THESIS TITLE: PLANNING STRATEGIES TO MITIGATE URBAN FLOOD IN DHAKA CITY: A CASE OF KALLYANPUR ZONE

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CANDIDATE'S DECLARATION

I hereby declare that the work, which is being presented in the dissertation entitled **"Planning Strategies to Mitigate Urban Flood In Dhaka City: A Case of Kallyanpur Zone"** in the partial fulfillment of the degree of ―Masters of Urban and Rural Planning‖, submitted in the Department of Architecture and Planning, Indian Institute of Technology, Roorkee, is the authentic record of my own work carried out during the period from July 2018 to May 2019, under the guidance of **Dr. Uttam Kumar Roy,** Department of Architecture and Planning, Indian Institute of Technology, Roorkee, India.
The matter embodied in this report has not been submitted by me for the award of any other degree.

Date: May 2019
Place: Roorkee **(Bushra Shahriar)**

This is to certify that the above statement made by the candidate **Ms. Bushra Shahriar** is true to the best of my knowledge.

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CERTIFICATE

Certified that report entitled **"Planning Strategies to Mitigate Urban Flood in DhakaCity: A Case of Kallyanpur Zone"** which has been submitted by Ms. Bushra Shahriar, in partial fulfillment of the requirement for the award of the post graduate degree of Master of Urban and Rural Planning, in the Department of Architecture and Planning, Indian Institute of Technology, Roorkee, is the student's own work carried out by her under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other degree.

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ABBREVIATION

BWFMS	Bangladesh Water and Flood Management Strategy
BWDB	Bangladesh Water Development Board
CUMEC	Cubic Meter Per Second
DoE	Department of Environment
DAP	Detail Area Plan
DCC	Dhaka City Corporation
DMDP	Dhaka Metropolitan Development Plan DSP Dhaka Structure Plan
DWASA	Dhaka Water Supply and Sewerage Authority FAP Flood Action Plan
FC	Flood Control
FCD	Flood Control and Drainage
FCDI	Flood Control and Drainage and Irrigation
FPCO	Flood Plan Coordination Organization
FM	Flood Management
GoB	Government of Bangladesh
GIS	Geographic Information System
GBM	Ganges, Brahmaputra and Megna
IFM	Integrated Flood Management
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
MLGRDC	Ministry of Local Government, Rural Department and Cooperatives
MoWR	Ministry of Water Resources
msl	Mean Sea Level
NWMP	National Water Management Plan
NWPo	National Water Policy

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CHAPTER-1

INTRODUCTION

1.1 Background

Bangladesh may be a developing country. Dhaka, the capital town of East Pakistan, is that the center of all development activities. Credit goes to unplanned rise of development activities ends up in important issues for the town dwellers. Urban Flooding is one in all the key issues for the town residents, particularly throughout the time of year though its a flat geographic land. The city is already densely inhabited and has become fourth most densely populated mega city within the world. Thanks to speedy urbanization East Pakistan is experiencing environmental degradation, increase in population, and manufacture. The method of urbanization is connected with the economic development, that makes Associate in Nursing more and more higher contribution of the economic system. Most of the cities and cities are unable to deal with ever-changing things thanks to their internal resources constraints and management limitations, however, once the expansion of urban population takes place at Associate in Nursing remarkably speedy rate. (Bari and Hasan, 2001).

Dhaka town is affected with variety of socio-environmental issues. Water work, traffic jam, solid waste disposal, black smoke from transport and industrial emissions, air and sound pollution, pollution of water bodies by industrial discharge, of these are the regular drawback of the town. now it wants some strategic selections and a few innovative ways to save lots of the individuals from coming environmental consequences and to create the town livable.

1.2 Problem Statement

Floods by nature are complex events. Reasons behind Flood is climate variability and a range of human activities, including inappropriate development planning. There are different ways of classifying and categorizing floods according to geographic and geophysical characteristics. As Bangladesh is located downstream of three large river basins: the Ganges, Brahmaputra and Meghna river basins, it experiences periods of extreme water availability – too much and too little water. Monsoon precipitation from June to September is the main source of water, and the country has less water available outside of this season, termed the

"dry period." Heavy rainfall during the monsoon period is the main cause of flooding; this occurs almost every year, with a devastating flood every 5–8 years (FFWC, 2004). Such flooding causes severe damage to agriculture and infrastructure and the loss of human lives. The total catchment area of these basins is 1.72 million km², with almost 93% of the catchment area situated outside the territories of Bangladesh – in Bhutan, China, India and Nepal. The topography, location and discharge from each of these three basins shape the annual hydrological cycle of the country. Dhaka the capital city of Bangladesh experiences waterlogging problem every year. Dhaka is one of the world's rapidly growing megacities, is an urban hotspot for climate risks. And for that reason now a days little rain causes a serious problem for certain areas, so that parts of Dhaka are inundated for several days. Regionally, the Dhaka is located in the central part of Bangladesh, and lies in the sub-tropical monsoon zone under the humid climatic condition. The city experiences about 2,000 mm annual rainfall, of which more than 80% occurs during the monsoon The surrounding rivers of Dhaka city are distributaries of the Brahmaputra River. Thus, the water level of the Brahmaputra and rainfall and runoff from the entire Brahmaputra Basin influence the process of river floods in and around the city. The entire drainage system is also influenced by water levels of the Ganges and Meghna rivers. At present, the western part of Dhaka is protected against river floods that formerly resulted from overflow of the Turag, Buriganga, and Balu rivers.

Dhaka is undergoing rapid urbanization, it faces constant threat of encroachment of water bodies i.e. lakes, canals and rivers. The invasion of migration and rapid growth of informal settlements, private housing and subsequent commercial developments prompt the process of encroachment. That's why the landscape of the city is changing radically. The urban expansion is threatening its ecological balance as well. This uncontrolled and unplanned urbanization is resulting in an ever expanding city boundary.

Dhaka has a long history of regular inundation during the monsoon season. Documented incidence of river flooding can be traced back to 1787–88, when floodwaters following heavy monsoons submerged city streets to a depth that required boats for moving around (Hunter 1877). River floods again devastated the city in 1833–34 and 1870. In the past century, the floods of 1954, 1955, 1962, 1966, 1974, 1987, 1988, 1998, and 2004 were of major significance in terms of lost lives and property (Haque 2010; Nishat et al. 2000; Rahman 2006).

Dhaka city suffers from drainage congestions and water logging especially during rainy season.

It creates an unhealthy environmental situation and causes inconvenience to the residents of the urban including damages to the infrastructure, loss of business and spreading of diseases.

It has been identified that improvement of the drainage system is one of the highest priority needs in urban area for a better and sustainable environment and livelihood. Under this circumstances, Dhaka need a proper guidelines and should adopt few planning strategies to mitigate urban flood and to avoid upcoming environmental degradation.

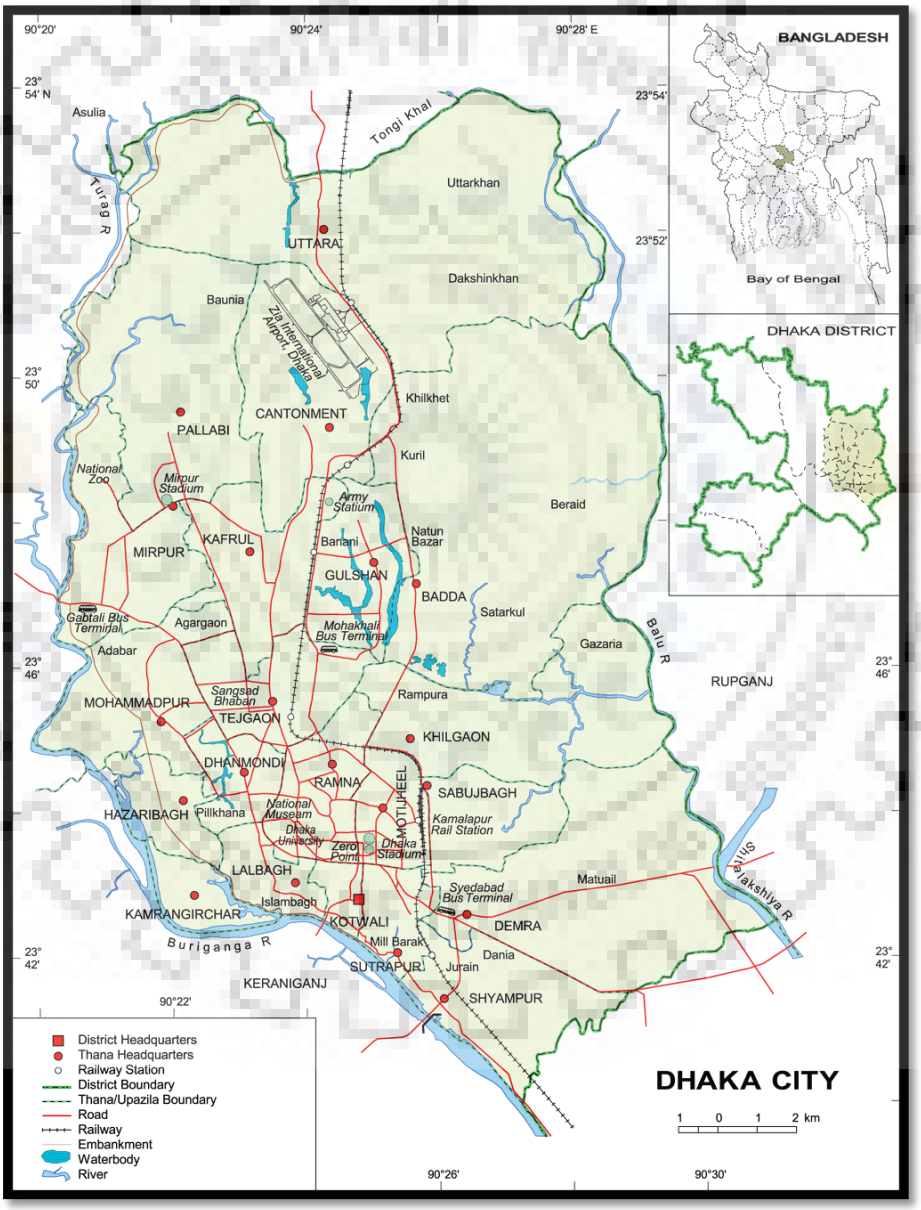


Figure 1 Dhaka City, Bangladesh

1.3 Need of The Study

- Historically, a major portion of the greater Dhaka area comprised of low lying lands which played effective role in retaining excess storm water and maintaining hydrological balance. But over the years, land development processes to accommodate the huge influx of the urban populace resulted in filling up of these natural wetlands/ waterbodies.
- Housing company and land grabbers are the matter of fact for the flood flow zone going to be reduced and in near future this eco-sensitive landuse will be vanished from the Dhaka city.
- Storm water drainage is an essential issue for this city where 40% of the people are slum dwellers who are facing acute problem during heavy monsoon. In Dhaka city there are no specific rules and regulations for operation and maintenance of stormwater drainage system. Existing drainage facilities of Dhaka city are quite inadequate and most of the natural drains are not functioning properly due to blockage by improperly handled construction material along the road sides, choked by garbage and poor maintenance. Thus in monsoon season city is facing rain induced flooding or Urban flooding problem. To overcome the Urban Flooding problem of Dhaka City, it is necessary to find out the inherent causes of this problem considering its associated impacts on human life.

Figure 2 Urban Flooding Situation in Dhaka City (Source: The Daily Star, 2004)

1.4 Objective of The Study

- To assess the vulnerabilities of Urban Flooding in Dhaka City.
- To identify critical areas and major causes of Urban Flood in Study area.
- To review of existing plan, policies and strategies relating urban flood of the study area.
- To suggest few strategies to mitigate urban flood in Kallyanpur zone within Dhaka city.

1.5 Aim and Vision

- The aim of this research is to develop few strategies to mitigate Urban Flooding Problem in the Study Area.

1.6 Scope of The Study

Natural factors and man made factors both are responsible for Urban flooding problem in Dhaka City. To find out all the inherent causes of Urban flooding in study area is the first task. Thus the study focuses on the major causes of Urban flooding, impacts of Urban flooding and current management strategies of Urban flooding in Dhaka City.

- Dhaka City's Drainage Masterplan, Structural Plan, Detailed Area Plan, Rainfall data, Flood History would be briefly studied to understand the vulnerabilities of Urban Flooding in Dhaka City.
- Public perception through questionnaire survey, Stakeholders opinions through informal interviews would be done to identify critical factors and major water logged areas within study area.
- A detailed study of Existing Policy, Acts, Flood management Strategies of Dhaka City will be done to identify gap, problem and issues.
- Few planning strategies will be developed to mitigate this Urban flood problem.

1.7 Limitations

While doing survey some limitations were faced to meet the all analysis objectives. These limitations area unit delineated below:

In decent literature to complement the analysis of this study. only a few studies were conducted associated with Urban flooding and system of Dhaka town.

Due to the dearth of careful elevation knowledge, typically it had been terribly arduous to live the particular depth of Urban Flooding.

Some vital knowledge like past system in terms of breadth, length, depth, capacity, choose flow, evacuation constant etc. and their layout weren't found. Therefore, to empty out the stagnant water from the affected space it had been required to calculate the capability of the present system. Sadly, authority couldn't facilitate to grant such reasonably knowledge.

During the form survey, some respondent didn't wish to form any comments against the accountable development authorities as they were terrified of the future harassment, what may be done by political cadre.

1.8 Probable Outcome

- Few planning strategies what will help to mitigate urban flood problem of Dhaka City in near future.

1.9 Contribution to planning

- A thorough review and data analysis on Urban flood in context of Bangladesh will help other researchers in future. What is urban flood? Why it occur and How it can be mitigated these types of questions will be answered through literature.
- Developing a Flood Risk Map what will be accessible by local authorities and people along with recommendations and inferences in terms of specific guidelines will be done thus giving a way forward.
- A critical review of existing policies, strategies will also be done to identify gaps. It will also specify the role of municipal, local authority, private organizations, NGO’s etc.

CHAPTER-2

RESEARCH METHODOLOGY

2.1 Introduction

This is a qualitative exploratory and descriptive type of research, which leads to the identification of the major causes and factors that are responsible for Urban flood problem in study area. Analyzing the impact of urban flood can help to improve the present situation of Urban flood in Dhaka city in near future.

It has already been mentioned earlier that flooding in Dhaka Metropolitan area can be classified into two types. One is river flooding that results from high water levels of peripheral river systems and another is rainfall induced flooding that is caused by high intensity storm rainfall runoff in the city area. The study would be focus on the rainfall induced flooding treated as water logging due to storm water in this study. The methodological approaches of the study are as follows-

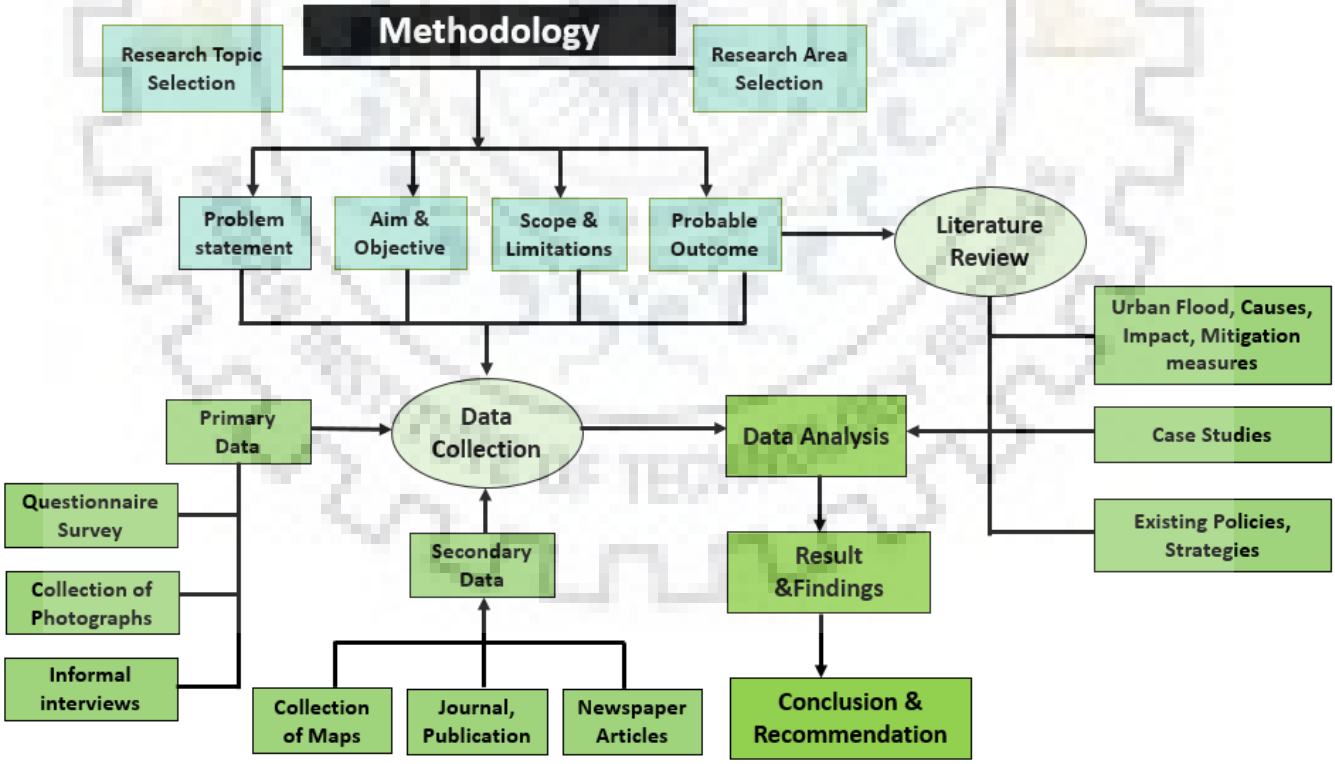


Figure 2.1 Research Methodology

2.2 Data Collection

Both primary and secondary data were collected to fulfil the objective of the study. All the necessary data has been collected from various sources.

2.2.1 Collection of Maps:

For the aim of the current study, geography map, Flood extend map, Dhaka City Corporation ward map, national capital Structure set up, the prevailing land use map has been collected from Rajdhani Unnayan Kartripakkha (RAJUK) and also the land use of various periods has been collected from some relevant literatures and organizations. Another necessary map square measure collected from Water and Flood Management (IWFM).

2.2.2 Other Secondary Data:

Rainfall data and the storm water drainage system data were needed for the study. The rainfall data has been collected from Meteorological Department of Bangladesh (MDE) and the drainage data has been collected from Drainage Department of Dhaka City Corporation (DCC). Dhaka Drainage Master plan was reviewed and this document was collected from DWASA.

2.2.3 Collection of Photographs:

Lots of photographs was also needed to illustrate the situation of urban flooding within the study area. So most of the photographs were collected during questionnaire survey. Some of these photographs have been collected from daily news papers as well as from internet websites.

2.2.4 Questionnaire Survey and Informal Interview:

Main supply of primary knowledge was form Survey and Informal Interviews by Stakeholders. The form was designed in such how that it might hunt down the matter from the origin and therefore the impact of the urban flooding within the section. Total one hundred sample were collected by getting cluster sampling technique. With cluster sampling, the man of science divides the population into separate teams, in step with geographical location. Then, a straightforward random sample of clusters is chosen from the population. The respondents were chosen totally different in several in numerous urban flooding prone space

at intervals the study space with different professions. To spot the standard of surroundings bound environmental parameters were mounted. It conjointly coated the people's perception on conservation/sustainable development of system. Informal interview of official specialists of various development agencies was conjointly tired order to grasp their read of causes and effects of urban flooding in Dacca town and property solutions.

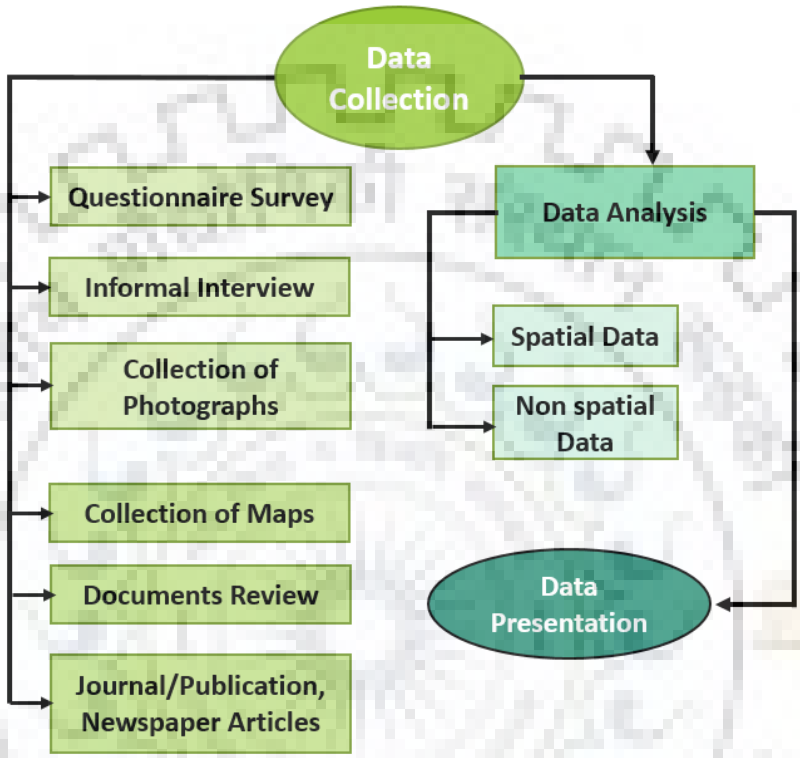


Figure 3 Data Collection

2.2.5 Data Analysis and Presentation

All the data both spatial and non-spatial collected from different sources has been analyzed separately. The spatial data has been analyzed by using some Geographic Information System (GIS) like Arc/info, Arc/view etc. and non-spatial data has been analyzed using some other statistical computer software like, Microsoft Excel, SPSS etc. Finally the both types of analyzed data have been integrated and presented as maps, tables, and graphs and putted in the report.

CHAPTER-3

LITERATURE REVIEW

3.1 Flood

Flood is defined by the Oxford English Dictionary as "An overflowing or irruption of a great body of water over land in a built up area not usually submerged." Floods are natural phenomena, but they become a cause for serious concern when they exceed the coping capacities of affected communities, damaging lives and property. Globally, floods are the most frequently occurring destructive natural events, affecting both rural and urban settlements. Urbanization has become the defining feature of the world's demographic growth, with the populations of cities, towns and villages swelling, particularly in developing countries. As a result, floods are affecting – and devastating – more urban areas, where unplanned development in floodplains, ageing drainage infrastructures, increased paving and other impermeable surfaces, and a lack of flood risk reduction activities all contribute to the impacts experienced. These problems are compounded by the effects of a changing climate.

Table 3.1: Factors contributing to Flooding

Meteorological Factors	**Hydrological factors**	**Human factors aggravating natural flood hazards**
Rainfall	Soil moisture level	Land-use changes
Cyclone storms	Groundwater level prior to storm	Occupation of the flood plain obstructing the flows
Small-scale storms	Natural surface infiltration rate	Inefficiency or non-maintenance of infrastructure
Temperature	Presence of impervious rate.	Too efficient drainage of upstream areas increases flood peaks
Snowfall and snowmelt	Presence of impervious cover High tide impeding drainage.	Climate change affects magnitude and frequency of precipitations and floods
	Channel cross-sectional shape and roughness	Urban microclimate may enforce precipitation events
	Presence or absence of over bank flow, channel network	
	Synchronization of run-offs from various parts of watershed	

Source: APFM, 2008

3.2 Flood and its Characteristics

A flood is Associate in Nursing overflow of water that submerges land that's sometimes dry. Floods may occur in watercourses once the rate exceeds the capability of the river channel, significantly at bends or meanders within the waterway. Floods usually cause injury to homes and businesses if they're within the natural flood plains of rivers. Flooding are often thanks to several reasons. sometimes this happens once the watercourse or the stream debilitating the world is over balanced by a awfully giant volume of water on the far side its capability. A watercourse channel is created by the forces of nature to be ready to convey the flow that's found most of the time. once the amount exceeds this, the water level rises on top of the banks and spreads in to the adjacent lands. This space is typically referred to as the flood plain of the watercourse. folks resident or operating within the flood plains should be conscious of the very fact that there's Associate in Nursing ever gift threat of floods. Even people who live on top of the amount of potential arrive a flood plain could realize their access or services bring to an end by floods. Such folks should acquire the information which will facilitate them to face floods confidently and mitigate the attendant the risks and discomforts.

3.3 Causes of Floods

Floods happen when prolonged rain, intense storms, or melting snow release more water than rivers or land can contain without causing damage, as a result they over-flow their banks usually into low lying surrounding areas. There can be different types of floods, which begin in different ways and will be discussed in due course.

There are diverse factors that cause or lead to floods and they are multifaceted and often unrelated. They can broadly be classified as Ecological/Natural causes and Anthropogenic/Manmade causes.

3.3.1 Ecological (Natural) Causes

These causes are on the far side human management and may be additional divided as Hydro-meteoric factors and geomorphological factors. Natural hazards, embody volcanos, seismic events, earthquakes, cyclones, typhoons, hurricane, tropical storms, floods, mudslides, tsunamis, and periodic event waves or storm surges.

Hydro- meteoric factors: Factors associated with weather like prolonged and intense downfall, cyclones, typhoons, storms and periodic event surges, precipitation, wind, water level rise, tide levels, wave action etc. kind the core of those factors, greatly poignant flooding. Hydrological factors include; however aren't restricted to ice and snow soften, rubber surfaces, saturated land, etc.

Hydro-Meteorological hazards result from atmospherically or hydrological processes; they're caused by the movement of water in some form or kind, and by weather patterns. Examples will embody floods, droughts, hurricanes, tornadoes, storms, blizzards among others. On a worldwide scale, the role of land use is usually unresolved, however on a watershed scale, land-use effects is as necessary as changes within the meteoric processes.

Geomorphologic factors: Topography and piece of land, soil type, poor infiltration rates, land erosion etc. or of a earth science nature (earthquakes, volcanic activity together with associated flooding, periodic event waves or tsunamis however conjointly soil movements, landslides, subsidence or the growth and retraction of clay soils). The information, perception and impact of natural hazards and associated disasters vary in step with the continent, soil, sub-soil, relief and climate. (Alifa Muneerudeen, June 2017)

3.3.2 Anthropogenic (Manmade) Causes

The phylogeny causes embrace increase and speedy urbanization, land use amendment, deforestation, intensive agriculture, unplanned control measures, poor drain and storm water management, impeding of stream channels, socioeconomic and development activities, etc, destruction of natural ecology –Marshes and Wetlands, technological hazards, global climate change, warming.

