?
7. What measures can be taken to increase urban greenery?
8. Do you think stormwater flooding can be solved? If yes how?

Table B2: Response from the local inhabitants, the table is produced by the author.

Name	**Profession**	**In which part of the city they live**	**Responded date & time**
Hasan Kabir Shamsuddin	Technical Manager	Mirpur	2/17/2021 14:03:45
Mir Riyanul Islam	Researcher	Mirpur	2/17/2021 14:02:22
Rushil	Student	Mirpur	2/17/2021 15:07:38
Md. Saidul Islam	Service	Dhanmondi	2/17/2021 15:31:56
Fouzia Kamal	Architect	Rampura, Banasree	2/17/2021 15:43:40
Md. Rezaul Karim	Retired from Government jobs.	Ahmedbag, Sabujbag, Basaboo. DSCC	2/17/2021 15:57:22
Md. Rafiul Islam	Retired Government Officer	Dhanmondi	2/17/2021 15:49:11

Utsho	Architect	Basabo	2/17/2021 16:00:10
Zahid Bin Hossain	Architect	Mirpur,Dhaka(North)	2/17/2021 15:51:32
Juthi	Architect	Uttara	2/17/2021 15:54:16
Hosne Ara Begum	Retired Officer	Dhanmondi	2/17/2021 15:56:20
A K M Imtiaz Ali	IT Professional	Mohammadpur	2/17/2021 15:54:58
Nayema Sultana	Architect	Mirpur	2/17/2021 15:59:46
Md Ratin	Aechitect	Mohammadpur	2/17/2021 15:57:01
Kamrul Hasan	Architect	Mirpur 1	2/17/2021 16:08:23
Zakir Joarder	Consultancy	Paribagh	2/17/2021 16:09:59
Safa Ahmed	Architect	Mohammadpur	2/17/2021 16:09:06
Nabila	Architect	Mirpur	2/17/2021 16:10:07
Anirban adhikari	Architect	Badda	2/17/2021 16:10:48
Wahida Afroz Mitu	House Wife	Kalabagan	2/17/2021 16:14:32
Adnan Sahil	Architect	Dhanmondi	2/17/2021 16:22:12
Md Tareq	Business	Mirpur	2/17/2021 16:24:30
Md Rashidul Islam	Service	Uttara10	2/17/2021 16:25:15
Rumana Rashid	Architect	Mirpur	2/17/2021 16:28:56
Faria Rahman Tulna	Doctor	Dhanmondi	2/17/2021 17:25:27
Prianka tony	Architect	Dhanmondi 15,dhaka	2/17/2021 16:35:22
Wasif	architect	mirpur	2/17/2021 16:43:35
Joy	Job Holder	Badda	2/17/2021 16:49:28
Nabila Noshin	Architect / Lecturer	Banani	2/17/2021 17:02:00
Umma nayer Sultana	Civil engineer	Mohammadpur	2/17/2021 17:31:38
Nafisa Harun	House maker	Lalmatia	2/17/2021 17:27:42
Dr Yasmin Joarder	Physician	Purana palton	2/17/2021 17:30:41
Sabekunnahar Shital	Student	Mirpur	2/17/2021 17:59:12
Sheikh Mohammad soud	Architect	Bosundhora	2/17/2021 17:50:45
Rakibul Hashan	Service branch	Mirpur	2/17/2021 17:59:52
Tasnim	Architect	Mirpur	2/17/2021 18:15:48
Anika	Architect and urban planner	Bashundhara	2/17/2021 21:16:12
Faria Afrin Ayon	Architect	Dhanmondi	2/17/2021 22:07:15
Md Foysal Rana	Private service	Mirpur	2/18/2021 9:40:35
Hasina parvin	Housewife	Vooter goli	2/18/2021 11:53:23
Rafsan	student	Pabna district form Rajshahi division	2/18/2021 13:54:51
Rashida Sultana	Housewife	Uttara	2/18/2021 14:37:57
Ricky D'Cruze	ICT consultant	Mohakhali	2/18/2021 18:12:02

Mohammad ali	Director (Metrology)Rtd	Uttara Model Town Uttara	2/19/2021 4:48:22
Nabila	Architect	Moghbazar	2/19/2021 9:18:27
Adiba	Architect	Mohakhali	2/23/2021 5:20:54
F. K. Yeasmin Afrin	Entrepreneur	Dhanmondi	2/23/2021 5:26:51
Firoz Ahmed	Engineer	Dhanmondi	2/23/2021 5:29:03
Ishtiaq Ahmed	Emgineer	Dhanmondi	2/23/2021 5:40:45
Imteaz Ahmad	Assistant General Manager	East Rajabazar	2/23/2021 5:43:10
Sumaiya Shanon Khan	Teaching	East Rajabazar	2/23/2021 5:44:15
S. N. Rashid	Lecturer	Jatrabari	2/23/2021 5:45:31