Technological hazards square measure either constant or accidental hazards directly coupled to human activities. Humans will build them worse by a shortsighted perspective or, on the contrary, mitigate their impact by previous security measures. These hazards will have serious consequences on human health, property and therefore the surroundings.

There square measure natural and phylogeny (human-induced) causes of flooding.

Flooding will naturally be attributed to:

Prolonged rain

When rain falls for a protracted amount of your time, the soil will become saturated. once water is unable to infiltrate into the saturated soil, it's forced to flow over the soil, therefore

increasing surface runoff. Rivers that square measure unable to accommodate excess rain water overflow their banks onto neighboring flood plains.

Intense/Heavy rain

When rain falls heavily; the rain drops hit the bottom with a force. this may cause the rain drops to bounce off the soil rather than infiltrating into the soil. The water from the rain is then forced to flow over the surface instead, therefore increasing the surface runoff.

Relief

Relief refers to the distinction tall between the very best purpose and therefore the lowest purpose toward land. once rain falls, the surface runoff will move terribly quickly from mountainous or craggy areas to low lying areas creating these low lying areas additional vulnerable to flooding.

Human activities that degrade the surroundings typically will increase flooding. These activities include:

Deforestation

The lack of vegetation encourages water to flow over the surface instead of infiltrate into the soil therefore increasing surface runoff.

Poor land use practices

Slash and burn agriculture, over-cultivation and over-grazing eventually cause the soil to become barren and unable to sustain vegetative growth. Consequently, the dearth of inexperienced cowl encourages water to flow over the surface instead of infiltrate into the soil therefore increasing surface runoff.

Urbanization

Leads to the replacement of permeable soil therewith of associate degree colorfast layer of pitch and concrete, through that water cannot infiltrate. This ends up in enlarged surface runoff that results in flash flooding.

Improper waste disposal

Oftentimes, garbage that's not properly disposed enters into drain systems and clogs drains. This obstructs the free flow of the water that enters into these drains inflicting water to keep a copy throughout rain flooding the encircling space. A build from ash bin additionally impede the natural flow of water in rivers and streams.

Quarrying

Quarrying is that the clearing of land for the removal of aggregates (mainly sand and gravel) that is to be utilized within the industry. The action of production leaves land blank and empty any trees and shrubs therefore increasing surface runoff created.

3.4 Types of Flooding

a. Riverine Flooding

River flooding is one of the most common types of inland flood; occurring when a body of water exceeds its capacity. To prevent flooding, rivers needs good defenses, especially in flat or populous areas. They are caused when water runoff collects in rivers and streams and eventually reaches levels that overflow the banks. When this occurs, the flood can cover an enormous area and affect downstream areas even if they didn't receive much rain themselves. Besides heavy rainfall, snowmelt and ice jams can cause rivers to top their banks. Although river flooding can be predicted, its effects, even over a longer period of time, can cause extensive damage to residents living near rivers and streams.

b. Flash Flooding

Flash flooding is caused by heavy and sudden rainfall, flash flooding happens when the ground cannot absorb the water as quickly as it falls. This type of flood usually subsides quickly, but while it lasts can be fast-moving and dangerous. Flash flooding can be prevented by good drainage systems and by avoiding over-development on floodplains.

c. Urban Flooding

Urban floods can be caused by flash, river or coastal flooding but most commonly, it is caused by high rainfall rates over developed areas that do not have the ability to absorb the water. Urbanization can increase water runoff as much as 2 to 6 times over what would occur on natural terrain. These floods can cause high economic damages to businesses and homes. Urban floods are also caused by improper land use planning.

- "Urban flooding is specific in the fact that the cause is a lack of drainage in an urban area."(Floodsite.net)
- "Urban flooding is significantly different from rural flooding as urbanization leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times"(NDMA)
- "Urban flooding caused by rainfall overwhelming drainage capacity." (Parliamentary Office of Science and Technology, UK)

- "Urban floods are the inundation caused by heavy rainfall, drainage congestion and water logging."(RAJUK, Bangladesh)

"Urban flooding is the inundation of land or property in a built environment, particularly in more densely populated areas, caused by rainfall overwhelming the capacity of drainage systems, such as storm sewers."

a. Coastal Flooding

These floods occur when ocean water is pushed inland. Hurricanes and tropical storms can cause large waves and actually raise the sea level, creating storm surge along beaches. Earthquakes can displace large amounts of water that cause waves called tsunamis to rush inland. On a much smaller scale, extremely high tides, sometimes associated with a full moon can cause minor coastal flooding.

b. Groundwater Flooding

As opposed to flash floods, groundwater flooding takes time to occur. As rain falls over an extended period, the ground becomes saturated with water until it cannot absorb any more. When this happens, water rises above the ground's surface and causes flooding. This type of flooding can last for weeks or sometimes even months.

3.5 Factors of Urban Flood

Floods are one of those hydrological phenomena that occur due to an exceedingly complex sequence of natural events. Therefore, prediction of such events is possible only when there is complete understanding of causes of flood-proceeding events in a basin. The frequency, duration and magnitude of floods are determined by numerous factors.

Physical damage to assets:

1. Buildings
2. Contents
3. Infrastructure

Tangible

4. Loss of life
5. Health Effects
6. Loss of ecological goods

Intangible

Indirect Losses are-

1. Loss of industrial production
2. Traffic disruption
3. Emergency costs
4. Inconvenience of post-flood recovery
5. Increased vulnerability of survivors

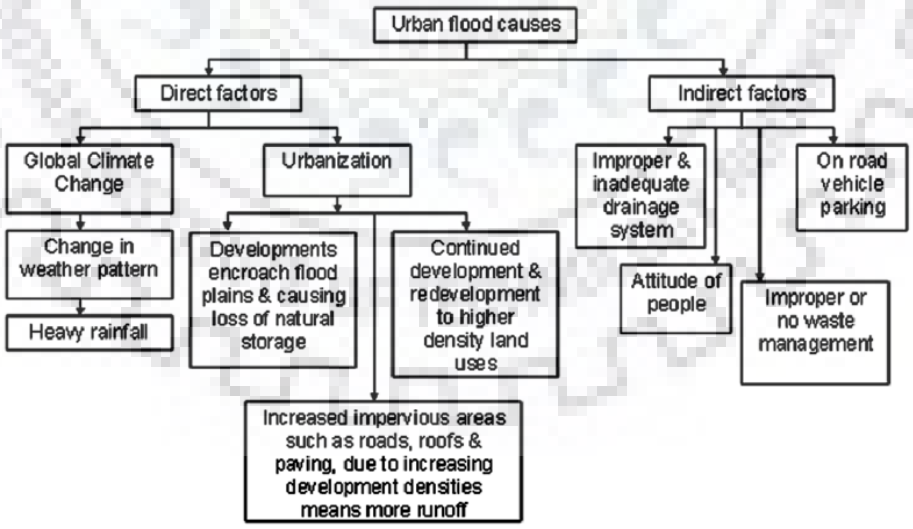


Figure 4 Factors of Urban Flood

3.6 Impacts of flooding

Urban floods are a great disturbance of daily life in the city. Roads can be blocked, people can't go to work or to schools. The economic damages are high but the number of casualties is usually very limited, because of the nature of the flood. The water slowly rises on the city streets. When the city is on flat terrain the flow speed is low and you can still see people driving through it. The water rises relatively slow and the water level usually does not reach life endangering heights.

- Injury or death to individuals and animals.
- Injury to homes and property and necessary possessions like furnishings, electrical appliances, etc.
- Sustenance of individuals as a result of floods destroy crops, farmlands and eutherian mammal.
- Food shortage.
- durable floods will disturb routine cultivation pattern.
- Eroding will occur when floods. Lands are sometimes coated with trash, sand or boulders which can cut back farming areas and fertility of soil.
- Injury to infrastructure and facilities like hospitals, clinics, schools, roads, railways, phone lines and electricity provides.
- Disruption of unpolluted water provides and contamination of sources of water which might later on cause diseases.
- Triggering of epidemics, water borne diseases, facilitate mosquitoes to breed leading to the unfold of protozoal infection and dengue fever.
- Stream or stream bank erosion wherever land adjacent to the most channel and tributaries is worn away by the sturdy floods currents. This event are often aggravated by such factors as in depth clearing of ingrained, natural vegetation on the banks for agricultural and concrete development, weakening the soundness of the stream or stream banks towards the erosive force of flood flows.
- Any disaster will have a profound impact on people's emotional prosperity touching their feelings, thoughts, actions, and relationships. The sharp over whelming disruption and danger to life and property will place tremendous psychological pressure on an individual, typically even touching however well he/she is ready to perform at the time of the crisis. The impact a disaster will wear an individual conjointly depends on his/her

past experiences of crises, however well he/she has been ready for such events each physically and mentally and his/her angle or level of resilience.

3.6.1 Urban Flood Loss/Damage

The magnitude of the injury depends on the flood sort (especially in terms of depth, flow rate, water quality, period and sediment load). whereas in rural square measureas the damages because of floods are principally direct in terms of loss of agricultural production, the damages in urban context square measure additional complicated. though the impacts of urban floods square measure virtually completely adverse, it ought to be unbroken in mind that riverine floods in rural areas usually have positive ecological effects. Damages because of floods is classified in these categories-

Direct losses: Losses ensuing from direct contact with flood water, to buildings and infrastructure.

Indirect losses: Losses ensuing from the event however not from its direct impact, for instance, transport disruption, business losses that can't be created up, losses of family financial gain etc. In each loss classes, there square measure 2 clear sub-categories of loss:

Tangible losses: Loss of things that have a financial (replacement) price, for instance, buildings, livestock, infrastructure etc.

Intangible losses: Loss of things that can't be bought and sold-out, for instance, lives and injuries, heritage things, record etc. (WMO, March 2008).

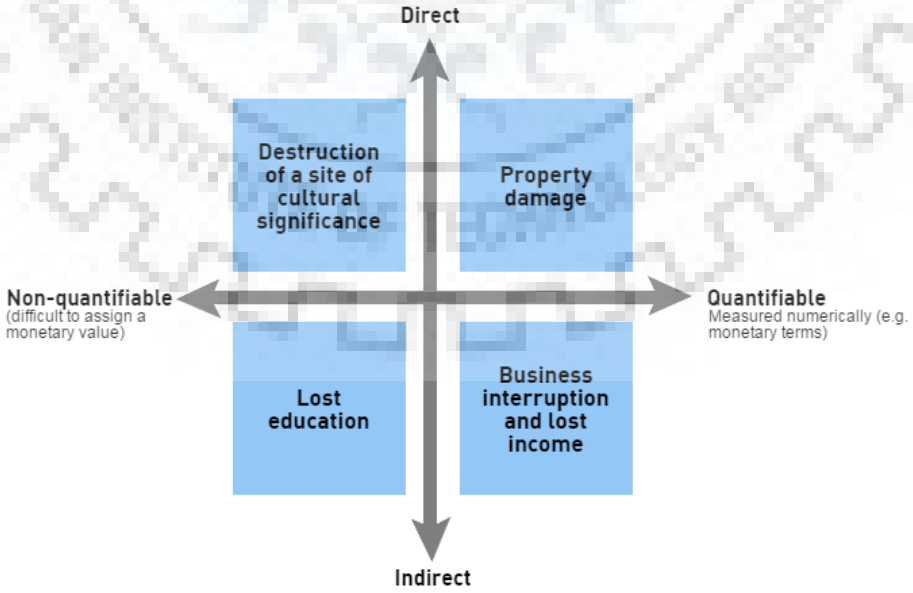


Figure 5 Direct Indirect Losses in Flood

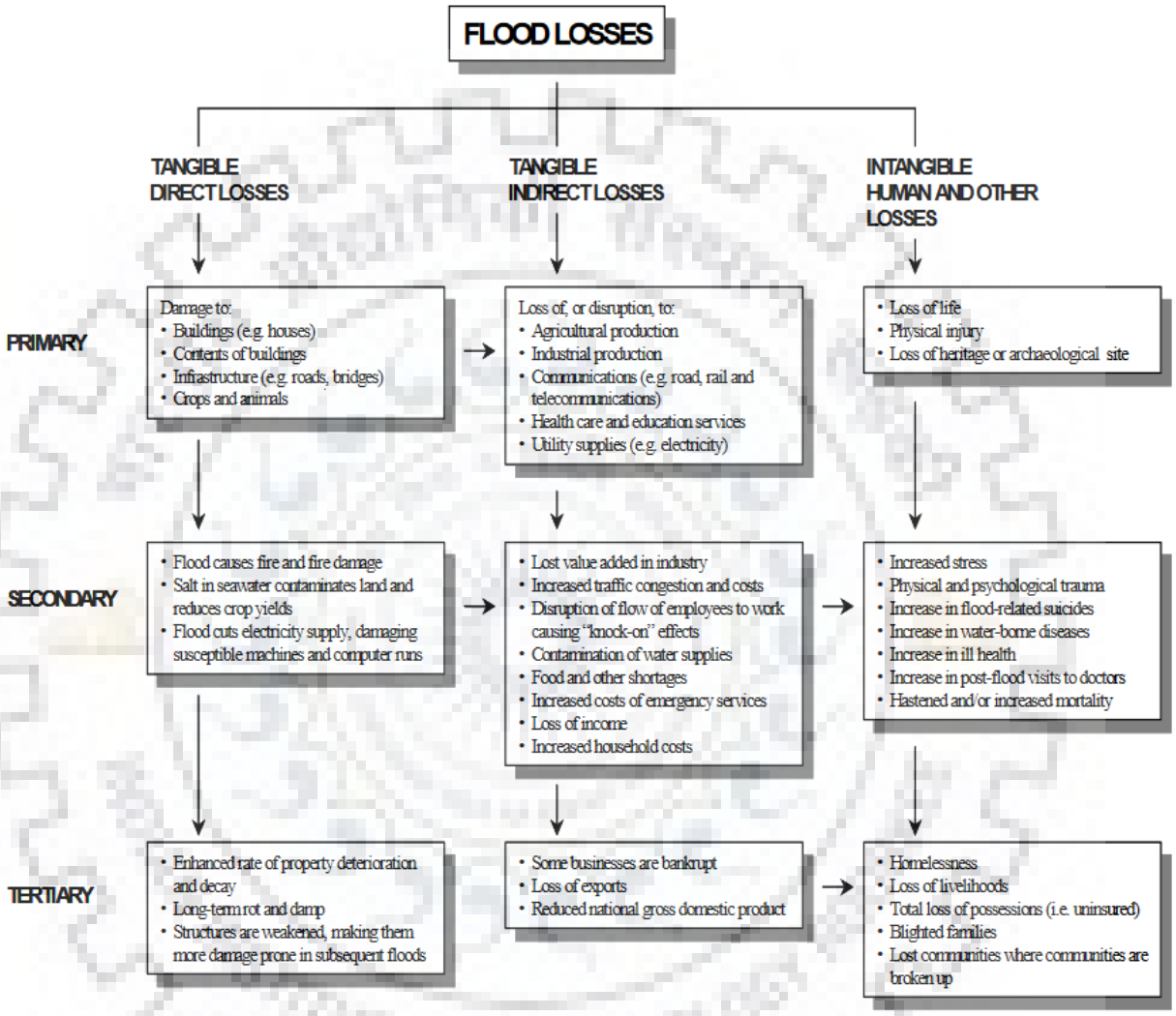


Figure 6 Categorization of Flood Losses Source- APFM, 2008

3.6.2 Vulnerabilities to flooding:

Vulnerability describes the characteristics and circumstances of a community that build it vulnerable to the damaging effects of a hazard. The following will build United States of America a lot of liable to flooding:

Physical

1. Building homes on the stream bank or on flood plains.
2. Constructing new housing settlements while not rising the prevailing system, so overwhelming the system.
3. The development of residential or industrial buildings while not taking into thought this and future flooding impacts will increase ones vulnerability.
4. Living near to the coast will build one liable to storm surges and coastal flooding.
5. Lack of maintenance of drains and waterways.

Social

1. Lack of education on the causes and mitigation measures that one will use to scale back the results of flooding.
2. Family Structure- feminine headed households and households with an outsized range of dependencies are thought about to be a lot of liable to the negative impacts of disasters.

Economic

1. State impairs the quantity of financial resources that one to scale back one's vulnerability to flooding.
2. Debt reduces ability to live through flood damages
3. Living in coastal areas susceptible to coastal flooding due to bread and butter, e.g., fishing.

Environmental

1. Deforestation or the removal of forest or vegetative cowl from land would lead to accrued flooding and would increase an area's vulnerability.
2. Pollution and also the indiscriminate marketing of garbage into drains and waterways would increase flooding events.
3. Forest fires/bush fires leave the land barren and empty of vegetation that will increase surface runoff and will increase one's vulnerability to flooding.

3.7 Urban Flood Risk

Urban Flood risks are a function of economic activities and exposure of people along with the vulnerability of social and economic fabric (APFM 2008). Exposure refers to whether or not people or values are in range of flood water (APFM 2008).

A number of urban characteristics are responsible particularly in low and middle income countries that have relevance to increase Flood risk:

- Concentrated population due to rigorous income earning opportunities;
- Construction of buildings large impermeable surfaces ;
- Without any formal disposal systems management of solid and liquid waste hampered;
- Congested drainage systems;
- High economic activities;
- High value of properties and infrastructure ;
- Increase the number of informal settlement;
- Unhealthy environment; and
- Changes in regions around cities.

This is also affected by socio-spatial segregation. With urbanization, land prices increase and as a result low-income people are forced to choose flood prone areas. These people are always suppressed to get support from government for the betterments of their living conditions.

3.7.1 Urban Flood Risk Management

Urban Flood Risk Management is a process for assessing flood risk, evaluating options to manage the risk, and implementing a strategic plan to reduce risk. Frequency and magnitude of flood in a urban area related with urbanization trend and population growth of that area. Flood risk is affected by some development activities in urban areas, such as water supply and sanitation, housing settlements, pollution control, transport systems, industrial activities; health and social welfare etc. The conceptual framework of urban flood risk management (UFRM) (figure 3.8) is based on three concepts (APFM 2008):

- Integrated Flood Management (IFM);
- Total Water Cycle Management (TWCM);
- Land-use Planning.

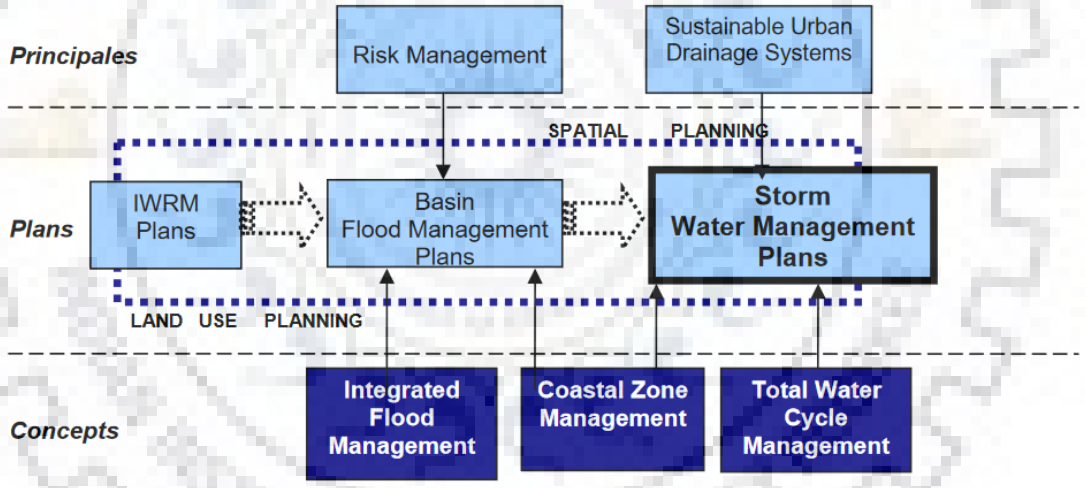


Figure 7 The conceptual framework of Urban Flood Risk Management, Source: APFM 2008

3.7.2 Integrated Flood Management (IFM)

The Integrated Flood Management (IFM) approach aims to maximize the productivity and efficient use of floodplains and coastal zones, while minimizing the loss of life and impact on livelihoods and assets through protective measures.

The IFM concept is based on the following principles:

• Take as a basin approach;

• Indulgence floods as part of the water cycle;
• Incorporate land and water management through an integrated manner ;
• Adopt a mix of strategies assembled with risk management approaches;
• Allow cooperation between different agencies; and
• Guarantee a participatory approach. (APFM, 2008)

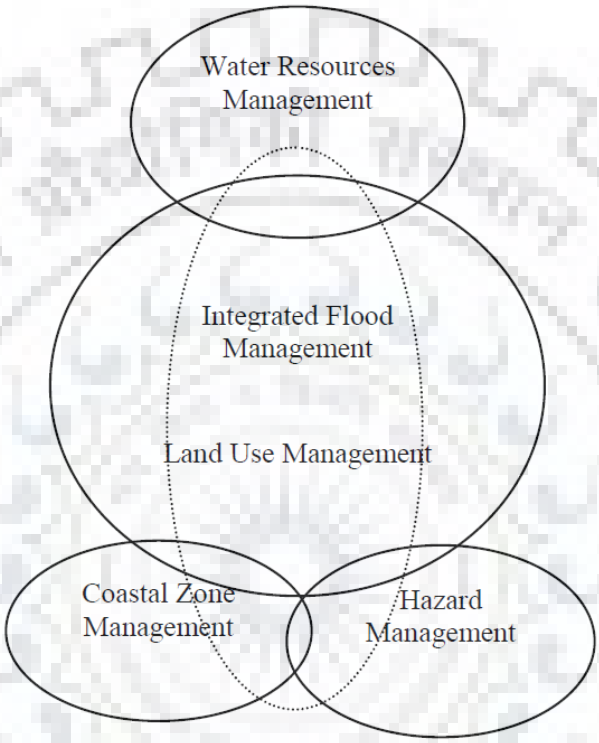


Figure 8 The Conceptual Model of IFM, Source: APFM, 2004

3.7.2 (a) Total Water Cycle Management

Total Water Cycle Management (TWCM) planning objects to consider all elements of the water of the water cycle to deliver the community's needs and aspirations for water in a way that enhances social and environmental benefits and reduces costs.

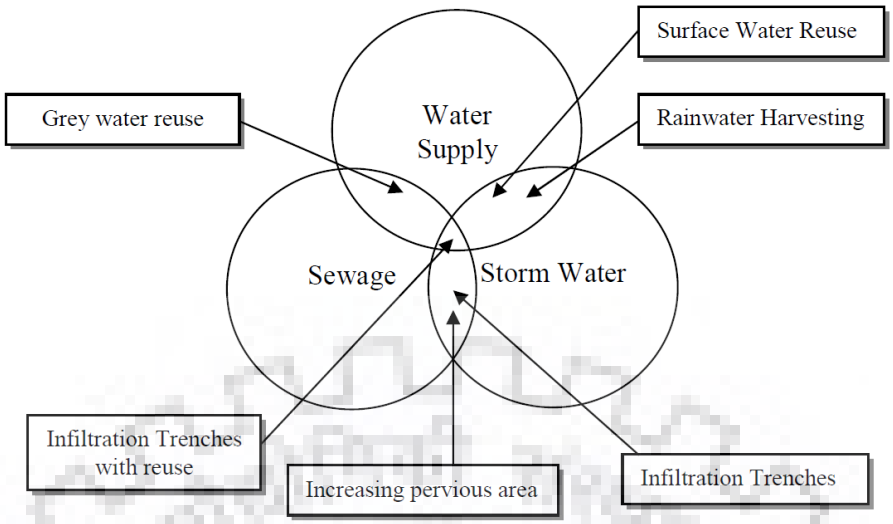


Figure 9 The Conceptual Model of Total Water Cycle Management, Source: APFM, 2008

The key principles of TWCM as follows:

- Natural Cycles - minimising water quality regimes and the alteration to natural flow
- Sustainable Limits - ensuring that the amount of water dig up from a source is sustainable for the community and the environment;
- Water Conservation – utilizing the all water resources and minimizing water demand through equitable distribution
- Diversity in New Supplies - bearing in mind all potential sources of water when new supplies are needed including reusing water and storm water;
- Water Quality – managing water quality.

To prevent future urban flood risks to both the site and its surroundings, Sustainable management of the urban drainage system is an essential element of TWCM (APFM, 2008). To reduce flood risk, improve water quality, recharge groundwater and enhance the potential biodiversity Sustainable Urban Drainage System (SUDS) aims at. The principle of SUDS comprises of run-off prevention, source control both local and regional results both from sources external to the development site and rain falling onto and around the site.

3.7.2 (b) Land use Planning

Flood management plan and Land use plan need coordination and close integration between them. However, many countries are struggling to plan suitable policies and organizational instruments that would facilitate such integration.Vital characteristics and the aims of those planning processes and policies have been determined. These are executed by different stakeholders and decision-makers as well.

It is a risk-based approach. Planning actions can diminish development in flood-prone zones; reduce water runoff through development controls for flood risk extenuation; designate routes and open spaces for better response and recovery efforts; mitigate damages from unavoidable floods; and accommodate urban growth and expansion in flood-safe areas—including through resettlement and reconstruction, when it is important to promote "build back better" practices within a risk-based land use planning framework.

- To reduce the inherent causes of flooding and ensure further development gains, risk-based land use planning must be prioritized by city.
- Land use planning to manage flood risks must balance competing needs.
- Land use planning offers many opportunities to manage floods in all stages of the disaster risk management cycle.
- Cities have used several land use tools to manage floods with varying degrees of success.
- Integrating flood risk in the land use planning process can be challenging, requiring coordination among multiple stakeholders and institutions, both formal and informal, as well responsible decision making. (UFCOP, April 2017).

3.7.2 (c) Participatory Approach

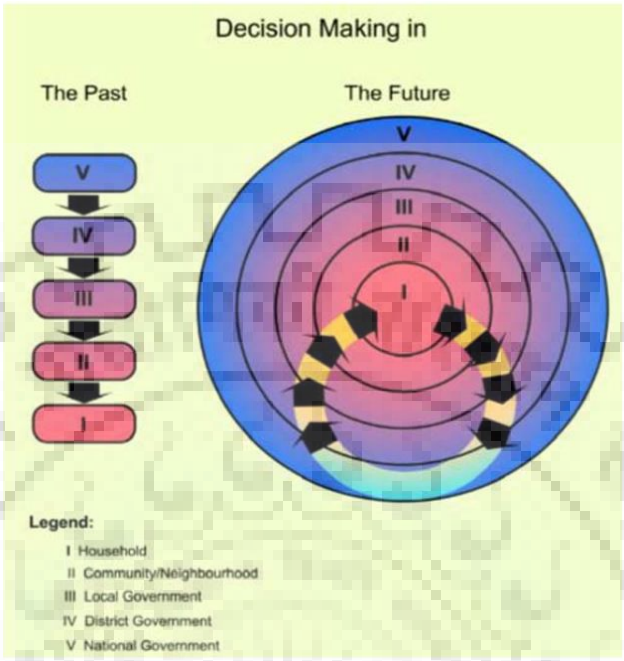


Figure 10 Way of Decision Making, Source: APFM, 2008

Participatory approach ensure the participation from local government district government, national government and from household as well in urban flood risk management. In this context decision making is understood as a combination of top-down and bottom-up approaches which enables the involvement of all stakeholders on the basis of equity. The process where the aspirations, concerns, capabilities and participation from local household to communities to local authorities to district and national institutions are adequately input in an iterative manner is shown in Figure 3.9. (APFM, 2008)

This approach deals with-

- Representatives of authorities in related fields such as land use planning or nature conservation and/or
- Stakeholders like non-governmental organisation (NGOs) and/or people or institutions who/which might be affected by management and planning issues (e.g. nature protection organisation, water users, business or potentially affected citizens) and/or.
- The general public who could be more or less directly affected by water and flood risk management issues and potential impacts by measures.

3.8 Sustainable Urban Drainage Control Systems

Increased urbanization causes redoubled flash flooding when explosive rain in several cities. because the space loses its ability to soak up fresh water, rain is directed to drain systems that causes urban flooding. the concept behind urban drain management systems is to empty away dirty and surface runoff through assortment, storage and cleansing before permitting it to be free into water courses. Past efforts were principally directed towards control of populated area with the pollution control being largely unnoticed.
Currently, it's necessary to develop style methodologies for each flood and pollution management within the town like Old Delhi as a result of there's serious pollution load in watercourse Yamuna. This criteria utilized in determinant water amount volumes in urban drain management systems design neglect precursor conditions ensuing from preceding rain. throughout the dry amount between rain events, treatment of storm water return and is taken into account complete when a selected fundamental measure. The inter-event-dry period refers thereto fundamental measure that happens between rain events.

It is terribly tough to determine SUDs in associate urban town like Old Delhi, India. there's no house accessible within the town to develop a brand new drain pattern. Therefore, it's necessary to follow associate integrated approach wherever engineers and planners should develop SUDs together with the present drain patterns within the town. From the GIS study, it had been conjointly found that another choice is to develop filter strips, ponds, basins, swales etc. close to bank of the watercourse Yamuna since waste material from the agricultural land pollutes the river directly. For Old Delhi city, the EMC’s of various physio chemical storm-water pollutants are calculable for various stations. (Nikita Jaswal, 2015)

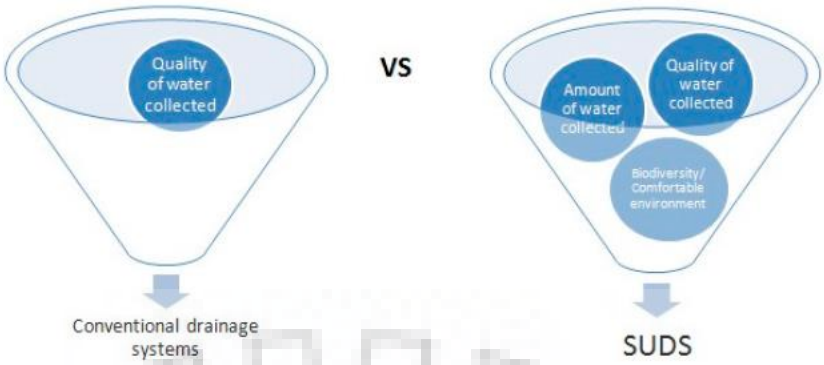


Figure 2. Comparison of conventional drainage systems and sustainable urban drainage systems (SUDS).

Figure 11 Sustainable Urban Drainage System

Land-use classification using GIS and remote sensing has been done. The next step is to study in detail the existing drainage pattern of the city and to locate the hot-spots for establishment of SUDs. In NCT, India for different scale, diffuse pollution problem can be tackled using following methods:

- Source Control: Constructing the filter drains, strips, infiltration trenches, PPS, soakaways and swales are required.

- Site Controls: Detention basins, filter drains, infiltration basins, soak-aways and swales can be established.

- Regional Controls: The treatment facility under this type of control incorporates retention ponds, storm-water wetlands and enhanced extended detention basins.

3.9 Green Infrastructure in Flood Management

Green Infrastructure (GI) is an approach that focuses on using natural processes for dealing wet weather impacts while conveying environmental, social, and economic benefits.
It is an interconnected system of natural areas and open space that:

•conserves ecosystem values,
•helps sustain clean air and water, and
•provides benefits to people and wildlife.

"Green infrastructure is a proactive, systematic, multifunctional model that views open space on a large scale and better integrates open/green space planning with other efforts to manage growth and development. It essentially uses stormwater storage areas, water conveyance areas and other natural flooded areas as part of the community infrastructure for stormwater and flood damage reduction, as well as for parks, trails and other recreation areas."(ASFPM)

3.9.1 Benefit of Green Infrastructure Solution

GI is an integrated approach it has so many positive aspects in reducing Flood risk. GI solutions include wetlands, bio shields, buffer zones, green roofing, street side swales, porous pavements, wetlands, mangroves, etc.

• Through this method we will determine elements of Flood risk and its importance.
• This solutions provide a complementary approach that decreases the flow of stormwater by connecting it to neighboring natural storage and overflow systems.
• It will scale back the danger of urban flooding by dominant surface runoff.
• GI additionally permits for a a lot of controlled method of evapotranspiration within the drainage area, that drains the water related to downfall associated rivers in an urban settlement.
GI will facilitate promote associate economic climate that draws high-value businesses and professionals.

3.9.2 Case Study: Urban Flood Management in Chennai City

Chennai, State capital of Tamil Nadu lies in the Eastern Coast of South India where three watercourses meanders through it namely, Cooum River, Adyar River and Buckingham Canal. Chennai is the fourth largest Metropolitan in India having a total population of nearly 47 Lakhsi with a growth rate of 13% and density of 26903. Within a century, Chennai has grown 8 fold times in population

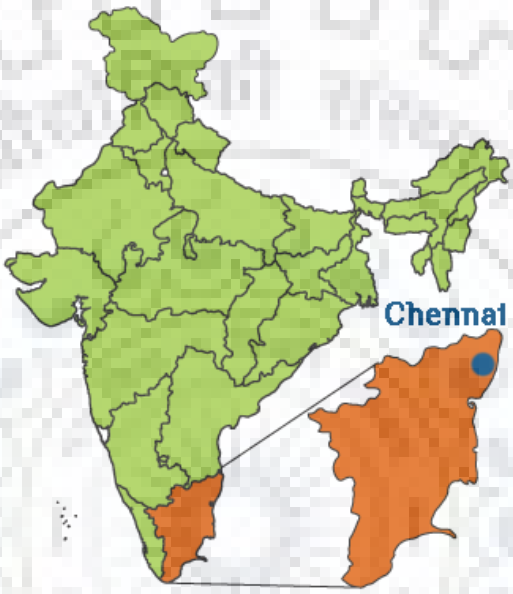


Figure 12 Map of Chennai City

Figure 13 Flood Scenario in Chennai

Growth of Chennai City

Chennai, having a plain terrain is bounded by Bay of Bengal in the East with an average elevation 6.7m from the mean sea level.

Chennai experiences most of its rainfall during October to December associated with Depressions & frequent cyclones during this period. Average annual rainfall is about 1200 mm – 1300 mm being situated on the coastal side.

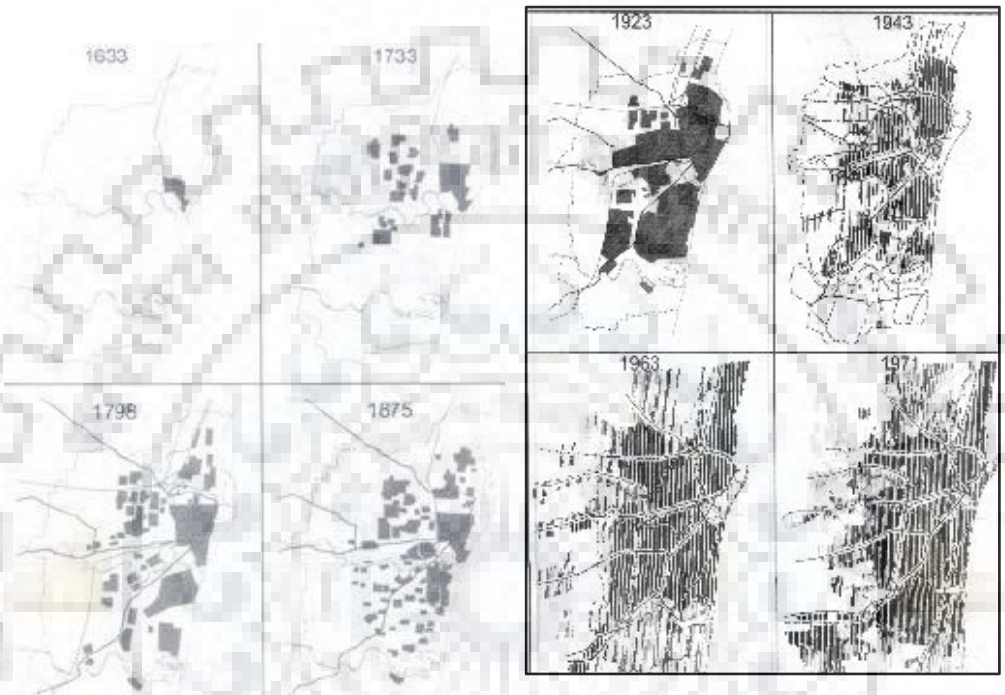


Figure 14 Growth of Chennai City

Causes of Chennai Flood

Chennai is not an exceptional one from other metros which is suffering due to rapid urbanization. It is also contributing with the increase in floating population every year as it is a hub of all major economical activities. The following are the factors[1] which hamper the living in Chennai due to floods though it can be categorized broadly under changes in climate & micro-regional environmental factors.

Direct Indicator

Heavy rainfall

- Chennai accounts to frequent flash floods due to consistent increase in the amount of rainfall also, out of which during 2005, 2008 & 2010 are considerable one (F*igure 3*).
- The city gets most of its seasonal rainfall from the north–east monsoon winds during mid of October to mid of December.
- Cyclones in the Bay of Bengal also sometimes hit the city.

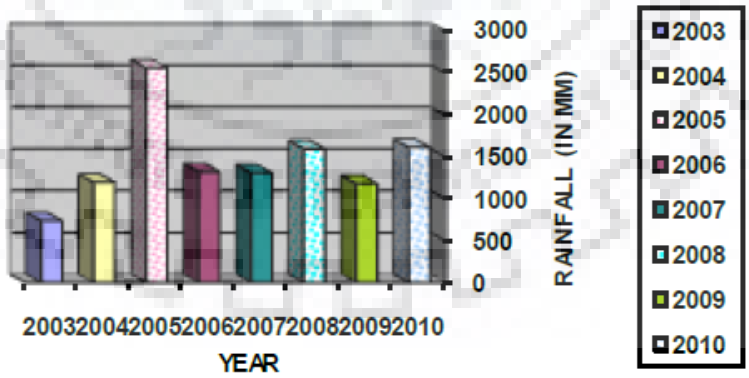


Figure 3. Average annual rainfall in Chennai(Source: Chennai Meteorological Department)

Urbanization

- As a known factor, the urbanization of any area is closely linked with the economic activities & the facilities provided in a particular area, Chennai - the capita l city of Ta mil Nadu is also linked with numerous economic prospects & the facilities also.
- It is flooded with number of employment prospects & henceforth the facilities so as to cater the current & future needs. Chennai has a large migrant population which accounts to 22% o f Chennai's population in 2001.
- Due to this, the encroachment of all water bodies as slums & for the development of urban infrastructure reduces the rain water carriage capacity of the few existing water ways.

Encroachments along Coouum River

MRTS Station, Mandaveli

Existing Mitigation Measures in Chennai

- Flood Alleviation Scheme funded by Government with a cost Rs.3000 million was launched in 1998 focusing mainly on structural measures with the objectives like adequacy of flow in the arteria l drainage system, safeguard against tidal and fluvial flooding, re moving impediments, relocation and rehabilitation of encroachers.
- Cleaning of certain waterways and lakes was also undertaken under packages 2 and 3 of the scheme.
- Chennai City River Conservation Project wh ich was launched in 2000[2] is aimed to imp rove the waterways, with an estimated outlay of Rs.17, 000 million.
- The Master Plan 1992–1993 incorporated Madras Metro Flood Relief/ Storm Water Drainage study outcomes in the form of structural and non-structural measures.

Recommended Mitigation Measures for Chennai City

1. *Preparation of Topographical Map*
2. *Distinguished Chennai River Restoration programme.*
3. *An integrated approach in Flood control and Management.*
4. *Clearing off the encroachments near the water bodies.*
5. *Scientific study about flood pattern.*
6. *River-front water development*
7. A *rapid assessment of flood inundation mapping .*
8. *Water shed management*
9. *Increasing Green cover*
10. *Public awareness*

3.9.3 Case Study: Integrated Flood Management in Jakarta

Greater Jakarta is the political and economic centre of Indonesia. It has an estimated population of about 28 million and accounts for a quarter of the Indonesia's non-oil GDP. Jakarta is located in a flat low-lying fan-shaped region intersected by thirteen rivers originating from the mountains to the south. Around 40 percent of the city is between one to one and a half meters below sea-level. Every year, large parts of the city are flooded during the rainy season. Floods were especially severe in February 2002 and February 2007. During the latter event, 36% percent of Jakarta was inundated with floods up to seven meters deep, causing over 70 deaths and displacing 340,000 people. In November 2007 rising sea tides created "little tsunamis" with gushing water inundating hundreds of houses in the low-lying neighborhoods in the northern part of the city. The floods in 2008 caused 30 deaths and shut down Jakarta's international airport for three days. Floods have caused severe disruption in the city: BAPPENAS, Indonesia's National Development Planning Agency, estimated the financial losses from the 2007
flood at US$900 million. However, the total socio-economic losses are significantly higher, and include loss of human life, health costs, labor and school days lost.

The objectives of the West Jakarta Flood Control System Project were:

–To construct the Sarinah/Thamrin Drainage Pumping Station and the Grogol/Sekretaris Interceptor in order to better control floodwaters in the west Jakarta region.

–Construction of the Cengkareng Floodway (non-ODA loan project).

–Repairs to Melati Regulating Pondage, Cideng Thamrin Waterway, and Krukut Waterway.

–Improvement of outlet works for Pluit Regulating Pondage.

BACKGROUND STUDY ON DHAKA CITY

4.1 Geographic Location of Dhaka City

Megacity Dhaka, the capital and the most densely populated city of Bangladesh, is located in the central region of Bangladesh, which is the flat deltaic plain of the three major rivers - the Ganges, the Brahmaputra and the Meghna. The city is surrounded by the distributaries of these three major rivers - the River Buriganga on the south, Turag on the west, Tongi khal on the north and Balu River on the east. Dhaka is situated between 23°42' and 23°54' north latitudes and 90°20' and 90°28' east longitudes. The geographical location of the city is given in Figure 13.

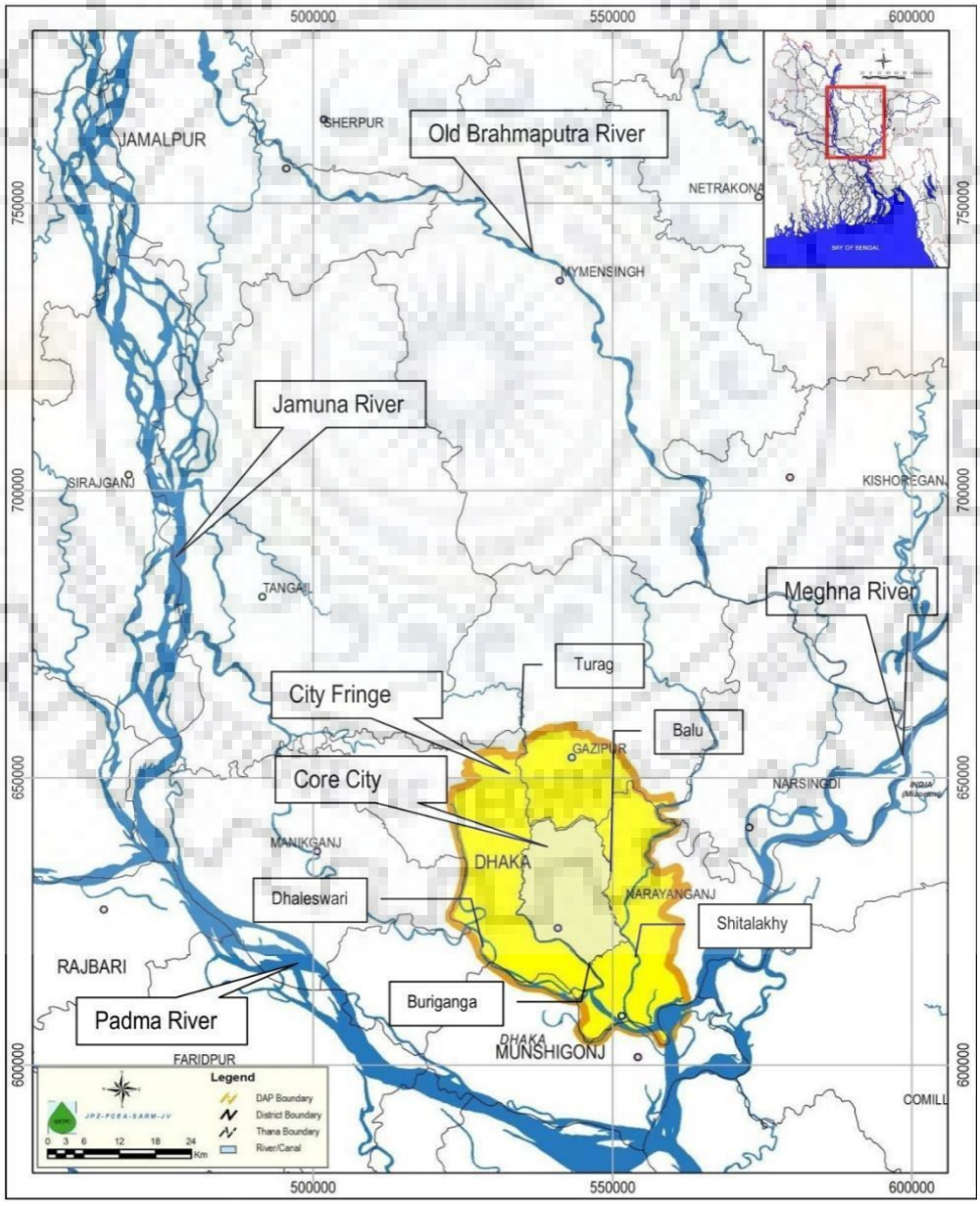


Figure 16 Geographical Location of Dhaka City (Source: RAJUK, 2013)

In spite of its water confinement on all sides Dhaka is considerably high above the water of surrounding rivers in ordinary seasons of inundation. The elevation of Greater Dhaka lies between 2 to 13 m above mean sea level (msl). Most of the urbanized area lies at the elevation of 6 to 8 m above msl. Dhaka's increasing growth and primacy is partly explained by its geographic location. Being centrally located enjoys good accessibility with rail, road, water and air connections with all major towns and cities of Bangladesh (Islam, 2001 in Islam (ed.), 2001).

4.1.1 Institutional Boundary of Dhaka

The study area comprises Dhaka City Corporation (South and North), Narayanganj City Corporation (including old Kadamrasul Municipality) and part of Gazipur City Corporation (including adjacent municipal areas of Savar, and Tongi). Important service providing organizations in this area are Dhaka Metropolitan Police (DMP), Dhaka Water and Sewerage Authority (DWASA), Dhaka Electric Supply Authority (DESA), Titas Gas Transmission and Distribution Limited (TGTDL), Bangladesh Telecommunication Company (BTCL), Rajdhani Unnyan Kortripakhkha (RAJUK), Dhaka Electricity Supply Company (DESCO), Dhaka Power Distribution Company (DPDC) and Department of Environment (DoE) which are serving city dwellers with specific services and facilities. Apart from these, health, education, planning, housing, transportation and other infrastructure related organizations do exist in the city area. Area under jurisdiction of different authorities serving Dhaka also varies. Dhaka Metropolitan Area (DMA) is somewhat larger than the DCC area, and currently holds 49 Police Stations. Dhaka Statistical Metropolitan Area (DSMA) is considered as Dhaka Mega city. Rajdhani Unnayan Kartripakkha (RAJUK) has a Strategic Planning Zone-wise plan of Dhaka city which is known as Dhaka Metropolitan Development Plan (DMDP). It currently consists of total 26 zones of which 19 may cover Dhaka Statistical Metropolitan Area, though the total area is about 1528 km2 (DMDP, 1997). Total areas under different jurisdictions are summarized in **Table 4.1.1**

Table 4.1.1: Different Jurisdictional Area in Dhaka

SL	Name of Area	Total Area (Sq. Km)
1	Dhaka North City Corporation (DNCC)	82
2	Dhaka South City Corporation (DSCC)	47
3	Dhaka Metropolitan Area (DMA)	360
4	Dhaka Statistical Metropolitan Area (DSMA)	1353
5	Dhaka Metropolitan Development Plan (DMDP)	1528
6	Detail Area Plan (DAP)	1528
7	Dhaka Water Supply and Sewerage Authority (DWASA)	360

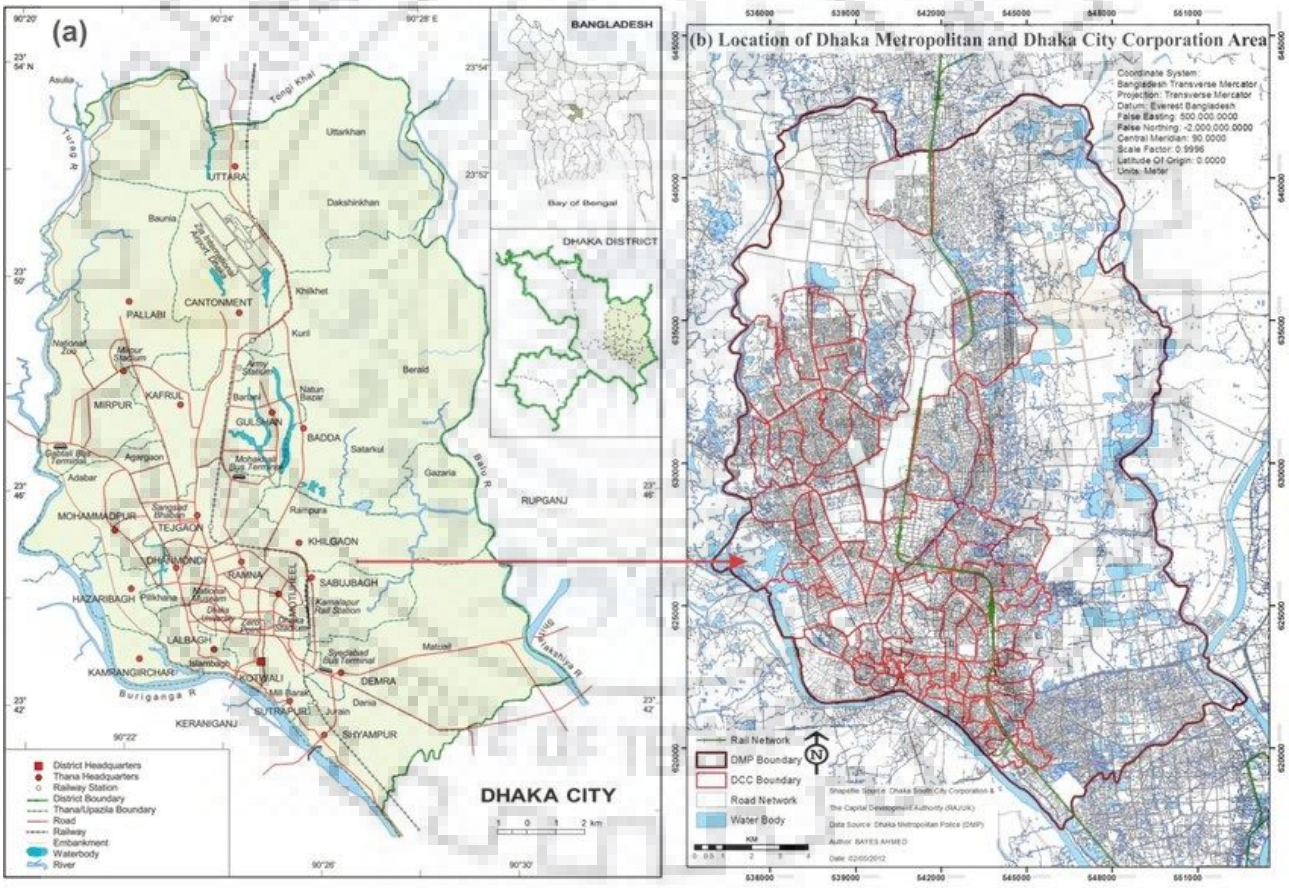


Figure 17 Map of DMDP and DCC

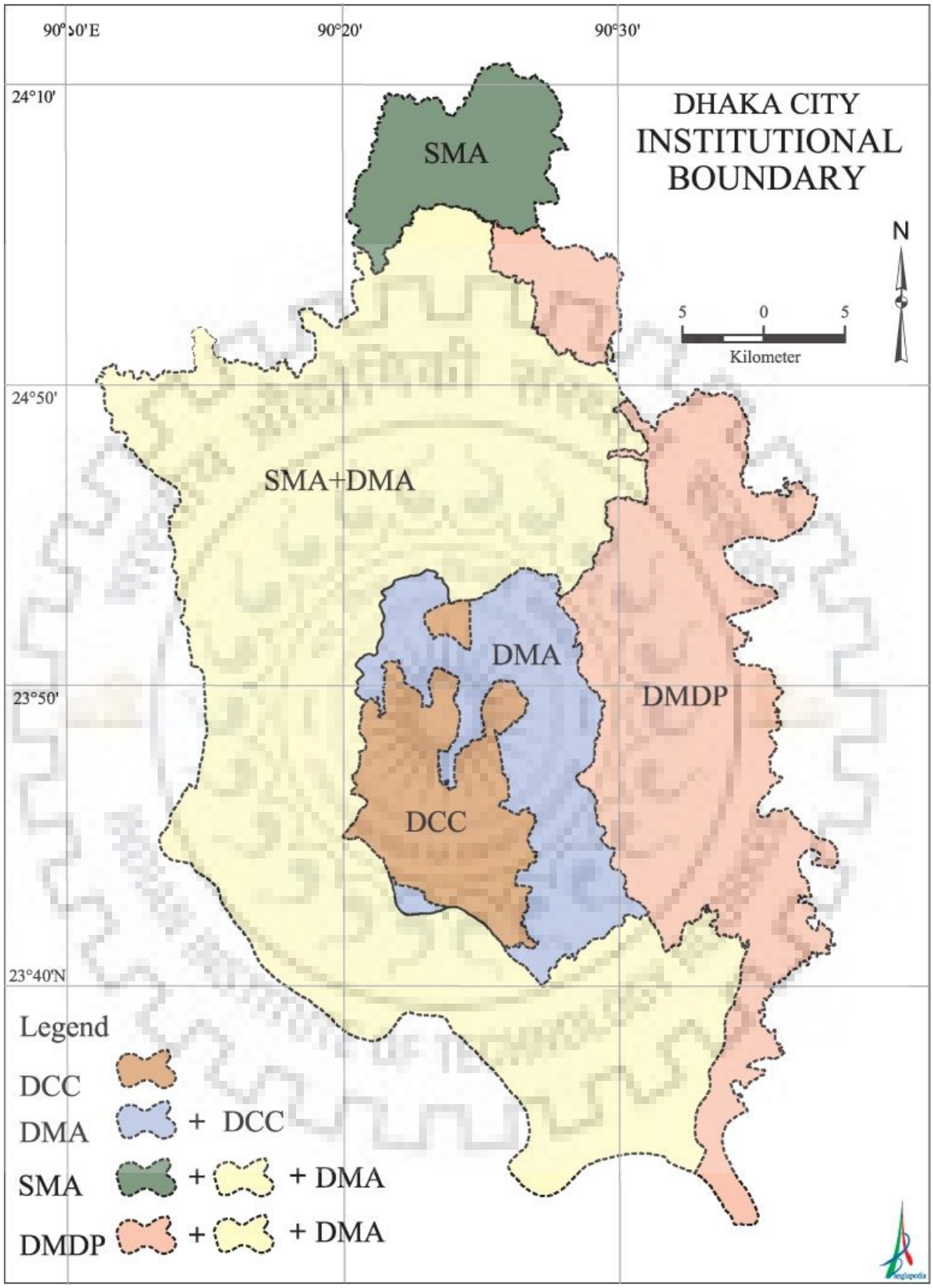


Figure 18 Dhaka Institutional Boundary

4.2 Socio Economic Condition

4.2.1 Population

In global and regional context, Bangladesh population has drawn considerable attention of the social scientists, policy planners and international organizations. Capital City Dhaka has emerged as a fast growing megacity in recent times. It began with a manageable population of 1.6 million in 1974 (according to 1974 censes) which reached 12.04 million in 2011 (2011 census). Its share of national urban population was 25% in 1981, 31% in 1991 and 34% in 2001 respectively. The growth rate of the population during 1974-2000 was 6.9% (UN, 1998). There is no city in the world, which has experienced such a high growth rate in population during this period. The United Nations (1999) describes the rapid population growth of this city as 'exceptional'. The rapid growth of population is sinking this overloaded metropolis. Dhaka City Corporation (DCC) area is the most densely populated area in our study area. It was found that present area under DCC (South and North) is 131 sq km and population density is 64,192 per sq km. Population growth rate in DCC area is 4.65%.

Table 4.2.1: Population of Dhaka City Corporation Area

SL	Year	Area (Sq km)	Population	Density (per sq km)	Growth Rate (%)
1	1981	62.4	2475,710	39,675	5.21
2	1991	131	3839,000	29,305	4.48
3	2001	131	5339,880	40,762	3.35
4	2011	131	8409,151	64,192	4.65

The core city of Dhaka managed to capture just over one-half the population growth, but because of its larger size, the slower percentage growth rate still resulted in half the additional population being in the city (Figure 6). Dhaka thus further confirms the axiom that as cities become larger, they become *less dense.*

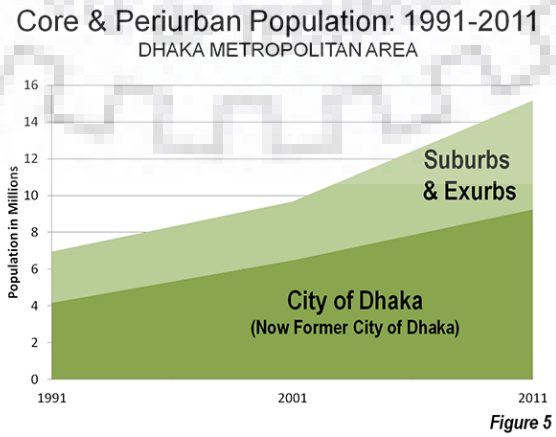


Figure 5

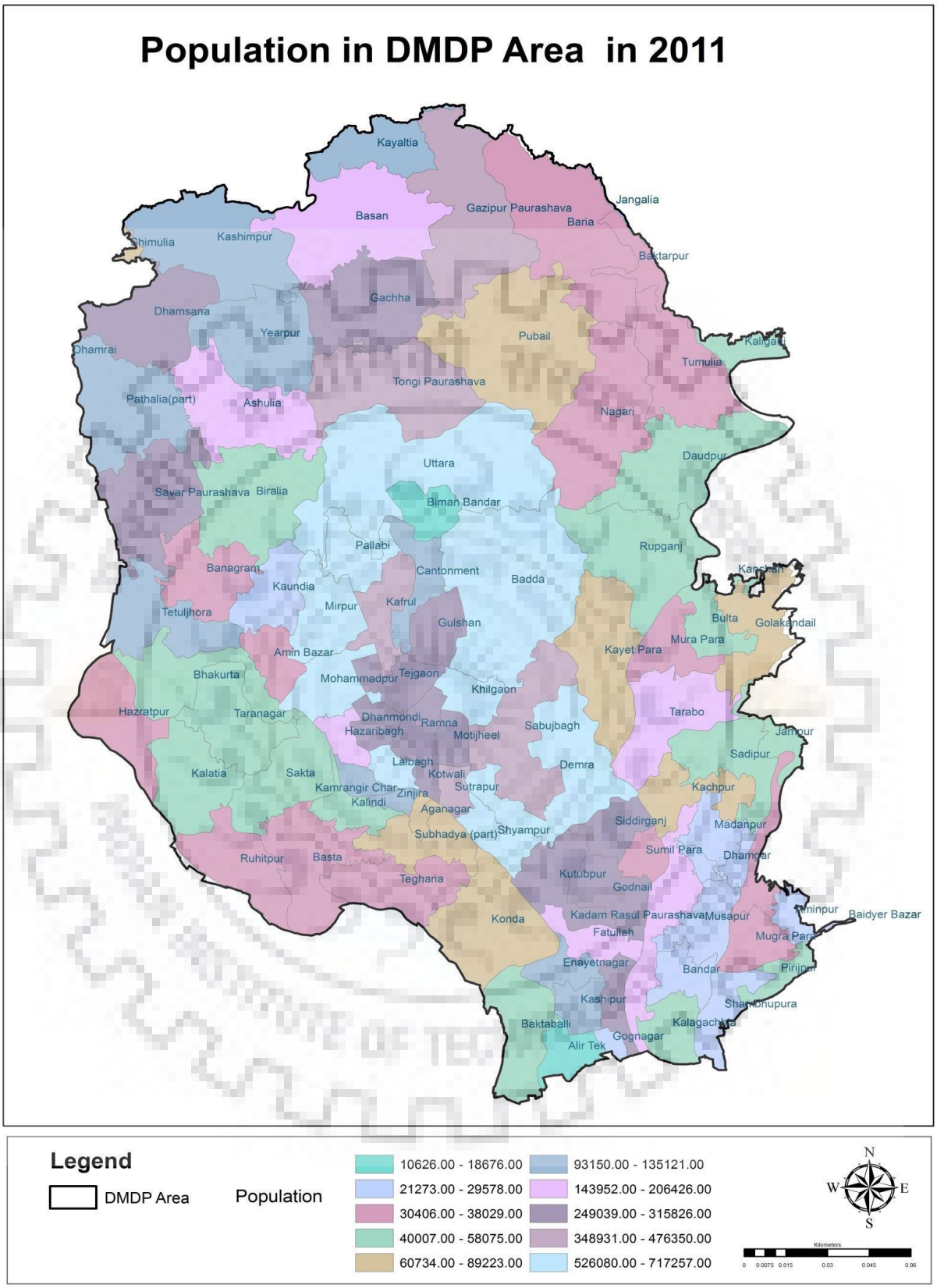


Figure 19 DMDP Population in 2011

4.2.2 History and Growth of Dhaka

The history of Dhaka dates back to 7th century. Under Mughal rule in 1608 A.D., Dhaka, also known as Jahangir Nagar, was founded as the Provincial capital of Bengal. The city was established on the north-eastern bank of the Buriganga River. The Mughal Rulers were attracted to the Buriganga River for communication and defense against enemies. Since then, Dhaka city has grown mainly on the northern and eastern banks of the Buriganga River until 1960s, mainly because of easy transportation (Khorshed, 2003). In 1765 the city came under British control and Dhaka became the capital of Eastern Bengal and Assam province (1905-12). In 1947 the city emerged as administrative capital of East Pakistan. Later in 1972, after the victory in the War of Liberation in 1971, Dhaka became the capital of the People's Republic of Bangladesh.

Increase of population of Dhaka over time series is described in **Table 12**. Population forecasting has been estimated for Dhaka city up to 2040.The distribution of population in DAP area in 2040 is presented in ***Figure 4.2.2***

Table 4.2.2 : Increase of Population in Dhaka City

SL	Period and Year	Approximate Area (Sqkm)	Population	Source
1	1600 Pre-Mughal Period	1	Unknown	Islam, 1974
2	1700 Mughal Capital	50	90,000	Taylor, 1840
3	1800 British Town	8	200,000	Taylor, 1840
4	1867 British Town	10	51,000	Census, 1901
5	1911 British Town	10	125,733	Census, 1911
6	1947 Capital of East Pakistan	12	250,000	Census, 1951
7	1951 Pakistan Period	85	335,928	Census, 1951
8	1961 Pakistan Period	28	550,143	Census, 1961
9	1974 Capital of Bangladesh	40	1,600,000	Census, 1974
10	1981 Dhaka Municipality	62.4	2,475,710	Census, 1981
11	1981 Dhaka SMA	155.4	3,440,147	Census, 1981
12	1991 Dhaka SMA	1353	6,950,920	Census, 1991

13	2001 Dhaka SMA	1530	9,912,908	Census , 2001
14	2011 Dhaka SMA	1530	12,043,977	Census , 2011

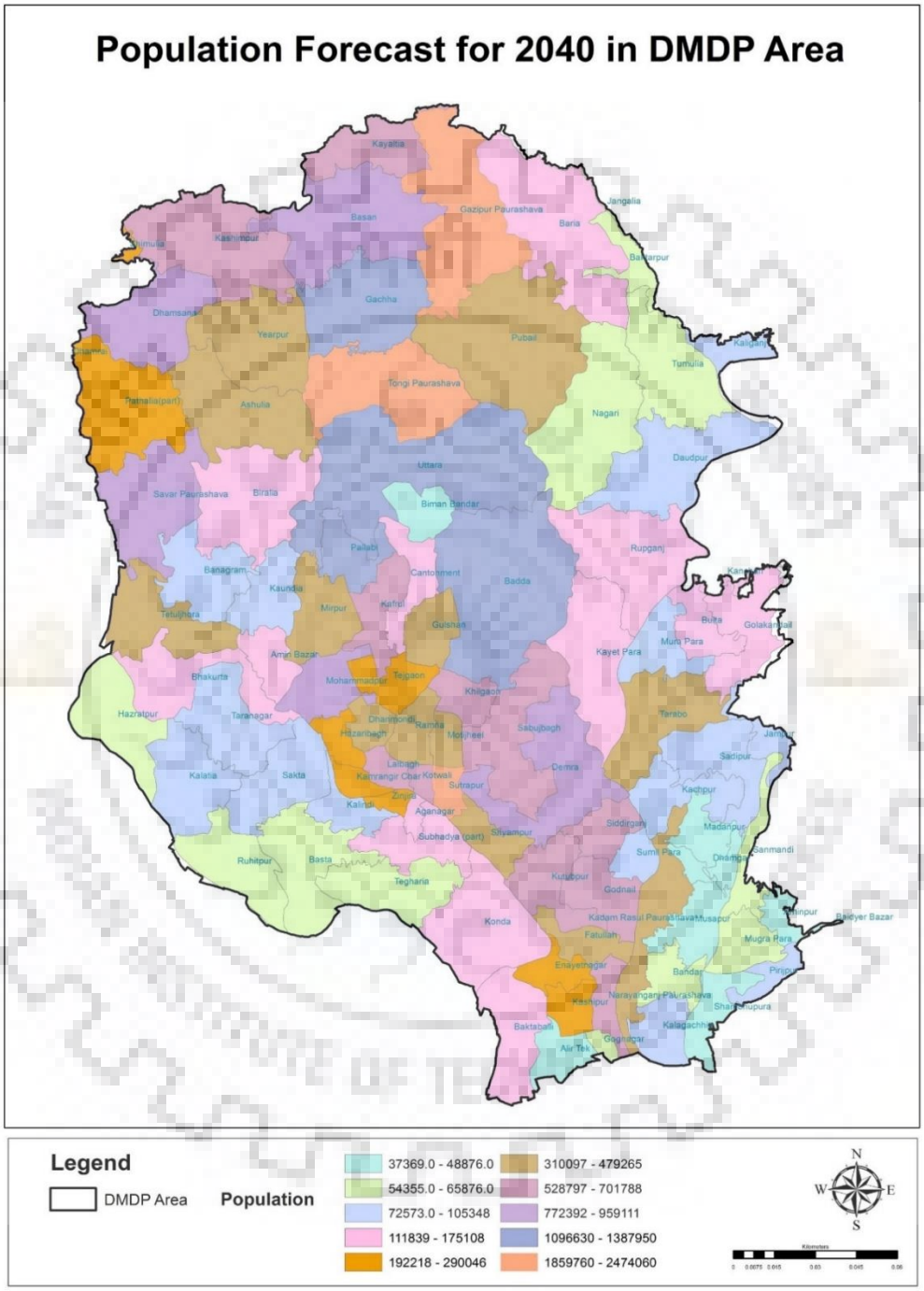


Figure 20 Population Forecast for 2040 in DMDP Area

4.2.3 Household Size

Dhaka is one of the world's fastest growing cities. This rapid urbanization has taken place in last 25 years and the growth rate of the population is 6.9% and almost 50% of these populations live below poverty level. The major portions of this population are migrant urban poor from rural areas for better economic opportunities due to various reasons. According to International Organization for Migration (IOM), about 78% populations of Dhaka city are migrant among which almost 70% migrants are living in slum. Average household size for the urban areas of Dhaka city in 2011 is 4.66 and rural areas is 4.93. Previously in 2001 average household size for urban and rural areas for Dhaka city were 4.26 and 4.15 respectively (Source: Community Report for Dhaka Zila, June 2012, BBS). Literacy rate for male and female here are respectively 69.6% and 58.7%, whereas overall literacy rate is 64.8%.

4.2.4 Land Ownership

Housing or arrangement of shelter is a major challenge for the inhabitants of Dhaka. As migrants are the lion's share of city's population who don't have their owned land here usually this declines the land ownership scenario of the city in a great extent. As long as migrants continue to arrive, they often end up in illegal settlements on precarious lands with major environmental concerns. The real scarcity of developable land is exacerbated by an artificial scarcity, stemming primarily from the current use of substantial amounts of public land in downtown Dhaka. In addition, close to 10 percent of the city's housing stock is publicly owned and held in low-rise building on very expensive land. In a study for the Government of Bangladesh and ADB in 1995, Islam et al. found that only 3.2 percent of the urban poor in Dhaka owned the plot of land on which their dwelling unit was located. The Government has developed a National Housing Policy which reflects an enabling approach to land and housing markets. This Policy, however, has not been implemented effectively. Among the inconsistencies in implementation are the estimated 70 percent of urban development in the City that is informal, large scale evictions of slum dwellers with no relocation plans, and building on environmentally sensitive public lands such as flood or retention ponds.

4.2.5 Income and Expenditure

A study at 2008 by DCC (Baseline Household Survey 2008: Dhaka City Corporation - UPHCP II) shows that the overall income is Tk. 6707 only. Alarming information is that almost 30% households have monthly income below 3,000 Tk. It indicates the extreme poverty level for a major part of Dhaka City's population. This sort of income level reflects as a huge inequality in expenditure distribution pattern for different class group of people. The poor spend the majority of their budget on food (62 %). Other major expenditures are housing (14 %), and other non-food items (14 %). Spending patterns are quite different as compared to the non-poor who spend a much lower proportion of their household budget on food (32%), but a higher proportion on housing (24 %), other non-food items (17 %), transport (10 %), and health and education (11 %)). Both household assets and savings appear to be minimal, though this does vary from household to household. According to "Baseline Household Survey 2008: Dhaka City Corporation" after bearing the monthly expenditure only 33% people living in this city able save something for their future. A good number of people (67%) reaming saving less which increase economic risk and vulnerability.

4.3 Geology and Topography

Geologically the cluster lies on the Madhupur Clay with its average thickness of about 10 meters consists of over consolidated clayey slit and is underlain by the Pleistocene Dupi Tila formation. Most depression and canals are tectonically controlled. Topographically the cluster is almost flat, with many depressions, natural khals, bounded by the Turag River. There are many vacant low lands on the bank of the Turag River, where many brick manufacturing industries exist. The depressions and canals are dominated by organic clay and peats. Topographically the study area is almost flat with slight undulations and stands few meters higher than the surrounding area (**Figure 5**). A large part of the study area is covered by low-lying depressions. The area slopes towards southeast, east and west, but general slope is from the north to southeast where the ground surface merges gently with the floodplains of the Buriganga River. The elevation of the surrounding floodplains of the area is variable. The average elevation of the Buriganga and Lakhya River floodplains are about 3 mPWD. The elevation of study area mostly varies from 0 mPWD to 12 mPWD. The western part of core city area is fully developed and elevation of most area varies from 5 mPWD to 8 mPWD.

On the other hand, eastern part is partly developed elevation of for area is in the range of 0 mPWD to 7 mPWD. The eastern part contains many depressions, natural khals and low lands. City fringe area belongs to the flood plain of five rivers around Dhaka with some exception in four municipal areas outside Dhaka. A contour map of Dhaka is generated from survey data and secondary data collected from DAP and Survey of Bangladesh. It was found that about 50% of DAP area is below 4.00 mPWD, 38% of the total area is in the range of 4.00 mPWD to 8.00 mPWD and about 10% of the area is above 8.00 mPWD level. **Table 3** summarizes a classified elevation of the study area.

Table 4.3: Classified Elevation of Dhaka City

SL	Range of Elevation	Area (Sq. km)	% of Total Area
1	Less than 4.00	7	50.8
2	4.00-8.00	5	38.3
3	8.00-12.00	1	9.48
4	Greater than 12.00	2	1.43
Total		**1528**	**100%**

4.3.1 Climate of Dhaka

The climate of Dhaka is characterized by hot wet sub tropical climate. the town has four seasons: Pre-Monsoon (March-May), Monsoon (June –September), Post monsoon (October-November) and time of year (December-February). the town experiences cool and short winter and hot, wet and long summers. The temperature in summer varies from twenty one.1°C to 36.7°C and in winter from ten.5°C to 31.7°C. The monthly downfall varies between three hundred and 450 millimeter. In time of year the mean downfall is concerning 50mm/day and 300-450mm/day from June to August. The mean monthly evaporation varies between concerning eighty millimeter in November and concerning one hundred thirty millimeter in August (JICA 1991).

Table 4.3.1: Climate Conditions in The Study Area

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp.(^{0}C)												
Max	**34.2**	**36.6**	**40.6**	**42.3**	**40.6**	**38.4**	**35.2**	**35.9**	**35.3**	**38.8**	**33.3**	**31.2**
Min	**5.6**	**4.5**	**10.4**	**15.6**	**18.4**	**20.4**	**21.7**	**21.0**	**22**	**10.4**	**10.6**	**6.7**
Average	**18.8**	**21.5**	**26.1**	**28.7**	**28.9**	**28.7**	**28.7**	**28.7**	**28.7**	**27.4**	**23.6**	**19.8**
Rel. humidity	**70**	**66**	**63**	**71**	**79**	**86**	**87**	**86**	**86**	**81**	**75**	**74**
Evaporation	**104**	**79**	**81**	**77**	**78**	**83**	**87**	**130**	**118**	**106**	**75**	**105**
Wind velocitities(knot	**2**	**2**	**3**	**5**	**5**	**4**	**4**	**4**	**3**	**2**	**1**	**1**
Average rainfall(mm)	**6.5**	**20.2**	**52.3**	**124.0**	**283**	**398.2**	**391.4**	**328.0**	**264.0**	**160**	**25.3**	**7.4**

(Source: BMD 2012)

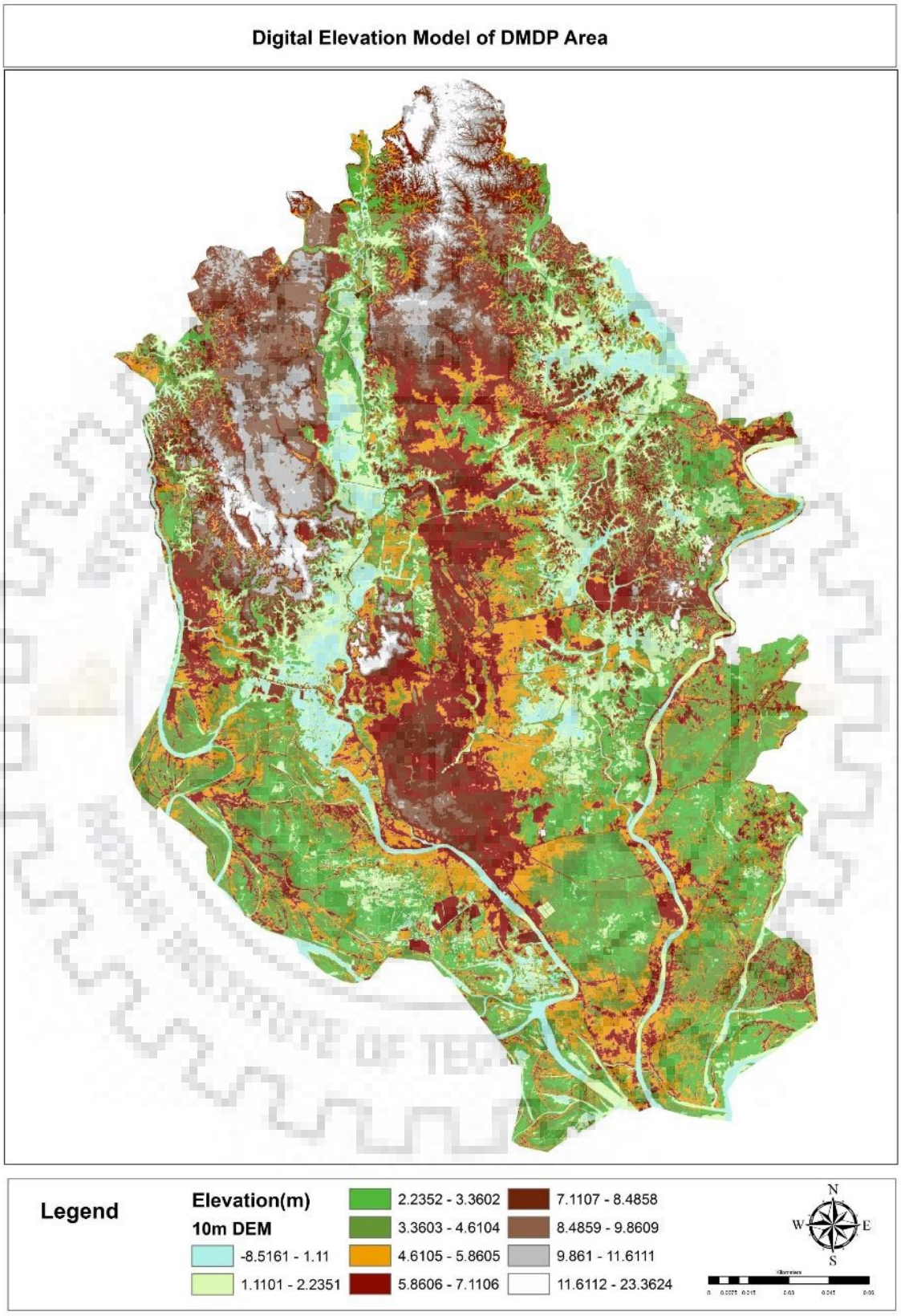


Figure 21 Digital Elevation Map of Dhaka City

4.3.2 Rainfall of Dhaka

Bangladesh Meteorological Department has 35 meteorological stations throughout the country. In our study area, BMD has one rainfall station at Agargaon. BWDB also has four rainfall stations around the Dhaka City. Rainfall data from the Dhaka station (BMD) for 1980 to 2012 show that the annual average rainfall in the city is about 2,117 millimetres, of which about 50 per cent falls during the months of June. July and August. Average rainfall during the winter months (December, January and February) is negligible, less than 2 per cent of annual rainfall. **Figure 4.3.2** shows average monthly rainfall of Dhaka. In the drainage study, maximum daily rainfall intensity is one of the most important design parameter. In case of Dhaka, people experiences flooding when a sudden heavy rainfall occurs. In September 2004, 341 mm rainfall occurred in 8 hours in Dhaka which led to severe urban flooding (Ahmed, 2008). Serious drainage congestion took place in Dhaka city due to 333 mm rainfall on 28 July, 2009 (Uddin, 2009). On that day around 290 mm rainfall occurred in six hours. A ranked list of historic highest rainfall is given in **Table 4.3.2**.

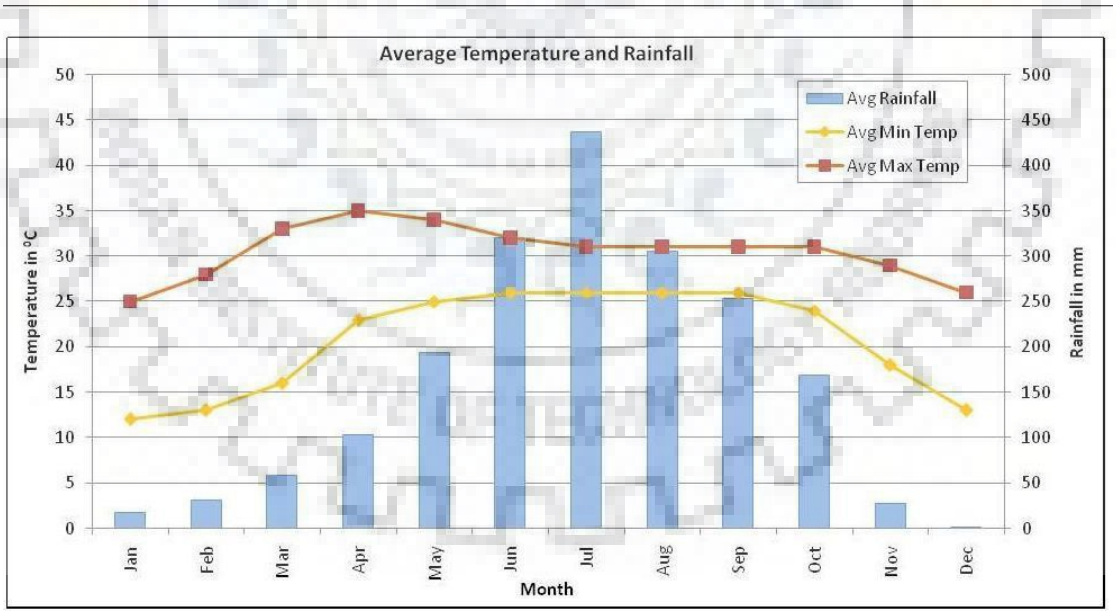


Figure 22 Average Rainfall and Temperature of Study Area

Table 4.3.2: Maximum Daily Rainfall in Dhaka

Rank	Date	Rainfall in mm/day
1	14-Sep-04	341
2	28-Jul-09	333
3	14-Jul-56	326
4	16-Sep-66	257
5	22-Jul-71	251
6	25-May-72	231
7	19-Jun-63	189
8	21-Jun-61	185
9	12-Sep-06	185
10	12-May-65	177

Source: (BMD, 2012)

4.4 Land use

4.4.1 Existing Land use

Dhaka began to develop in an exceedingly additional planned means once 1947 once it gained regional and political importance (Chowdhury, J.U., 1998). The land use pattern of Dhaka city is speedily ever-changing throughout the last twenty years.. Previously, industrial and residential areas were located facet by facet, principally focused beside the slim roads, recent Dhaka still presents this case with a combination industrial, residential and tiny industries. once preparation of the program of town in 1958, the industrial centers of town was stirred to Motijheel and a high territory was developed at Dhanmondi. Housing colonies for presidency workers, universities, parks, industrial and industrial zones, lakes and different public facilities were developed step by step to fulfill the strain of the increasing town. The core town space is sort of developed and it occurred in an unpredictable means .Four adjacent municipality areas also are developing and therefore the land use pattern is thence ever-changing. Specific tips were missing for the event from the terribly starting. a number of years past RAJUK ready a Detail space set up (DAP) within which a detail land use set up for every space of Dhaka town was known by giving specific define of the areas in terms of usage.

Table 6 presents area under different types of land use. **Figure-7** describes existing land use pattern of Dhaka.

Table 4.4.1: Existing Land Use Classified Area

SL No	Land use Classification	Area in Acre	Area in Percentage
1	Agriculture	118825	38.07
2	Residential	73091	23.42
3	Flood Flow Zone	29021	9.30
4	Rural Settlement Zone	21830	6.99
5	Waterbody	19104	6.12
6	Diplomatic (Purbachal)	6292	2.02
7	Proposed Road	6098	1.95
8	Existing Road	5654	1.81
9	Education and Research	4727	1.51
10	Commercial Activity	3914	1.25
11	Manufacturing and Processing Activity	3813	1.22
12	Restricted Area	3754	1.20
13	Overlay Zone	3470	1.11
14	Mixed Use	3275	1.05
15	Vacant Land	2037	0.65
16	Circulation Network	1523	0.49
17	Water Retention Area	1502	0.48
18	Open Space	1321	0.42
19	Transport and Communication	623	0.20
20	Recreational Facilities	446	0.14
21	Heavy Industrial Zone	406	0.13
22	Miscellaneous	1368	0.44

(Source: RAJUK, 2012)

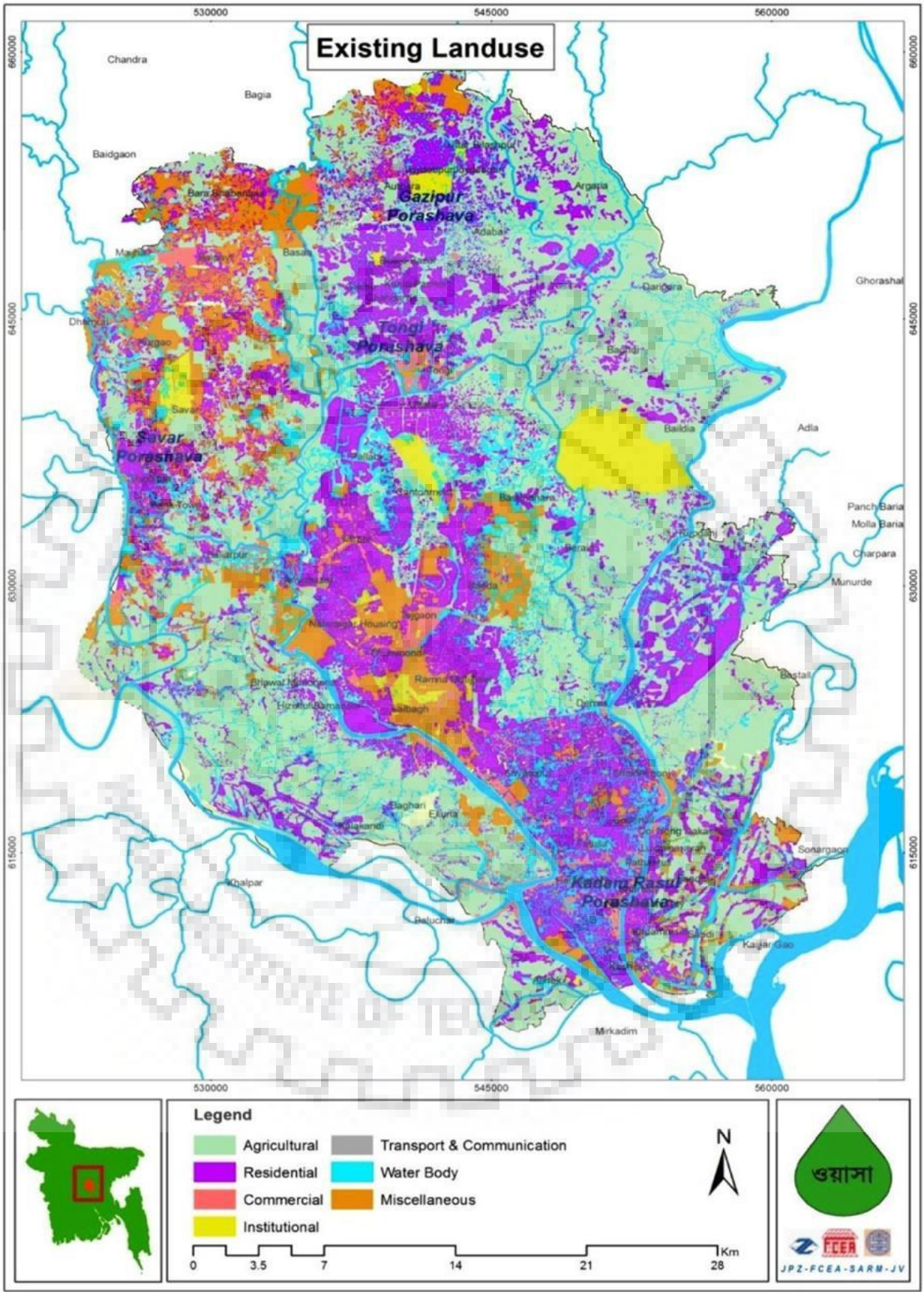


Figure 23 Existing Landuse Map od Dhaka City

4.4.2 Proposed Land use

The city development authority RAJUK has prepared detail area plan (DAP) where future land use pattern has been proposed. The future land use pattern contains water body, flood flow zone, agricultural zone and open space along with residential, commercial, industrial and other area. **Figure-4.4.2** presents future land use pattern of southern part of Dhaka city.

Land use Type	Area (ha)		
	All Zones	Core city	Fringe Area
Agriculture	55882.20916	144.06050	55738.14866
Commercial Activity	1011.75767	220.44924	791.30843
Community Service	12.77622		12.77622
Diplomatic	2451.81446		2451.81446
Education & Research	1556.57868	374.81909	1181.75959
Filled Land	1012.64498		1012.64498
Forest Area	870.27111		870.27111
Governmental Services	79.11531		79.11531
Graveyard	22.91163	20.24366	2.66797
Health	68.80122	68.80122	0.00000
Historical	7.18149	7.18149	0.00000
Homestead	2570.26141		2570.26141
Industry	45.06417		45.06417
Institutional	523.29944	492.21298	31.08646
Manufacturing and Processing Activity	2137.41133	238.07354	1899.33779
Miscellaneous	363.69518	354.37024	9.32494
Mixed Use	1182.65531	1033.92130	148.73401
Non Governmental Services	0.00208		0.00208
Open Space	1838.73351	132.91147	1705.82204
Recreational Facilities	16.96656		16.96656
Residential	35015.77393	8598.34436	26417.42956
Restricted Area	1646.25719	682.20893	964.04826
Rural Homestead	168.33360		168.33360
Service Activity	187.01270	60.20670	126.80599
Transport & Communication	2979.60846	895.16021	2084.44825
Vacant Land	9673.16194	1.56870	9671.59324
Waterbody	12948.99183	812.27774	12136.71409

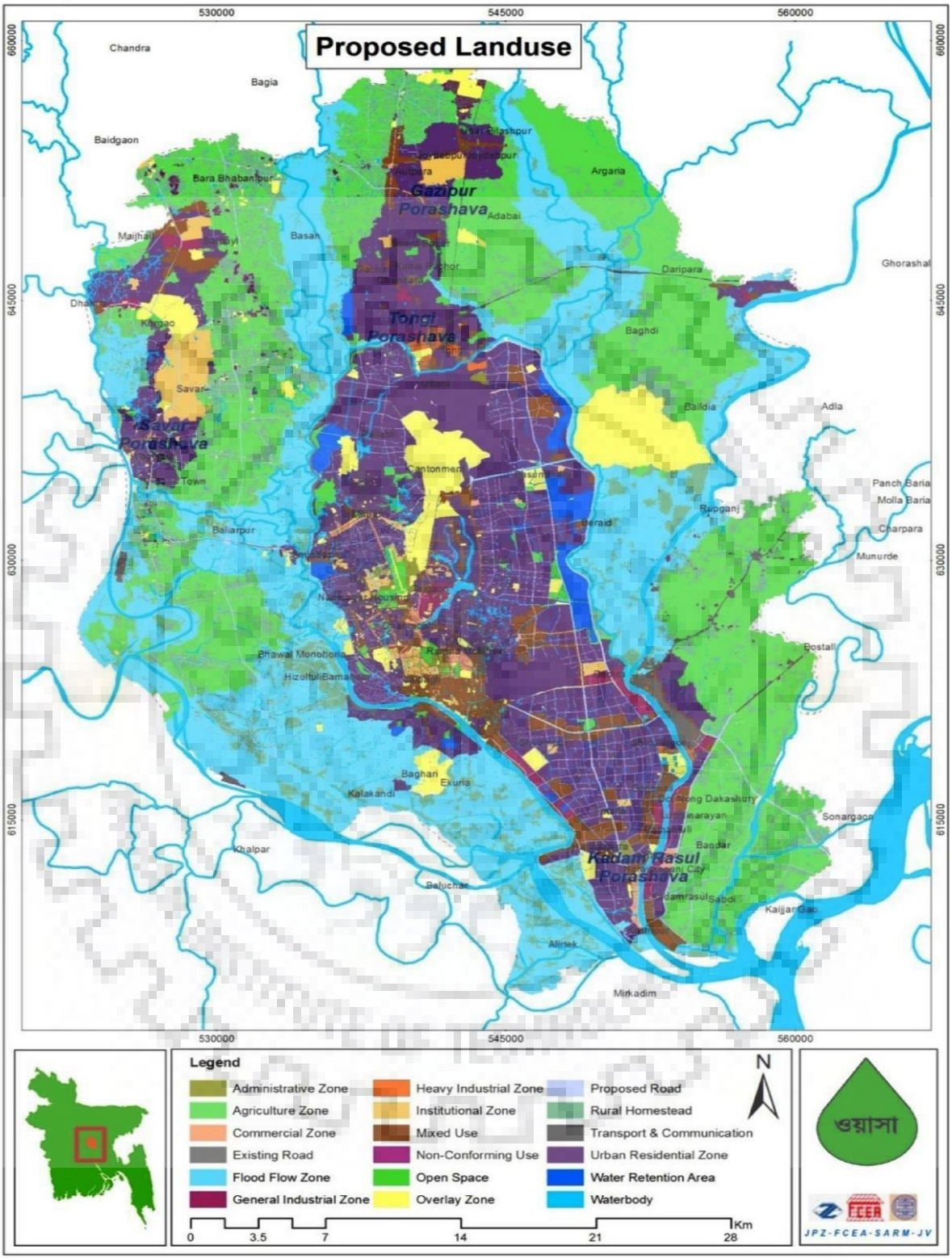


Figure 24 Proposed Landuse Map of Dhaka City

4.5 Infrastructures

Infrastructure of Dhaka city is merely inadequate against the demand of 12 million people. Traffic congestion is one manifestation of inefficient and insufficient road and poor management. To carry out the demand of housing the city already covered every corner in an unplanned manner. The services providing organization are facing tremendous pressure with their limited resources and capacity. DCC and DWASA are the essential city dwelling services providing Authority. DWASA currently supplies water to about 70% of the population of the Dhaka City Corporation (DCC) and its suburbs i.e., the Dhaka Metropolitan Area (DMA). Sewerage networks are only existent in the urban core area ostensibly covering about 30% of core Dhaka. DWASA is also responsible for developing and operating the city's storm water drainage system that covers an area of about 140 km, including a network of storm water drainage canals ("khals") and pumping stations. The city's storm water drainage system covers about 38% of the DCC area, to drain out flood waters through natural canals into adjoining rivers. While DWASA is responsible for the storm water drainage systems in Dhaka, solid waste management in Dhaka remains the responsibility of the Dhaka City Corporation (DCC). Inefficient solid waste management in Dhaka adversely affects DWASA's operations of the storm water drainage, particularly in slum areas where solid and other wastes are frequently thrown into the canals. Many drains in DCC also double up as combined sewers carrying domestic sewage form the residence. Back-flow of sewage into residential premises is a common occurrence during monsoon, period.

4.5.1 Road Network

Dhaka City has very inadequate road networks. For a standard city, where the minimum road requirement is 25%, Dhaka has only 7.5% road of its total area. **Figure-10** describes the road network of a portion of core city in DAP area. 30% of the existing road of core city area is also occupied by the hawkers, salesman and shopkeepers. A significant portion is occupied by construction materials and waste-containers of the City Corporation which also cause drainage congestion. It has become a regular practice to park the car on road, such who build the drains and maintain them, whether they are built following and drainage standard etc. Besides this, in most cases roads are serpentine rather than being straight. This ultimately breeds a number of unnecessary junctions where vehicles automatically slow down. Again, these roads are also not well constructed and regularly repaired. City Corporation, DESA, Bushra Shahriar, 17511002, MURP-2017-2019, IIT Roorkee

WASA, BTCL excavate the roads randomly without any integrated and central plan. Limited parking arrangement is another major cause of excessive traffic in Dhaka City.

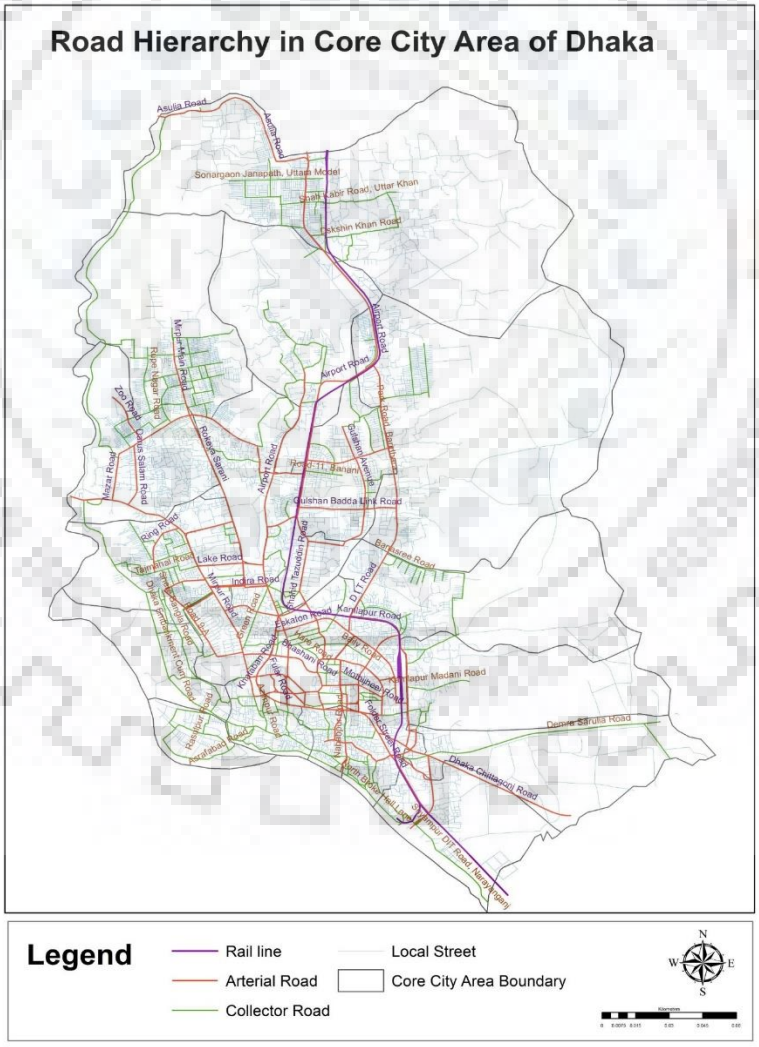


Figure 25 Road Hierarchy in Core City Area of Dhaka

4.5.2 Drainage System

The existing internal drainage systems of Dhaka City consists of storm sewer lines, surface drains and open channels (locally known as Khals) that ideally carry the storm water as well as a part of waste water generated in the city to the surrounding rivers. It may be mentioned that there were a good number of open channels in the city areas which played a vital role to provide storm water drainage to the city. Also there was sufficient low land around the city which acted as water retention area of the concerned command area to retain the excess water for time being. With rapid urbanization and unplanned development, most of these khals and water retention area have been filled up and the capacity of natural drainage has diminished dramatically.

It is estimated that there are approximately 45 natural khals, total about 142 km that are part of the natural drainage system. In addition to the open channels and lakes, there are about 380 km of storm sewer lines that covers about 140 sq km of Dhaka and 8.75 km of box culverts under DWASA making up the storm water system of Dhaka.

Table 4.5.2 lists the flood control structure in core city area. **Figure 4.5.2** shows the location map of existing drainage network and flood control structure of Dhaka WASA. Western Dhaka is protected from river flooding by the embankment constructed along Turag and Buriganga rivers under FAP8 program. There are 2 pumping stations and 11 sluice gates along the western embankment. These pump stations are located at Kallyanpur and Goranchatbari, evacuating stormwater from western and north-western part of the city. Capacities of these stations are 20m3/sec and 22m3/sec respectively.

Figure 26 Poor Drainage Management in Dhaka City

Table 4.5.2 lists the flood control structure in core city area.

SL	Structure ID	Longitude	Latitude	Structure Type	Location
1	S1	Not identified			Uttara
2	S2	90.392117585	23.880247018	Sluice	Uttara
3	S3	90.360290328	23.882324408	Sluice	Uttara sector 18
4	S4	90.340030675	23.836963279	Sluice	Mirpur
5	S5	90.343204741	23.828826429	Sluice	Mirpur
6	S6	90.344479466	23.772737449	Sluice	Gabtoli
7	S7	90.359511660	23.744676116	Sluice	Rayer Bazar
8	S8	90.367348990	23.727280029	Sluice	Nawabganj
9	S9	90.375618571	23.721733318	Sluice	Amligola
10	S10	90.378923360	23.718683224	Sluice	Shahid Nagar
11	S11	90.388909735	23.711988936	Sluice	Kamalbag
12	FS1	90.40594444	23.87472222	Sluice	Uttara (Rail Line)
13	FS2	90.40633333	23.85944444	Open B/Culvert	Uttara (Rail Line)
14	FS3	90.41861111	23.83791667	Sluice	Opposite of Nikunja-1
15	FS4	90.42080556	23.82469444	Sluice	Opposite of Nikunja-2
16	FS5	90.42510221	23.82461341	Sluice	Baridhara, Radison hotel
17	FS6	Not identified			Gulshan
18	FS7	90.42533333	23.78911111	Sluice	Shahjadpur
19	FS8	90.42330556	23.76841667	Sluice	Rampura
20	FS9	90.42022222	23.74886111	Sluice	Khilgaon
21	FS10	Not identified			Shahjahanpur-Tilpapara
22	FS11	90.42466667	23.73630556	Sluice	Kamlapur
23	FS12	90.42861111	23.72408333	Sluice	Manik Nagar
24	FS13	90.42947222	23.71183333	Pipe Sluice	Saidabad

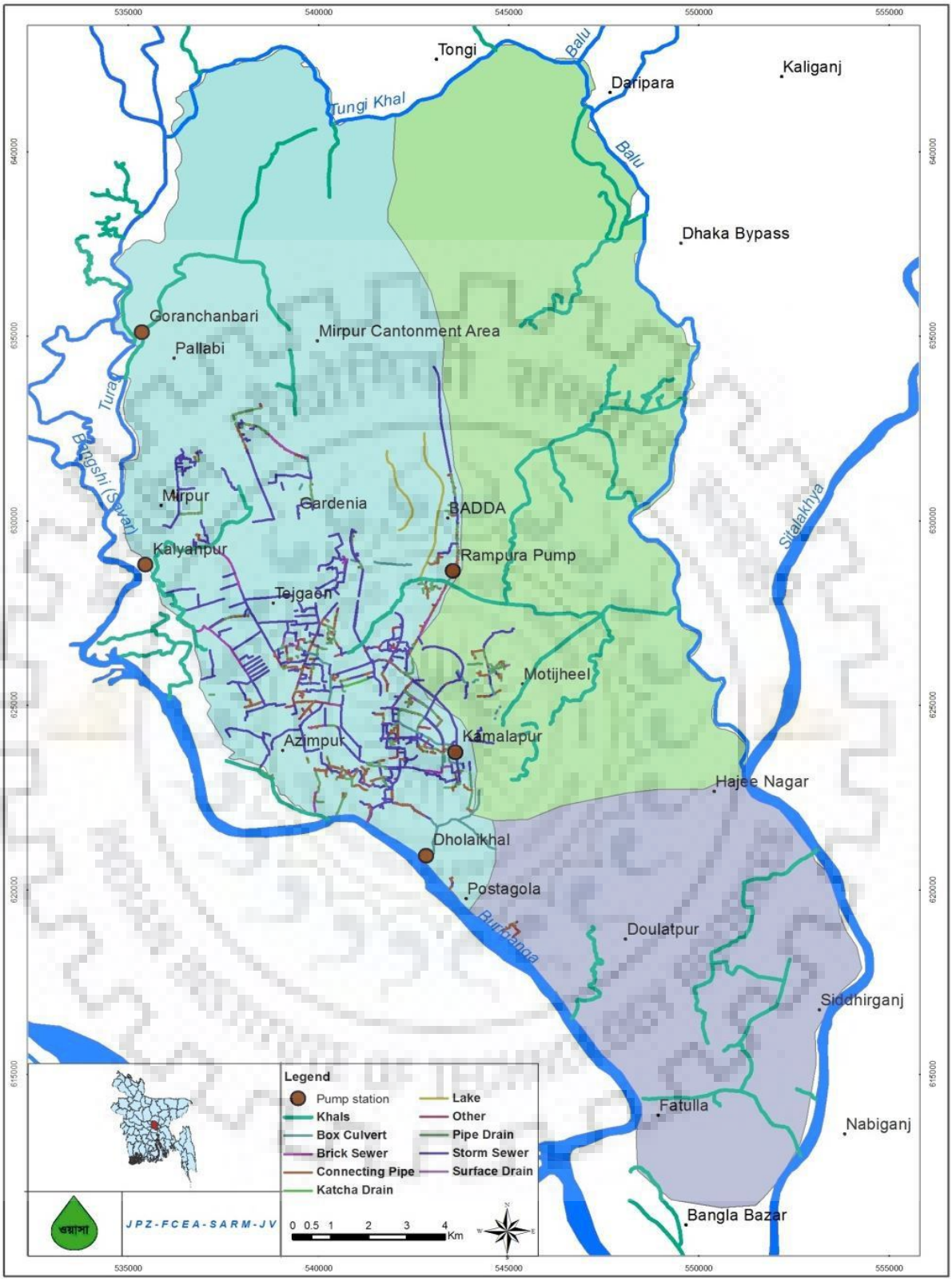


Figure 27 Existing Drainage Network in Dhaka City

4.5.3 Water Supply

DWASA currently supplies water to about 70% of the population of the Dhaka City Corporation (DCC) and its suburbs i.e., the Dhaka Metropolitan Area (DMA). The quality and quantity of service provision throughout the area are not even. In particular, service provision is rudimentary in slum areas where the majority of the poor resides. There are no piped distribution networks available in slum areas, although urban slums account for 37% of the population of DMA (about 4 million people). Dhaka WASA has about 2600 km water line and about 3 lac water connection to supply potable water to city dwellers. It covers more than 360 sq. km service area with 12.5 million people with a production of almost 2110 million liters per day (MLD). Main source of water supply of Dhaka WASA is ground water. Dhaka WASA has about 600 deep tube wells throughout the city from where about 87 % of supplied water is extracted. Dhaka WASA has almost 100% water coverage and the water demand in Dhaka city is 2.25 million cubic meters per day (2250 MLD), which slightly exceeds the present supply of almost 2.11 million cubic meters per day (2110 MLD). At present 87% of the supplied water is from ground water abstraction from Dhaka WASA's 605 deep tube wells. The remaining 13% water comes from surface water treatments. The upper and lower aquifers of Dhaka city are about to exceed its withdrawal limit. Ground water depletion is occurring at alarming rate. DWASA has already taken steps to switch water supply from ground water to surface water. A summary of wate rsupply system of Dhaka WASA is tabulated in **Table 9**

Table 9: Water Supply System of Dhaka WASA

SL	Structures	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2012-2013
1	Deep Tube well	465	490	519	560	599	644
2	Water Treatment Plant	4	4	4	4	4	4
3	Water Production/day	1700 MLD	1760 MLD	1880 MLD	1990 MLD	2150 MLD	2420 MLD
4	Water Line	2533.73 km	2600 km	2600 km	2600 km	2600 km	3040 km
5	Water Connection	2,43,477	2,56,477	2,74,368	2,86,911	3,02,132	325717
6	Hydrant (active)	38	38	38	38	38	38

7	Roadside Tap	1643	1643	1643	1727	1727	1727

4.5.4 Sewerage System

Along with water supply and drainage, Dhaka WASA is responsible for operation and maintenance of the sewerage system and sewage treatment plants within the defined area of Dhaka City. At present there are 882 kilometres of sewerage lines in Dhaka while there are 30 lift stations, one main pump station, one sewerage treatment plant and small bore sewerage system at Mirpur. The domestic-consumption of water in Dhaka is currently at 2250 MLD, out of which 80% is generated as sewage. Thus the sewage generated by the city is 1800 MLD. Only 30% of it is from the city core area which has public sewer system and the remaining 70% of the sewage is discharged into the city's storm water drainage system. Thus the discharge of sewage into drains not only pose environmental and health hazard to public but it also diminishes the carrying capacity of the drainage system which has a significant impact during monsoon period.

Table 10 provides a summary of sewerage system of DWASA. Over three lac households occupying 70% of the city area are currently out of WASA's sewerage network. The areas include Uttara, Baridhara, Badda, part of Mirpur, Mohammadpur, part of Gulshan and Jatrabari, Donia, Shyamoli, Kalyanpur, and a large area of the capital's northern part. Untreated waste of these residential areas is dumped in rivers, canals and other water bodies in and around the capital causing heavy pollution to surface water.

SL	Structures	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2012-2013
1	Connection to Religious Place	1827	1896	1898	1898	1898	1898
2	Sewer Line	881.02 km	882 km	882 km	882 km	882 km	885
3	Sewer Lift Station	29	29	30	30	30	26

Dhaka WASA has developed a Sewerage Master Plan to provide public sewerage system for the entire city. The Sewerage Master Plan proposes five new waste treatment plants in Dasher Kandi, North Dhaka, South Dhaka, Gabtoli and Uttara and setting up of new pipelines by 2035 to provide sewerage service for about 32 million people. In the first phase, the capacity of Pagla Sewerage Treatment Plant would be increased to two lac cubic metre per day. Sewerage system, transmission mains and treatment plants would be constructed at Uttara, Mirpur, Rupganj, DND-Demra, Narayanganj and Rayerbazar catchments in the second phase. In the third phase, sewerage treatment plants would be constructed within greater Dhaka including Gazipur, Tongi, Savar and Keraniganj.

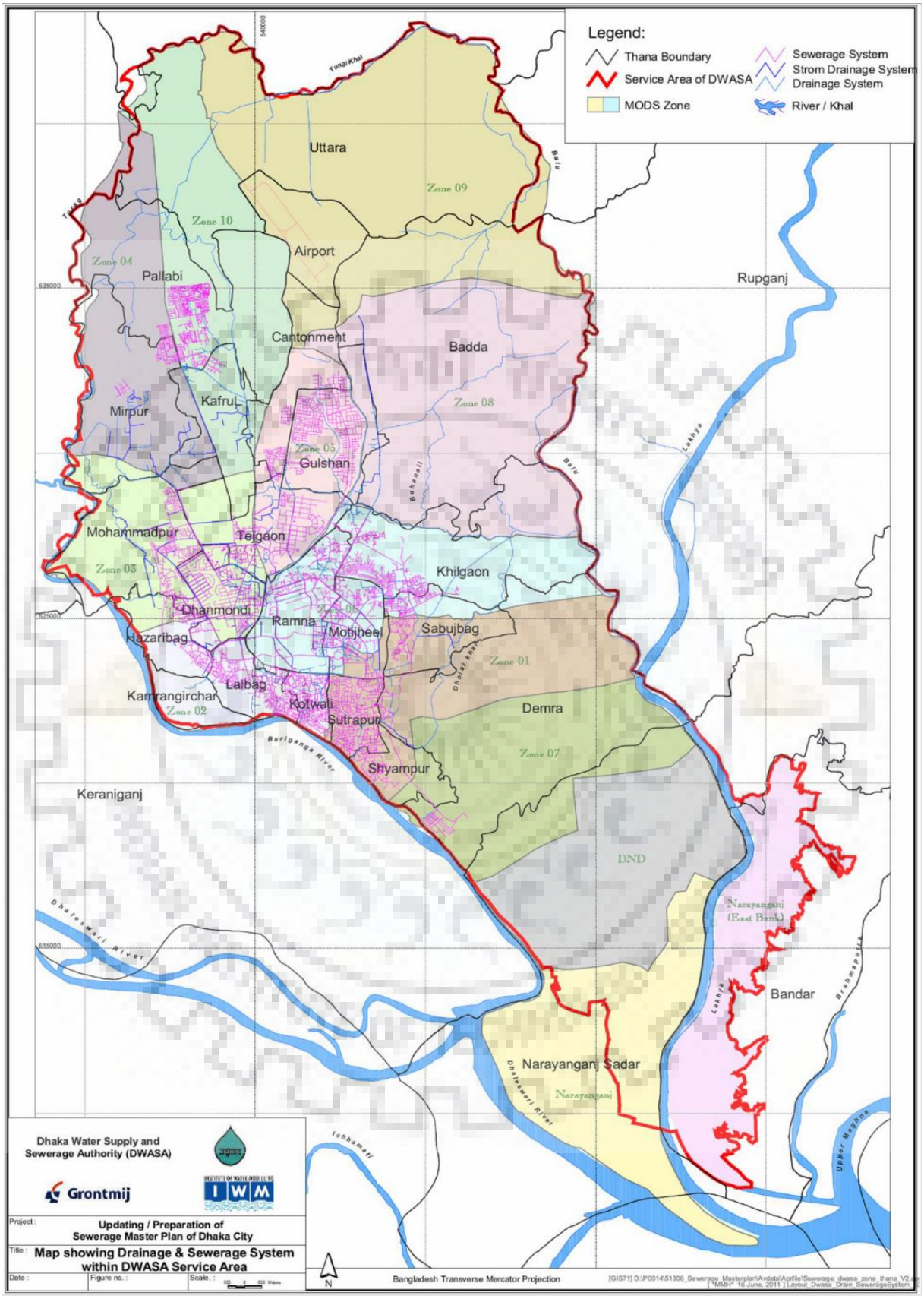


Figure 28 Sewerage Network in Dhaka City

CHAPTER-5

STORM WATER DRAINAGE SYSTEM OF DHAKA CITY

5.1 Introduction

Dhaka is known as a water logging and drainage congestion city– losing its past glory for numerous natural khals and wetlands of fresh water. Wetlands in Dhaka city are divided into two categories water bodies and lowlands which comprises the surrounding rivers, the lakes, ponds, khals, and low-lying areas. The surface water area of Dhaka Central Region is about 13% of total land area. In Dhaka, flooding may be classified into two types. One results from overflow of the surrounding river systems, thus rendering any natural drainage ineffective. The other type is caused by high intensity rainfall runoff in the city area, which causes flooding also in situations where natural drainage might be possible. River floods generally take place in the low laying fringe areas outside the protective embankments. On the other hand, Rainfall induced flooding occurs in the built-up areas of the inner city on various scales (Mark and Chusit, 2002).Inadequate drainage channels and their improper operation and management mainly cause these floods.

Existing Natural Drainage System of Dhaka City

The natural drainage system in the Dhaka city comprises of several retention and detention areas including khals (canals), which are linked to the surrounding rivers. The city rainfall-runoff is accumulated in the retention and detention areas and discharged to the surrounding rivers through the khals.

River Network

The local surface water hydrology around Dhaka is complex. The Dhaleswari River, a tributary of the Jamuna River flows by the south-eastern part of the North Central Region of Bangladesh, close to the confluence of the Padma River (Ganzes) and Upper Meghna River (Map-8.1). The Lakhya River joins Dhaleswari at 11 km downstream of the Buriganga confluence. About 5 km below the Dhaleswari-Lakhya confluence, the Dhaleswari meets the Meghna River, which in turn flows into the Padma River, a further 20 km downstream.The Buriganga is fed mainly by the Turag River, which receives flows from local rainfall and spill flows from the left bank of the Jamuna River.

The Lakhya River drains a large catchment lying between the central forested areas and the Old Bramaputra. Additional inflows to the system originate from the Balu which drains a small catchment to the west of the Lakhya. The Dhaleswari-Buriganga-lakhya-Balu River system is tidal during the dry season when upstream inflows are minimal.

Storage Area (Lakes)

There are many water storage areas such as lakes, ponds, and low laying lands. The characteristics of major lakes in Dhaka City are shown in the Table-3.1.

Name	Length (m)	Avg. Depth (m)	Area (Km^2)	Volume (m^3)
Dhanmondi Lake	2,400	2.5	0.176	440,000
Ramna Lake	400	4.5	0.020	90,000
Crescent Lake	650	2.5	0.016	40,000
Gulshan Lake	3,800	2.5	0.480	1,200,000
Hateer Jheel	3,000	2.0	1.078	2,160,000

The Khal System (Channels)

The Dhaka West has 13 khals having a total length of more than 31 km while the Dhaka East has 27 khals of total length of about 60 kilometer. Approximately 80% of the city area is drained through these channels to the surrounding rivers. The catchments area of the khals in the Dhaka West varies from 6 to 40 sq. km (Chowdhury, 2000).The canals within the mega city Dhaka and the rivers surrounding the city were acting as natural drainage system, water reservoir, and the river route. However, this natural flow is severely hampered by human intervention, like land filling, waste dumping etc., and the present conditions of these canals become grim. The length of the major khals are given in **Table- 5.1**

Table- 5.1 The length of the major khals

FID	Canal Name	Length(km^2)	FID	Canal Name	Length(km^2)
1	Kashaibari- Boalia Khal	4.21	24	Kamrangirchar Khal	1.61
2	Tongi Khal	23.45	25	Kashibari Uttara	3.32
3	Abdullahpur khal	5.6	26	Katasur Khal	2.27
4	Baistec Khal	0.5	27	Khilgaon Basabo	1.48
5	Baunia khal	7.64	28	Khilkhet Boalia Khal	4.34
6	Begunbari khal	2.61	29	Kuril-Boalia Khal	6.6
7	Bowalia Bowfar Khal	3.04	30	Manda Khal	4.13
8	Dhakhingaon Nandipara	4.68	31	Meradia Gojaria	2.67
9	Diabari Khal	1.82	32	Mirpur Housing	1.01
10	Digun Khal	4.15	33	Mohakhali Khal	0.47
11	Dumni Khal	5.42	34	Nandipara Trimohini	1.66

12	Gerani Khal	4.1	35	Nasirabad Nandipara	1.6
13	Gobindapur Khal	3.84	36	Norail Khal	2.2
14	Gulshan Banani Khal	2.78	37	Ramchandrapur Khal	1.42
15	Hazaribag Khal	0.44	38	Rayerbazar Khal	0.85
16	Housing Khal	0.73	39	Sec-6 Digun Khal	4.15
17	Ibrahimpur Khal	0.85	40	Segunbagicha Khal	1.79
18	Kallayanpur Branch KA	2.66	41	Shahajadpur Khal	1.9
19	Kallayanpur Branch KHA	3.33	42	Shajahanpur khal	0.84
FID	Canal Name	Length(km^2)	FID	Canal Name	Length(km^2)
20	Kallayanpur Cha Khal	0.94	43	Shangbadik Colony	1.91
21	Kallayanpur Gha Khal	1.21	44	Sutivola Khal	7.53
22	Kallayanpur Main Khal	2.86	45	Dholai khal	.306
23	Kallayanpur Uma Khal	1.06		TOTAL	142

5.2 Inventory of Khals in Dhaka City

The drainage lines of Core City of Dhaka include khals, storm sewer and tertiary drains and pipes. The stormwater goes to storm sewer line through tertiary drains and pipes. Then the storm sewer carries the water to khals which ultimately convey the water to pump stations. The major khals in Core City of Dhaka are as follows:

1. **Kallayanpur Main Khal:**

Total Length is about 2.86 km starting from the junction of Kallyanpur Uma khal and Kallyanpur Gha khal. The khal ends at Kallyanpur pump station. There were two box culverts in between upstream end and Kallyanpur Bridge where the khal is reduced in cross section. Furthermore, the bed level of this khal is raised by sediment deposition. Solid waste was found on the surface in most places of the khal.

2. **Kallayanpur Branch Khals:**

These khals include five branches of Kallayanpur khal as KA, KHA, GHA, UMA and CHA khal. Kallyanpur GHA khal (1.21 km) is carrying stormwater from mostly Mirpur area and is suffering encroachment problem from starting point to end. This branch also has sedimentation problem and filling with solid waste in different places. Kallayanpur UMA khal is about 1.06 km long and main problem is blocking with sediment and solid waste. Kallyanpur KHA khal (3.33 km) starts from Mirpur 1 and falls on main khal at Gabtoli. At upstream part the khal is sedimented at some point. Solid waste was found floating all through the khal.

3. **Katasur Khal:**

This khal having a length of 2.27 km starts from Zafarabad area and ends on Ramchandrapur Khal. Katasur Khal carries stormwater from Dhanmondi-Shonkor area. This khal also has common problem of encroachment. Dumping of solid waste was found in many places which need to clean. There exists 14 road crossing on the khal through culvert and crossing with bamboo in many places (more than 25). At upstream part the khal is full with solid waste.

4. **Ramchandrapur Khal:**

It starts at the ending of Katasur khal. Total length is 1.42 km which drains out stormwater of Mohammadpur area. The khal is narrowed in some places. During pick flow it overflows on box culvert near Mohammadpur.

Figure 29 Waste disposal scenario in Ramchandrapur Khal

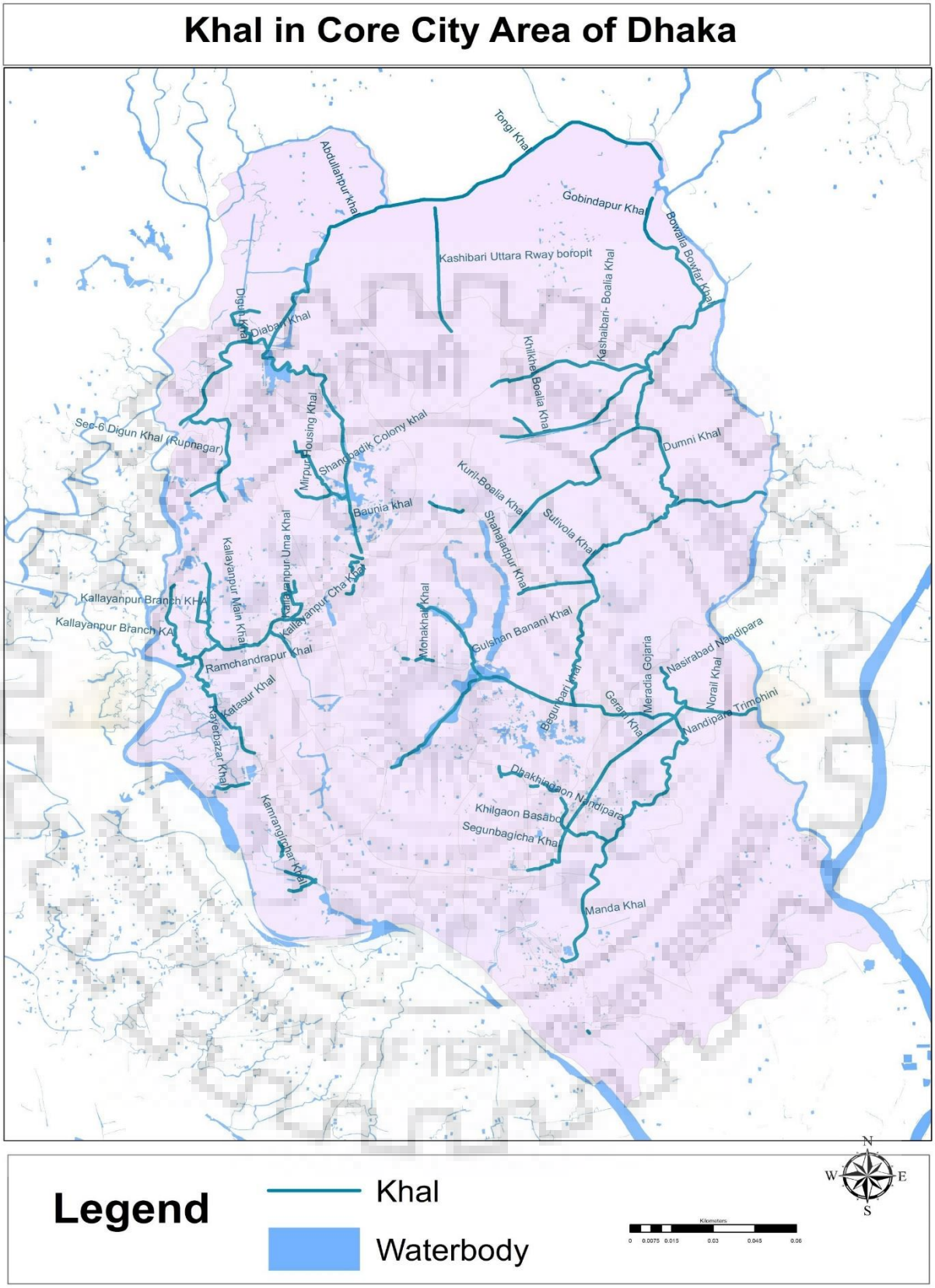


Figure 30 Major Khals in Core City Area

5. **Ibrahimpur Khal:**

This khals starts from north corner of old airport and ends near Kachukhat bazaar area and is connected to Baunia khal through box culvert. Total length is about 0.85 km. The bed of the khal is raised by sedimentation.

6. **Baunia khal:**

It has a length of 7.64 km starts from Mirpur 14 and falls on Digun khal. It has a bridge near Kalshi. At upstream part of the bridge there exists water body which holds stormwater. But this water body is under threat of landfilling.

7. **Abdullahpur Khal:**

The length of the khal is 5.6 km which starts from Abdullahpur sluice gate and falls on Digun khal. The khal is in good condition but solid waste and sedimentation is reducing the capacity.

8. **Digun Khal:**

This khals having a length of 4.15 km starts from the confluence of Abdullahpur khal and Baunia khal and ends at reservoir of Goranchotbari pump station. This khal is also in good condition.

9. **Shangbadik Colony khal:**

This khal is 1.91 km long which starts from Mirpur 11 and falls on Baistec khal. This khal is rectangular channel and main problem is sedimentation and solid waste. Another issue is sewerage connection.

10. **Mirpur Housing Khal:**

Length of this khal is 1.01 km staring from Mirpur 11 and ends on Baistec khal. People are encroaching from both side of the khal. Solid waste is also reducing the carring capacity of this khal.

11. **Baistec khal:**

Length is 0.5 km and carrying the combined discharge of Shangbadik Colony khal and Mirpur Housing khal. It falls on Baunia khal.

12. **Sec-6 Digun Khal (Rupnagar):**

Rupnagar khal is carring the stormwater generated from Rupnagar area. The length of this khal is 4.09 km.

13. **Hazaribagh Khal:**

Length of this khal is 0.44 km and it carries stormwater from hazaribag area. The khal is carrying huge tannery waste. Solid waste is also reducing the capacity of the khal.

5.3 Different Issues in Drainage System of Dhaka City

5.3.1 Non-Structural Issues

Lack of Operation and Maintenance

The drainage system of Dhaka city is suffering from negligence in operation and maintenance from its very beginning. Initially the problem was not so miserable. During last 30 years, the city expanded in rapid motion and population increased in booming way. As a result, incredible pressure impinges on the natural drainage which changes the drainage system in such condition that maintenance and cleaning is required every year.

Lack of Act, Legislation and Enforcement

There was no specific act and legislation regarding drainage from the very beginning of the city. There is no binding to work jointly among the different organizations. Furthermore, some people took the benefit of lacking of act by grabbing, developing, filling and encroaching lands which are important for drainage. The available acts and legislation are Embankment and Drainage Act (1952), National Water Policy (1999), Water Supply and Sanitation Act (1996), Drainage Policy (2006), The Bangladesh Environment Conservation Act (1995), Open space, park and natural water reservoir Conservation Act (2000) etc. Most of the existing laws and regulations for planning and development of Dhaka City are very old and in some cases outdated in terms of present development, control and needs. Necessity of an appropriate urban drainage act integrated with present and future planning and development work is a crying need of time for Dhaka city as well as other urban areas. At present, Dhaka WASA has three Magistrates for enforcement activity. The magistrates are driving their activity mainly for disconnecting illegal connections. Special drive is required to make free the illegal encroached drainage land which requires cooperation of other organizations also.

Lack of Proper Planning and Implementation

During last 30 years, Dhaka city developed and expanded in rapid motion. In most cases, urbanization is driven in unplanned way, which is transforming the existing landscape without considering the possible consequences and requirement for environmental sustainability.

RAJUK has approved a Detail Area Plan recently but it is far away from implementation. In the meantime, rapid unplanned urbanization, unpredictable pressure of population, filling up and encroaching of the natural drains and improper construction of roads of city has already messed up the entire natural drainage system. The earliest detailed study to prepare a Master plan for flood protection and internal drainage of Dhaka city was undertaken by the Department of Public Health Engineering (DPHE) in 1968. The study covering an area of 75 sq. km included construction of an embankment around the City, pump stations, and other internal drainage facilities. In 1978, DPHE reviewed the 1968 Master Plan and prepared a plan of flood control and drainage works. A Study on Stormwater Drainage System Improvement Project in Dhaka City was carried out by JICA (JICA, 1987). Another study was done under FAP8 in 1991. After that study IWM performed a study in 2006 regarding drainage Master plan of Dhaka city. However, Dhaka WASA has not a complete guideline or master plan regarding drainage and the drainage situation in a mega city like Dhaka is still far from being satisfactory, which is acutely evident during periods of even moderate showers.

CHAPTER-6

URBAN FLOOD SITUATION IN STUDY AREA

6.1 Kallyanpur Zone

Densely populated area of about 32.03 km^2 is situated at the western edge of Dhaka along the banks of the Turag River. Kallyanpur shares adjoining borders with Goranchatbari to the north, Central Dhaka to the east, and Old Dhaka to the south. The Western Embankment along the left bank of the Turag River protects the area from river flooding. Kallyanpur is a key contributor to Dhaka's economy, featuring a variety of manufacturing and processing factories; commercial activities; and offices, clinics, and schools.

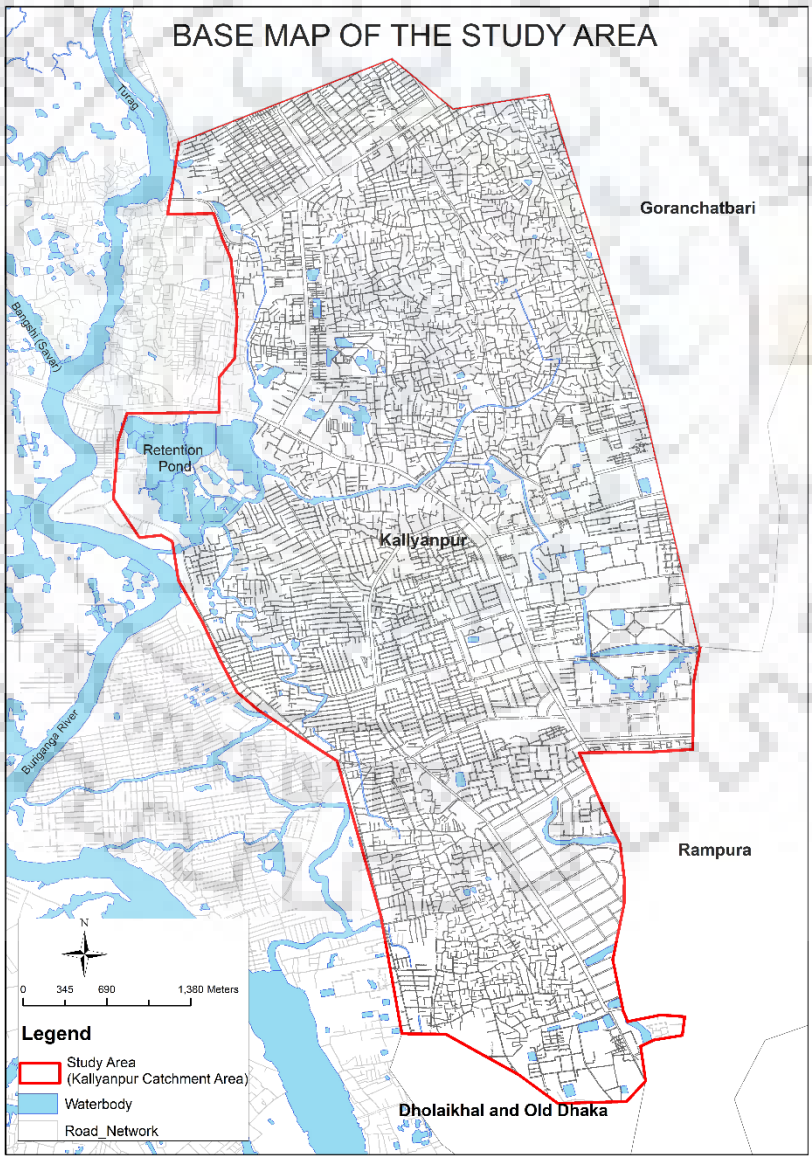


Figure 35 Base map of Study Area

Study Area consist of 18 wards respectively Ward 7, 8, 9, 10, 11, 12, 13, 14, 41, 42, 43, 44, 45, 46, 47, 48 and 49. Among these wards 15 wards are under Dhaka North City Corporation and rest of two wards are under Dhaka South City Corporation.

Table represents name of all the areas that cover the whole study area and population density ward wise.

Table 6.1 Ward wise area details within study area

Dhaka City Corporation	Ward	Area Name	Population Density (km2)
Dhaka North City Corporation	**07**	Mirpur Sec-2, Rupnagar Govt. Housing	**72, 862**
Dhaka North City Corporation	**08**	Mirpur Zoo, Bikshil Residential Area, Staff Quarter	**35,385**
Dhaka North City Corporation	**09**	Golartek, Anondo Nagar, Darus Salam	**52,994**
Dhaka North City Corporation	**10**	Darus Salam, Gabtoli Colony (1, 2, 3)	**63,238**
Dhaka North City Corporation	**11**	Kallyanpur, Paikpara	**102,859**
Dhaka North City Corporation	**12**	Shah Ali Bag, Tolar Bag, Staff Quarter	**82,482**
Dhaka North City Corporation	**13**	Boro bag, Pirer Bag, Monipur	**104,084**
Dhaka North City Corporation	**14**	Kazipara , Shewra Para	**101,091**
Dhaka North City Corporation	**41**	Agargaon, Taltola, Agargaon Staff Quarter	**51,864**
Dhaka North City Corporation	**42**	Mohammadpur (Johuri Moholla)	**92,336**
Dhaka North City Corporation	**43**	Mohammadpur (Shyamoli Ring Road, P.C Culture Housing, Baitul Aman Housing)	**94,065**
Dhaka North City Corporation	**44**	Mohammadpur (Zakir Hossain Road, Kazi Nazrul Islam Road)	**98,113**
Dhaka North City Corporation	**45**	Mohammadpur (Lalmatia, Asad gate, Iqbal Road, Babor road, Sir Syed Road)	**56,145**
Dhaka North City Corporation	**46**	Mohammadpur (Bosila, Katasur, Mohammadia Housing, Bashbari)	**24,647**
Dhaka North City Corporation	**47**	West Dhanmondi, Shankar, Dhanmondi 27	**93,955**
Dhaka South City Corporation	**48**	Rayer Bazar, Hazaribag, Tollarbag	**29,959**
Dhaka South City Corporation	**49**	Dhanmondi 6,7,8,9,10, City College	**30,961**

According the table, its clearly shown that ward 11, 13, 14 are the most populated ward within the study area. (Source: Census 2011)

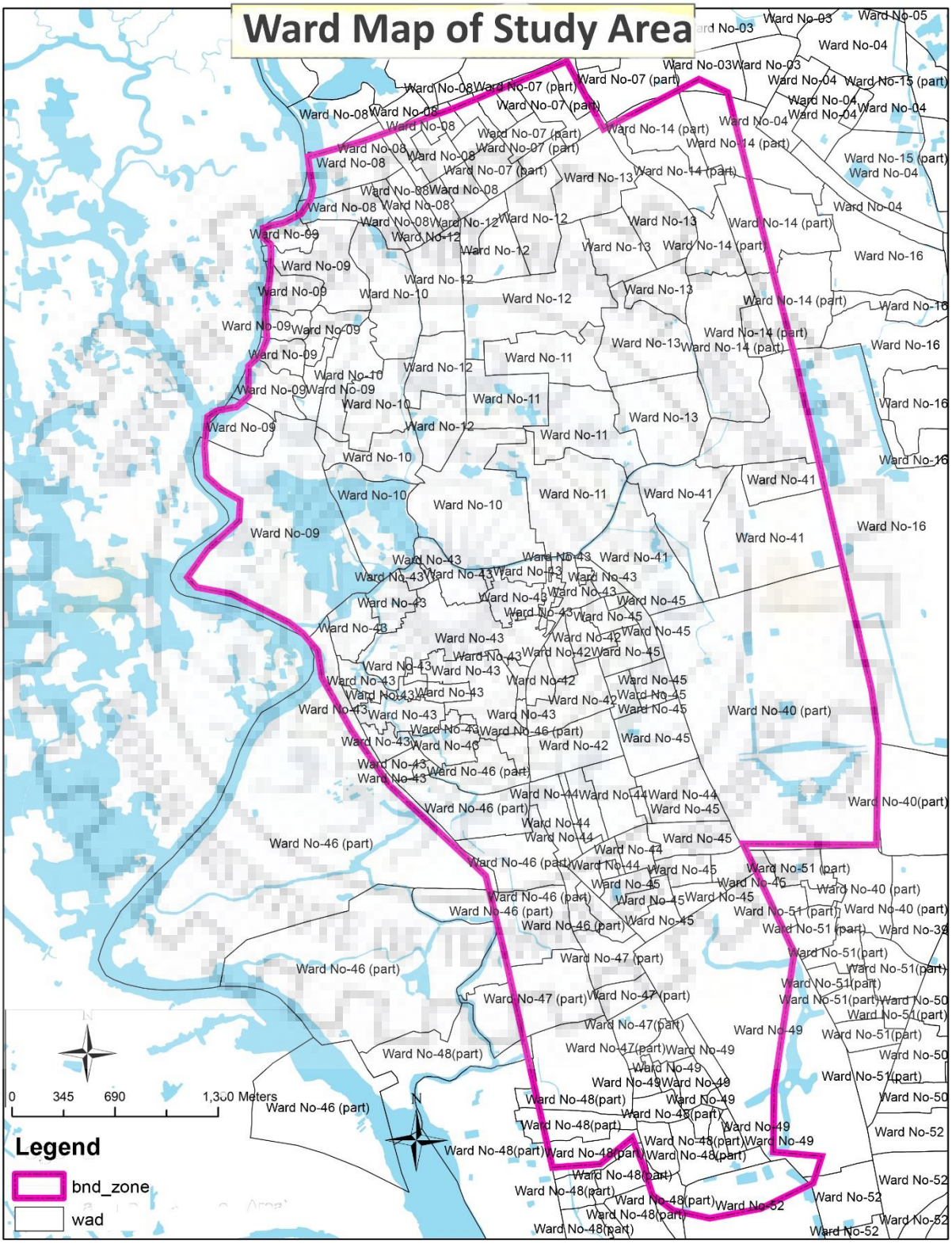


Figure 36 Ward Map of Study Area

6.2 Socio Economic Profile:

Study area is mostly Muslim dominated. Almost 85% of the population identifying as Muslim. Most Muslims are Sunni. Hinduism is the second most practiced religion within study area. In many wards, education level is higher and in most of the wards literacy rate is higher than the national average. Like in Dhanmondi area literacy rate is much higher than Mirpur area. However, people are not aware of natural hazards, or they do not simply think about it because there are more important and urgent issues in their daily life. Though they experienced severe floods in the past communities are not well prepared for disasters. The supports from NGOs, CBOs, and religious groups exist, those are not for disaster mitigation and preparedness, they are mainly for post disaster relief. At the community level preparedness in terms of logistics, materials, and management, voluntary evacuation, provision of shelter or emergency support are things that needs to be considered.

According to the questionnaire survey its found that social infrastructural facilities vary from Ward to ward. For example The number of schools, colleges and Universities are more in Mohammadpur and Dhanmondi as compared with Mirpur area. As well as literacy rate is less in Mirpur area compare with Mohammadpur and Dhanmondi.

Occupation wise most of the localities in Mirpur are employed in Business. On the other hand in Ward 42, 43, 44, 45, 46, 47, 49 maximum localities are employed in Government job or Private job. Income wise middle to higher income group people are living in Mohammadpur and Dhanmondi area where as in Mirpur most of the people are low to middle income group.

Table Shows the demographic characteristics of the respondent.

Table 6.2 demographic characteristics of the respondent

Respondant	**Categories**	**Count**	**Percentage (%)**
Gender	Male	81	**79.70**
	Female	19	**18.90**
	Total	100	**100**
Age	18-35 years	46	**44.2**
	35-50 years	41	**43.3**
	Above 50 years	13	**12.5**
	Total	100	**100**

Education	HSC or Equivalent	5	**4.8**
	Graduation	38	**36.5**
	Post Graduation	57	**58.7**
	Total	100	**100**
Level of Employee	Govt.	9	**8.7**
	Private	73	**73.1**
	Businessman	18	**18.3**
	Total	100	**100**
Religion	Muslim	86	**85.6**
	Hindu	11	**11.6**
	Christian	2	**1.9**
	Buddhist	1	**1.0**
	Total	100	**100**
Source: Questionnaire survey 2018			

6.3 Land use of Study area

About 90% of land use in the study area comprise Residential, Restricted area, manufacturing and processing activity, Education and Institution, transportation Network and water bodies**.** More than three- fifth of land of this area will have been zoned for either residential use or the transportation network by 2050 RAJUK has mentioned in Dhaka City structure plan.

6.4 Land cover

Land cover maps shows that Built-up area is almost 72% and Non built-up area is about 18%. In Dhaka Structure Plan RAJUK mentioned that By replacing Restricted areas and Agriculture areas, vacant land and waterbodies can be increased.

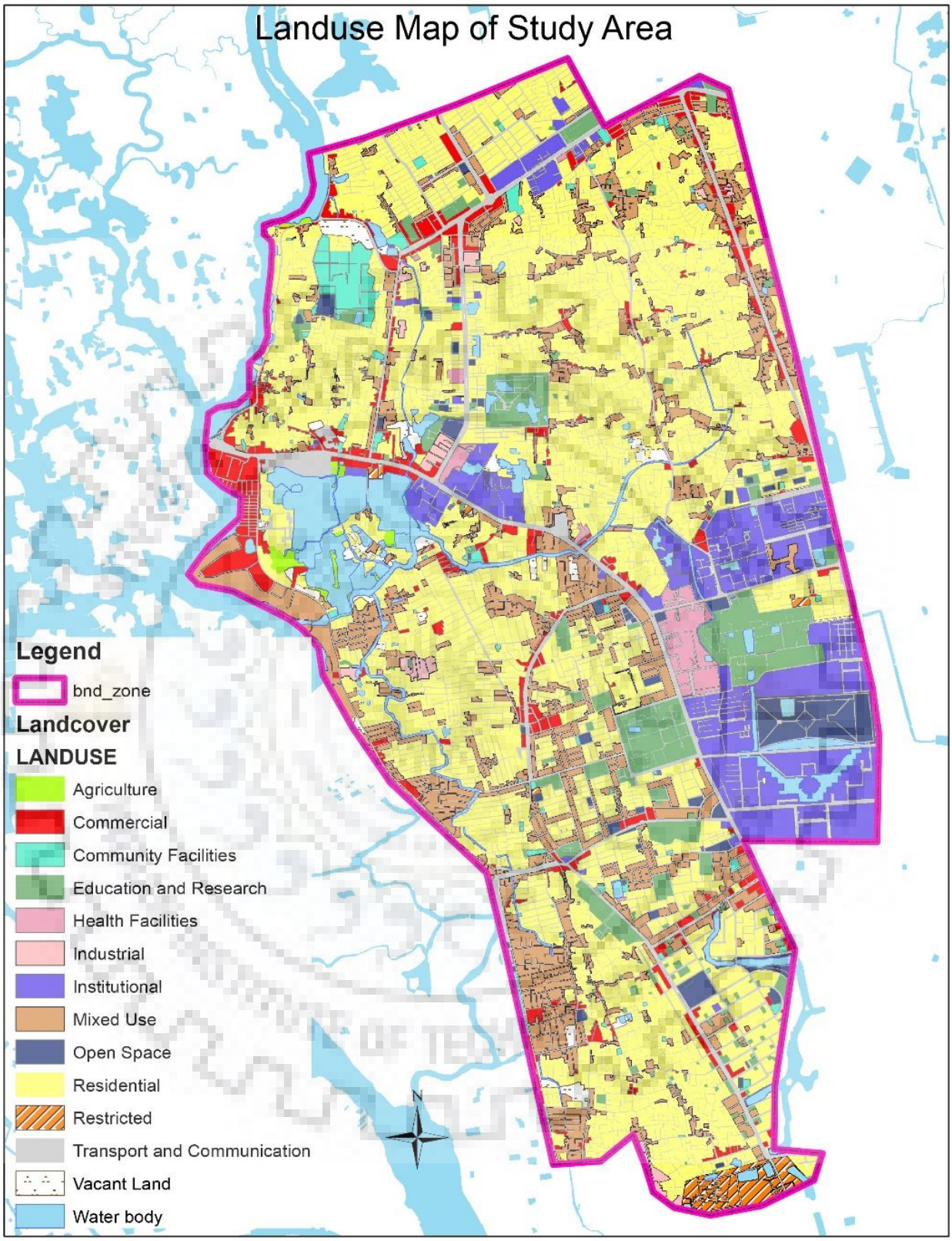


Figure 37 Landuse map of study area

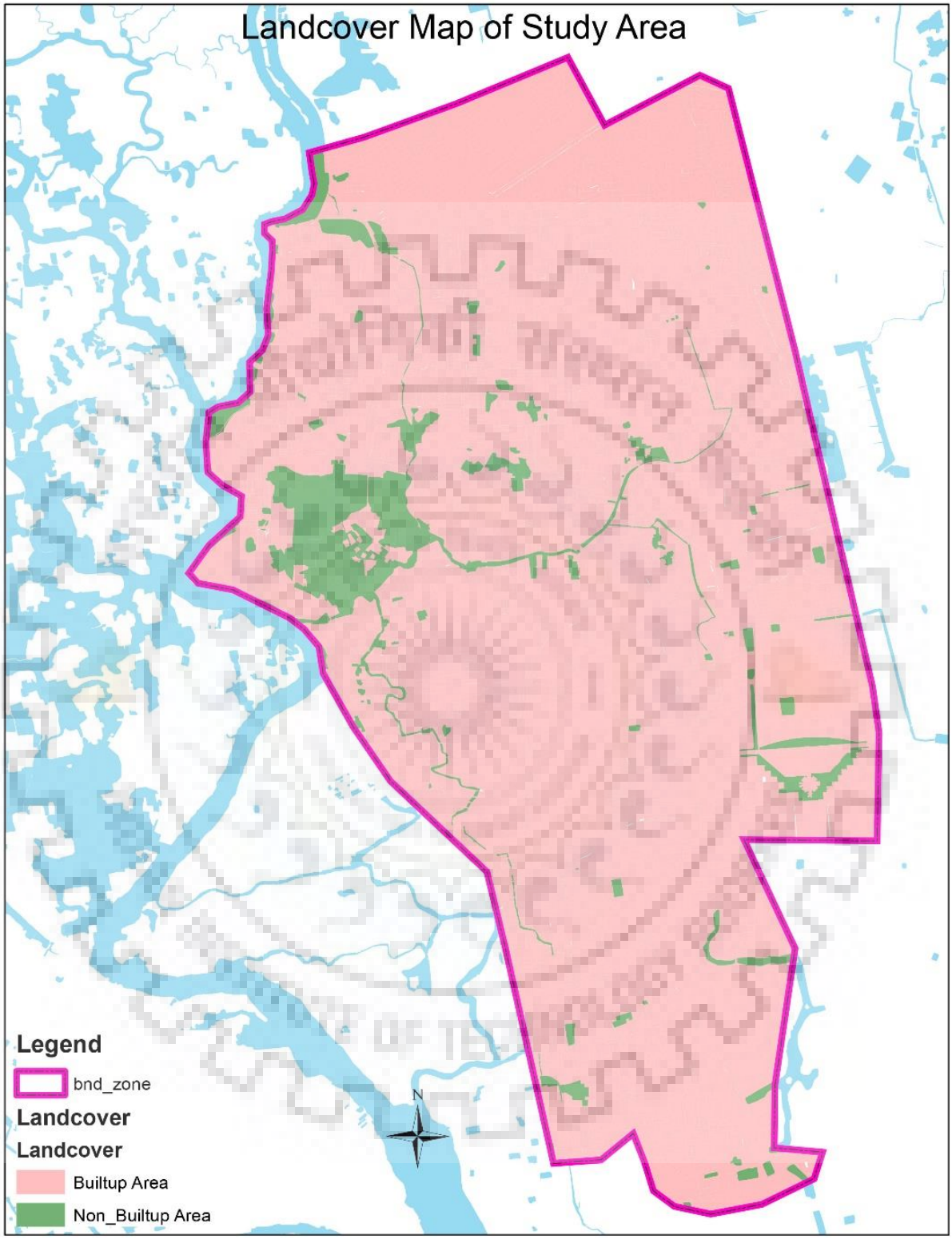


Figure 38 Land cover Map od Study Area

Built-up area within Ward 13, 14 is almost 90% which is alarming. Population density is also high in these wards. On the other hand, Ward 10, 11, 41, 48 still have some vacant land and green spaces. As population growth is increasing in alarming way its high time to restrict wetland, retention areas, flood flow zone by lay to avoid upcoming environmental degradation.

6.5 Topography

Most of the areas feature Flat terrain. Low-lying areas are found along the western embankment. Almost 93% of study area is above 6m PWD.

Bosila, Nobodoy Housing, Tolarbag, Some areas in 60 ft area, Rayer bazar these areas are mostly low lying areas, elevation varies from 5m to 9 m PWD.

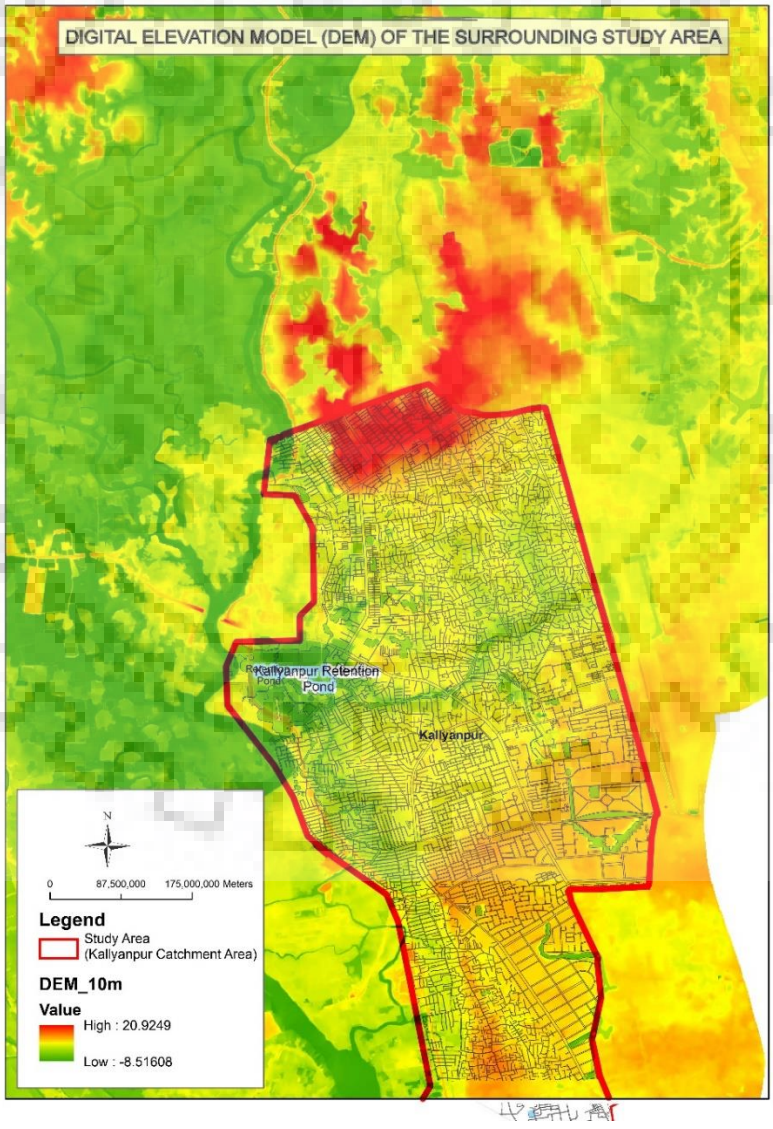


Figure 39 Digital Elevation map of study area

6.6 Rainfall

The annual average rainfall in Dhaka city is about 2161 mm/yr. The monthly average maximum rainfall was recorded as 433 mm in the month of July and the monsoon rainfall was about 1742 mm. Maximum rainfall in a single day is found 333 mm in September and maximum average rainy days in a month is found 24 in June. (Source: BMD 2001-2011)

Last year this area experienced heavy rainfall in July. Average rainfall in july within this area was 340 mm/hour. Due to heavy rainfall Mirpur-1, Kazipara, Shewrapara, Dhanmondi area experiences severe waterlogging problem in monsoon.

6.7 Drainage System

Two types drainage area available- (i) Natural Drainage and (ii) Man made Drainage. The whole areas drainage system consists mainly of pipes, box-culverts, khals, and lakes. The main khals are Ramchandrapur, Katasur, and Kallyanpur Branches Khal in the northern part of Study area. Most of the drains and khals carry storm water to the Kallyanpur Retention Pond.This retention pond is of one-km^2 (100 ha) located in the northwest part of the area. Storm water is pumped from the pond to the Turag River via the Western Embankment. The whole study area has about 29974 m storm water sewer line for waste water drainage, which only cover 40% of the whole area. Then almost 665.05 m primary and tertiary drains are located in different areas for accelerate the drainage system.

The main features in this area is a permanent pump station at Kallyanpur with a 10 m^3/s capacity. Its efficiency rate is almost 80%. There are four temporary pump stations (one located at Rayerbazar and one near Sikder Medical College with respective capacities of 0.14 m^3/s and 0.56 m^3/s and two in Hazaribag, each with a 0.35 m^3/s capacity). These all pump station has working efficiency of 60%.

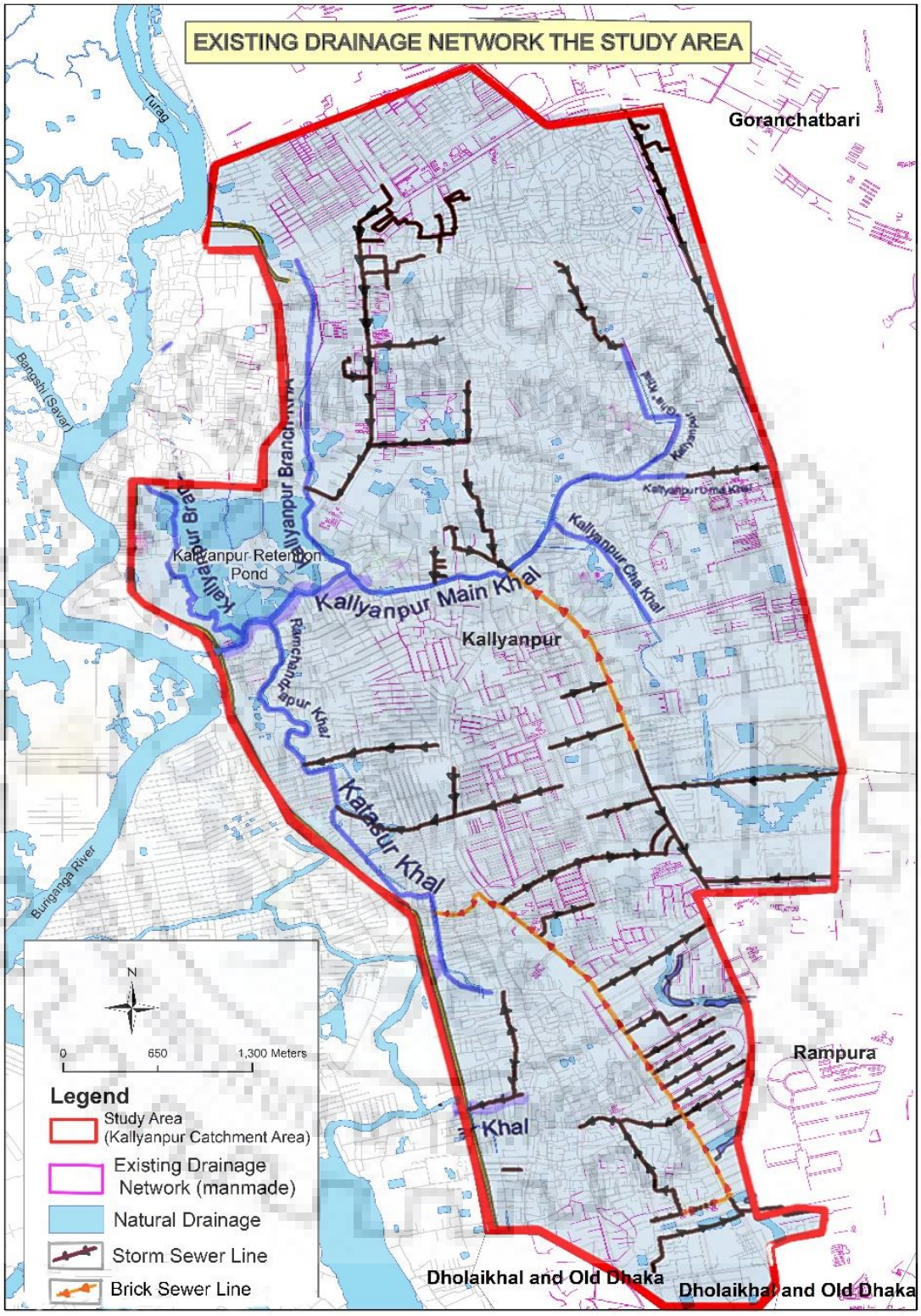


Figure 40 Existing Drainage Map of Study Area

6.7.1 Major Issues Regarding Drainage System

Encroachment in Waterbodies

Kallyanpur main khal, Kallyanpur Branch khal, Ramchandrapur Khal, Katasur Khal these area the main khal within study area. All of the canals are almost encroached with waste materials. Kallyanpur 'Ka' Khal khal is almost captured by a section of grabbers, who have captured both sides of the Khal, one of the most important point of passing out sewerage water from the capital, again and built structures due to lack of monitoring by authorities. Waterlogging at the residential areas of Kallyanpur, Shyamoli and the surrounding areas has been a regular feature of the last couple of years. A Shyamoli resident said during survey that the prolonged waterlogging with sewerage water was having an adverse impact on the lives and health of the people there. According to a 2007 Dhaka Wasa survey, the 2.2km Kallyanpur main canal was 18-36m wide. Encroachment by land-grabbers has narrowed the width of the key drainage route down to 10-12m in places.

Table 6.7.1 Major Khals in Study Area

SL No.	Name of Canal	Length
1.	Kallyanpur Main Khal	2.86 km
2.	Kallyanpur Gha Khal	1.21 km
3.	Kallyanpur Cha Khal	0.94 km
4.	Kallyanpur Uma Khal	1.06 km
5.	Kallyanpur Branch ka	3.33 km
6.	Kallyanpur Branch kha	2.66 km
7.	Ramchandrapur Khal	1.42 km
8.	Katasur Khal	2.47 km

Poor Capacity of Drainage System

According to the 80% respondents poor performance of operation and maintenance of drainage system is one of the main reason of waterlogging. Poor maintenance, Lack of Institutional co-ordination, lack of public awareness etc are the main reason of poor capacity of drainage system. lack of comprehensive and planned maintenance program, equipments, adequate budget, staffing, proper monitoring program and institutional set up to effectively operate and maintain the drainage network these area some other reason behind this issue. Poor solid waste management is the main problem to maintain the storm water drainage. Municipal agencies (DCC in Dhaka City area) responsible for solid waste management,

but DCC totally failed to manage solid waste within study area for lack of sufficient resources and equipment for drain cleaning.

6.7.2 History of Urban Flood within Study Area

Severe Urban Flood Took Place in 2004, 2007 and 2009 as well. And in all these three years different area of study area were affected badly. During monsoon season wards 9,10, 11, 12, 13, 14 in the study area got affected in every year. These area main urban flood hazard wards within study area.

Last year Dhanmondi, Mirpur, Sher-e- Bangla Nagar, Some part of Mohammadpur area were inundated due to heavy rain fall. The main reason of this inundation problem is lack of drainage facility.

Figure 41 Mirpur area got inundated due to heavy rainfall in july in last year

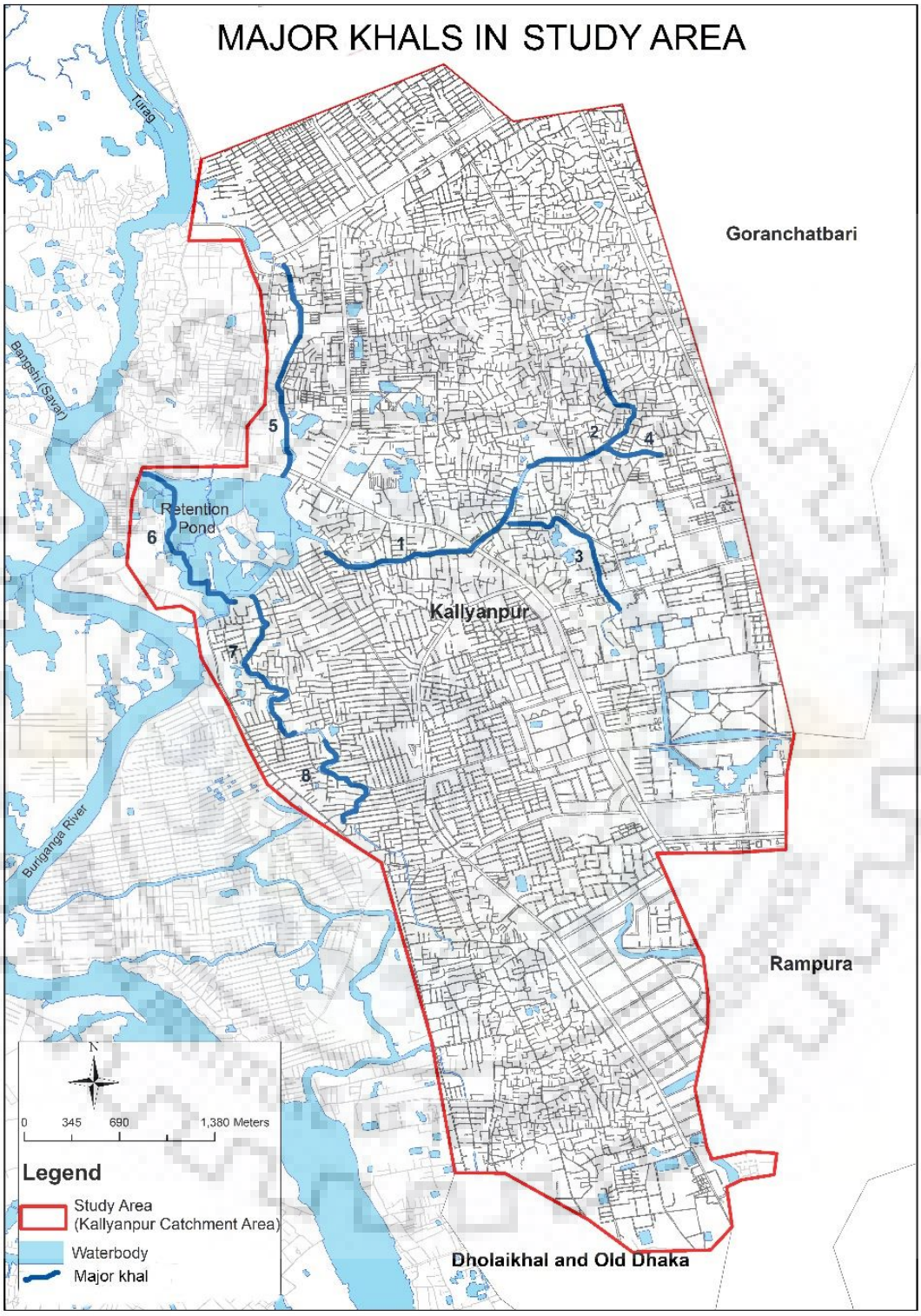


Figure 42 Major Khals in Study Area

6.8 Analysis Through Ranking the Identified Causes

To Analyze the Urban Flooding situation within Study Area some important indicators are come out through Questionnaire Survey and From Stakeholders input. So to identify the critically urban prone areas within study area we will adopt ranking approach thus to measure the magnitude, exposure, hazard of Urban Flooding.

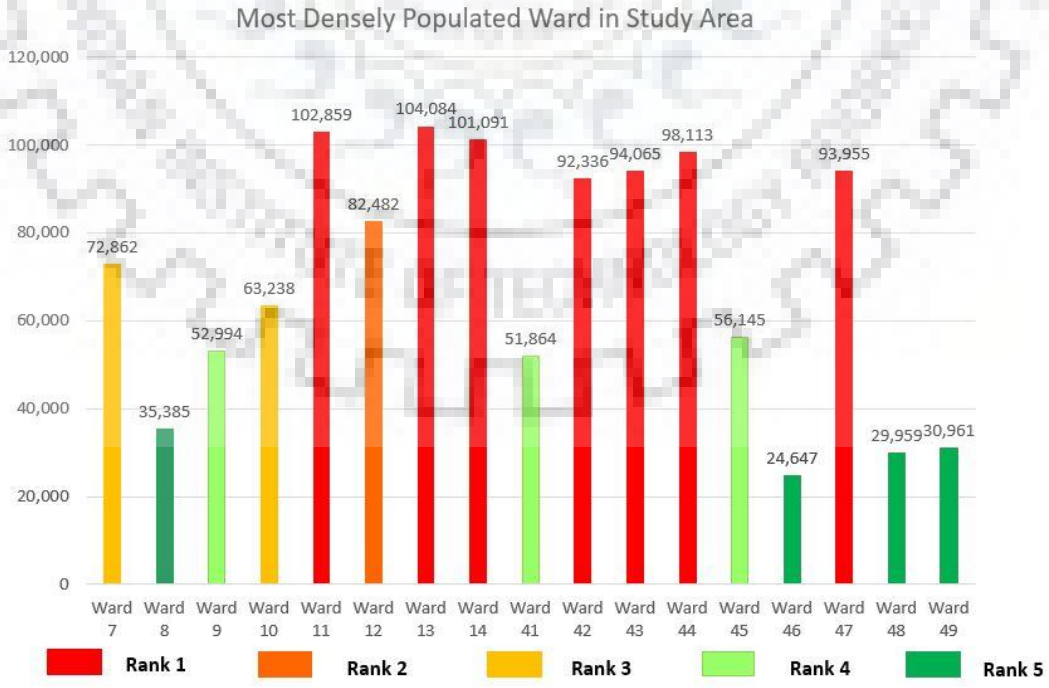
6.8.1 Population Density

Table 6.8.1 Population Density Ranking

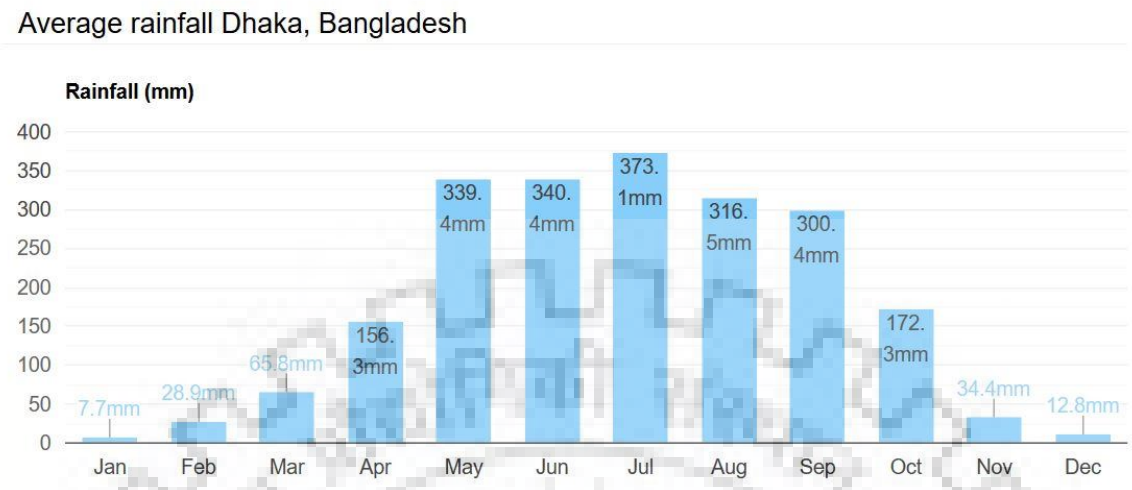
Dhaka City Corporation	Ward	Area Name	Population Density (km2)	Rank
Dhaka North City Corporation	**07**	Mirpur Sec-2, Rupnagar Govt. Housing	**72, 862**	**3**
Dhaka North City Corporation	**08**	Mirpur Zoo, Bikshil Residential Area, Staff Quarter	**35,385**	**5**
Dhaka North City Corporation	**09**	Golartek, Anondo Nagar, Darus Salam	**52,994**	**4**
Dhaka North City Corporation	**10**	Darus Salam, Gabtoli Colony (1, 2, 3)	**63,238**	**3**
Dhaka North City Corporation	**11**	Kallyanpur, Paikpara	**102,859**	**1**
Dhaka North City Corporation	**12**	Shah Ali Bag, Tolar Bag, Staff Quarter	**82,482**	**2**
Dhaka North City Corporation	**13**	Boro bag, Pirer Bag, Monipur	**104,084**	**1**
Dhaka North City Corporation	**14**	Kazipara , Shewra Para	**101,091**	**1**
Dhaka North City Corporation	**41**	Agargaon, Taltola, Agargaon Staff Quarter	**51,864**	**4**
Dhaka North City Corporation	**42**	Mohammadpur (Johuri Moholla)	**92,336**	**1**
Dhaka North City Corporation	**43**	Mohammadpur (Shyamoli Ring Road, P.C Culture Housing, Baitul Aman Housing)	**94,065**	**1**

Dhaka North City Corporation	**44**	Mohammadpur (Zakir Hossain Road, Kazi Nazrul Islam Road)	**98,113**	**1**
Dhaka North City Corporation	**45**	Mohammadpur (Lalmatia, Asad gate, Iqbal Road, Babor road, Sir Syed Road)	**56,145**	**4**
Dhaka North City Corporation	**46**	Mohammadpur (Bosila, Katasur, Mohammadia Housing, Bashbari)	**24,647**	**5**
Dhaka North City Corporation	**47**	West Dhanmondi, Shankar, Dhanmondi 27	**93,955**	**1**
Dhaka South City Corporation	**48**	Rayer Bazar, Hazaribag, Tollarbag	**29,959**	**5**
Dhaka South City Corporation	**49**	Dhanmondi 6,7,8,9,10, City College	**30,961**	**5**

According this ranking table its clearly visible that Ward 11, 12, 13, 14, Ward 42, 43 and 47 is mostly populated wards within the study area. High population density signifies the built-up area of that particular area. Because its very obvious that to accommodate more number of people it is needed to construct more buildings. And population density also deals with generation of solid waste. If number of people is high in a locality means the rate of waste generation will be high as well compared with other less densified area.



6.8.2 Rainfall Intensity



Average rainfall data in 2019 of study area was collected from BMD.

- The average rainfall in January: 7.7mm
- The average rainfall in February: 28.9mm
- The average rainfall in March: 65.8mm
- The average rainfall in April: 156.3mm
- The average rainfall in May: 339.4mm
- The average rainfall in June: 340.4mm
- The average rainfall in July: 373.1mm
- The average rainfall in August: 316.5mm
- The average rainfall in September: 300.4mm
- The average rainfall in October: 172.3mm
- The average rainfall in November: 34.4mm
- The average rainfall in December: 12.8mm

The wettest month (with the highest rainfall) is July (373.1mm). The driest month (with the lowest rainfall) is January (7.7mm).

Rainfall intensity responsible for Urban Flooding within Study area

	Rank	Rain Duration (320mm/hour Monsoon Season) responsible for UF	Ward 7	Ward 8	Ward 9	Ward 10	Ward 11	Ward 12	Ward 13	Ward 14	Ward 41	Ward 42	Ward 43	Ward 44	Ward 45	Ward 46	Ward 47	Ward 48	Ward 49
	1	30 mins- 1 hour					Y	Y	Y	Y									
	2	1 hour- 2 hours	Y	Y	Y	Y													
	3	2 hours- 3 hours									Y								Y
	4	5 hours- 4 hours														Y	Y	Y	
	5	More than 6 hours										Y	N	N	N				
			2	2	2	2	1	1	1	1	3	5	5	5	5	4	4	3	3

This analysis shows that during monsoon if its rain for 30 mins to 1 hour (270mm/hour to 320mm/hour) ward 11, 12, 13, 14 will be inundated adversely.

6.8.3 Analysing the History of Urban Flooding in Study area

Ward	Area Name	2004	2007	2009	2018	
		341 mm	277 mm	324.75 mm	320 mm	
		Flooded (Yes/No)				
07	Mirpur Sec-2, Rupnagar Govt. Housing	Y	N	N	N	
08	Mirpur Zoo, Bikshil Residential Area, Staff Quarter	Y	Y	N	N	
09	Golartek, Anondo Nagar, Darus Salam	Y	Y	Y	Y	
10	Darus Salam, Gabtoli Colony (1, 2, 3)	Y	Y	Y	Y	
11	Kallyanpur, Paikpara	Y	Y	Y	Y	
12	Shah Ali Bag, Tolar Bag, Staff Quarter	Y	Y	Y	Y	
13	Boro bag, Pirer Bag, Monipur	Y	Y	Y	Y	
14	Kazipara , Shewra Para	Y	Y	Y	Y	
41	Agargaon, Taltola, Agargaon Staff Quarter	Y	Y	N	Y	
42	Mohammadpur (Johuri Moholla)	Y	N	N	N	
43	Mohammadpur (Shyamoli Ring Road, P.C Culture Housing, Baitul Aman Housing)	N	N	N	N	
44	Mohammadpur (Zakir Hossain Road, Kazi Nazrul Islam Road)	N	N	N	N	
45	Mohammadpur (Lalmatia, Asad gate, Iqbal Road, Babor road, Sir Syed Road)	N	N	N	N	
46	Mohammadpur (Bosila, Katasur, Mohammadia Housing, Bashbari)	Y	Y	N	N	
47	West Dhanmondi, Shankar, Dhanmondi 27	Y	N	Y	Y	
48	Rayer Bazar, Hazaribag, Tollarbag	Y	Y	Y	Y	
49	Dhanmondi 6,7,8,9,10, City College	Y	Y	Y	N	

- Encroachment of surface water bodies (canals, rivers and ponds) one of the main reason of Urban flooding.
- Micro-drainage system cannot carry out the load and they are not being upgraded, maintained and managed on a regular basis.
- Law and enforcement failure.

These are the major reason of encroachment in water bodies. Analysis shows that Urban Flood situation in ward 9-14 and in Ward 48 is very critical. These wards experience Urban Flood or waterlogging problem every year.

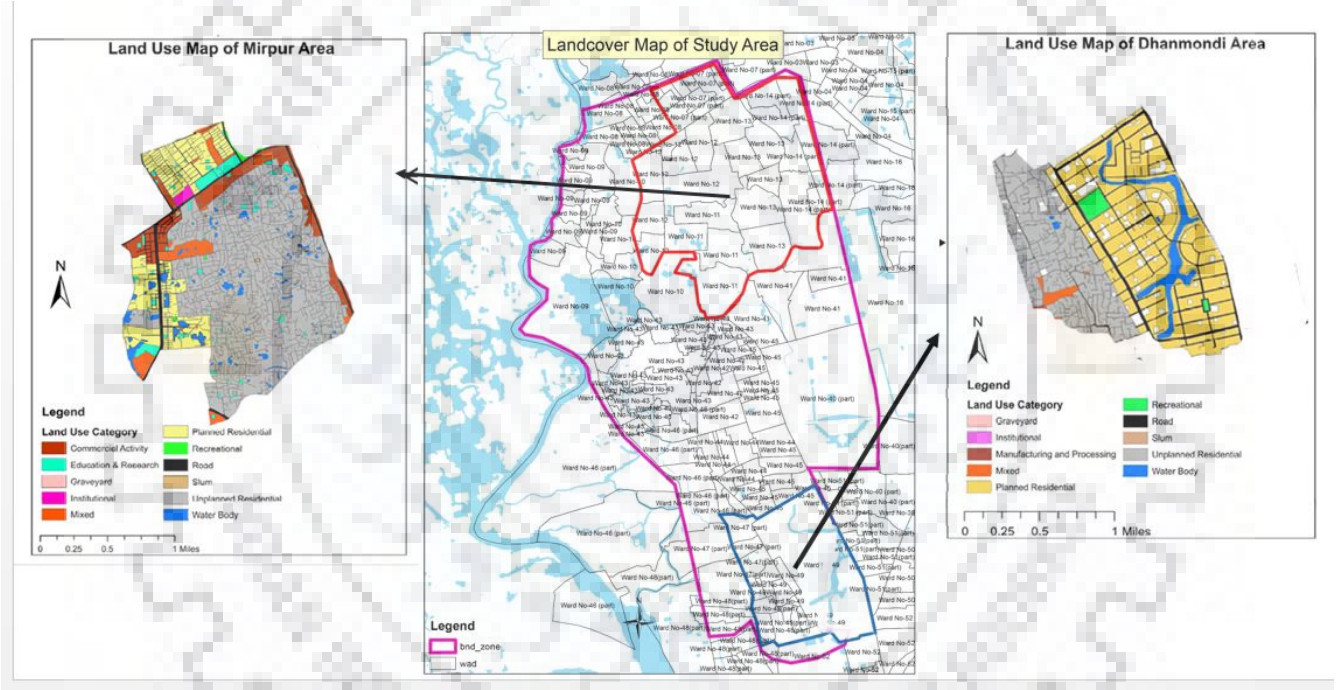
6.8.4 Unplanned Residential Area

Through this analysis we tried to find the percentage of unplanned residential area according wards.

Table 6.8.4 Unplanned Residential Area Ranking

Ward	Area Name	Unplanned Residential Area	Rank
07	Mirpur Sec-2, Rupnagar Govt. Housing	**65%**	**2**
08	Mirpur Zoo, Bikshil Residential Area, Staff Quarter	**18%**	**4**
09	Golartek, Anondo Nagar, Darus Salam	**70%**	**2**
10	Darus Salam, Gabtoli Colony (1, 2, 3)	**65%**	**2**
11	Kallyanpur, Paikpara	**70%**	**2**
12	Shah Ali Bag, Tolar Bag, Staff Quarter	**72%**	**1**
13	Boro bag, Pirer Bag, Monipur	**76%**	**1**
14	Kazipara , Shewra Para	**74%**	**1**
41	Agargaon, Taltola, Agargaon Staff Quarter	**35%**	**3**
42	Mohammadpur (Johuri Moholla)	**28%**	**4**
43	Mohammadpur (Shyamoli Ring Road, P.C Culture Housing, Baitul Aman Housing)	**12%**	**4**
44	Mohammadpur (Zakir Hossain Road, Kazi Nazrul Islam Road)	**10%**	**4**

45	Mohammadpur (Lalmatia, Asad gate, Iqbal Road, Babor road, Sir Syed Road)	**8%**	**5**
46	Mohammadpur (Bosila, Katasur, Mohammadia Housing, Bashbari)	**22%**	**4**
47	West Dhanmondi, Shankar, Dhanmondi 27	**30%**	**3**
48	Rayer Bazar, Hazaribag, Tollarbag	**40%**	**3**
49	Dhanmondi 6,7,8,9,10, City College	**18%**	**2**



6.8.5 Drainage Network Types

Category 1	Category 2	Category 3	Category 4	Category 5
Ward 44	Ward 43	Part of Ward 11	Part of Ward 11	Part of Ward 12
Ward 45	Ward 46	Ward 7	Part of Ward 12	Ward 13
Ward 49	Ward 41	Ward 10	Ward 8	Ward 14
Ward 47				Ward 48
Ward 42				Ward 9

Category 1- Storm water drainage line + Pipe drain/ Surface drain (Good Condition)

Category 2- Storm water drainage line + Pipe drain/ Surface drain + Natural drainage (encroached)

Category 3- Natural Drainage (encroached) + Pipe drain

Category 4- Pipe drain (Poor Condition)

Category 5- inadequate drainage facility

Figure 43 Poor Condition of Drainage Facility in Study Area

6.8.6 Solid Waste Management

Kallyanpur Zone four types of waste collection system is available-

Door to door Collection By DCC

Waste collection through Community Bins

Waste disposal at open space

Waste disposal randomly

To analyze the waste management system within study area I have ranked each and every wards according the management performance.

Wards are been ranked through 5 categories like-

- **Category 1-** Door to door collection (Everyday Basis)
- **Category 2-** Dumping waste in Roadside Bins
- **Category 3-** Dumping waste in Open spaces(Timely Transferred Cleaned by Authority)
- **Category 4-** Dumping waste in open spaces (Poor maintenance by Authority)
- **Category 5-** Dumping waste randomly

Category 1	Category 2	Category 3	Category 4	Category 5
Excellent	Good	Average	Poor	Very Poor
Ward 44	Ward 8	Ward 10	Part of ward 46	Ward 11
Ward 45	Ward 7		Ward 14	Ward 12
Ward 49			Ward 13	Ward 9
Ward 47				Ward 48
Ward 42				
Ward 43				
Ward 41				
Part of 46				

6.8.7 Final Score of Ranking

Ward No.	Indicator	07	08	09	10	11	12	13	14	41	42	43	44	45	46	47	48	49
Score/ Rank	RI	2	2	2	2	1	1	1	1	3	5	5	5	5	4	4	4	3
Score/ Rank	HUF	4	4	1	1	1	1	1	1	2	4	5	5	5	4	2	1	3
Score/ Rank	LE	5	5	1	2	2	3	3	2	3	4	2	4	4	3	4	3	4
Score/ Rank	PD	3	5	4	3	1	2	1	1	4	1	1	1	4	5	1	5	5
Score/ Rank	UR	2	4	2	2	2	1	1	1	3	4	4	4	5	4	3	3	2
Score/ Rank	DT	3	2	1	3	2.5	2.5	1	1	4	5	4	5	5	4	5	1	5
Score/ Rank	DC	3	3	2	2	1	1	1	2	4	5	4	5	5	4	5	3	5
Score/ Rank	SWM	4	4	1	3	1	1	2	2	5	5	5	5	5	3.5	5	1	5
	Final	26	29	14	18	11.5	12.5	11	11	28	33	30	34	38	31.5	29	21	32

According the final ranking it has been identified that Ward 11, 12, 13, 14 area critically Urban Flood prone area. Because on the ranking process these four wards obtained lowest score. In respect of all the parameters , these areas are very vulnerable to urban flood. On the other hand Ward 44, 45 has got highest score in this ranking process.

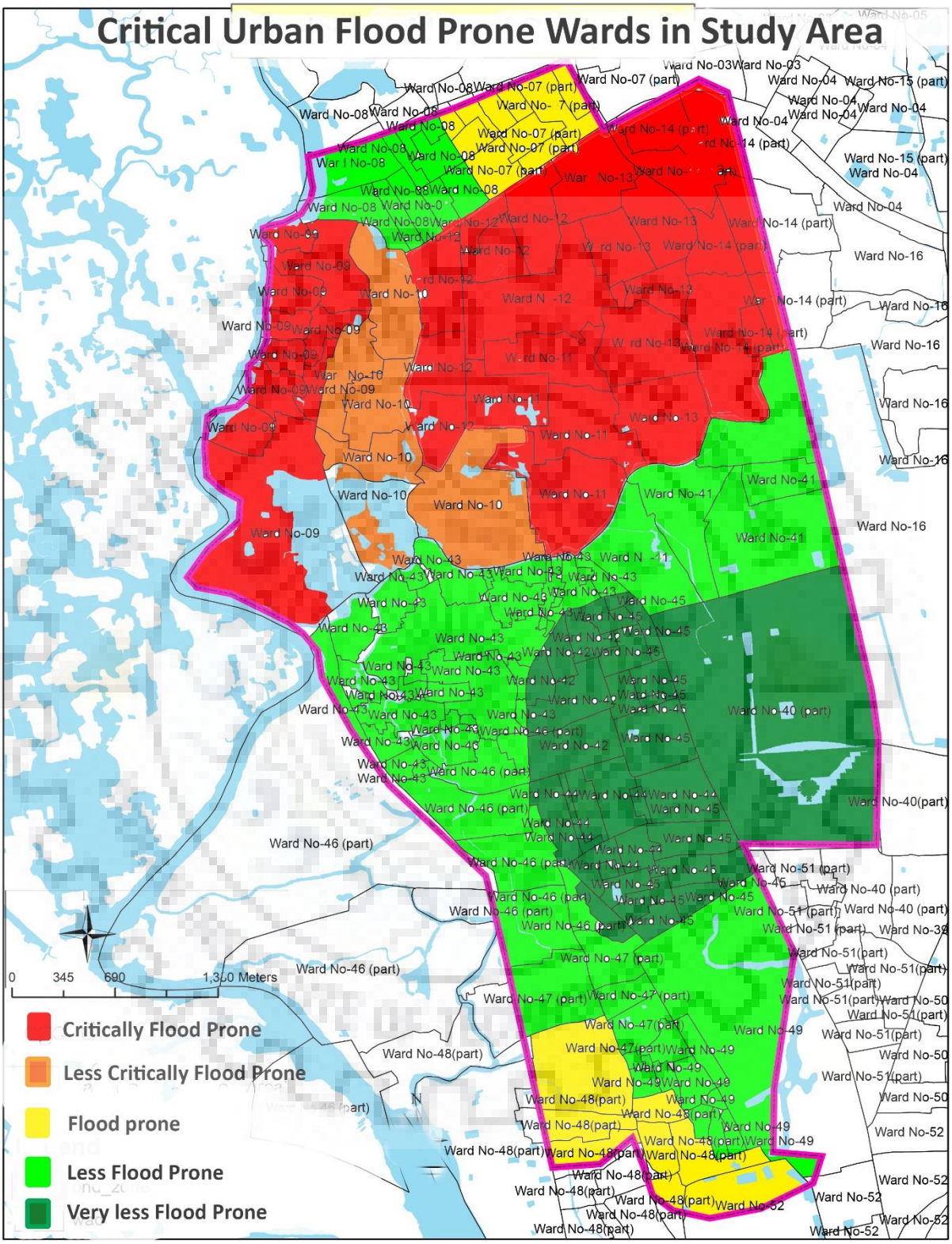


Figure 44 Critically Urban Flood Prone Wards in Study Area

6.9 Urban Flood Impact

Urban runoff causes issues. These become obvious once a created system fails. Urbanization disrupts natural evacuation patterns; natural watercourses are destroyed; natural retention of runoff by plants and soil is removed and also the creation of moth-resistant surfaces will increase the number of runoff. This runoff becomes contaminated as solid waste, silt and contaminants are washed off roads. the rise in volume and rate of runoff causes erosion and siltation. Therefore, it becomes a burden for the inhabitants of town, resulting in water work and making consultant social, physical, economical furthermore as environmental impacts.

A field survey as form survey, informal interview and open discussion has been conducted with inhabitants of Dhaka City to understand the matter faces because of water work. the full sample was one hundred in several elements of town as well as authorities of various involved organizations, specialists and general individuals and their summarized opinions regarding the matter faces because of water work are as follows (Table-6.9).

Table 6.9 Types of Problems Faced due to Urban Flooding Problem in Study area

Problems	Percentage
Disruption of traffic movement	87
Disruption of normal life	92
Damage of roads	72
Damage of katcha houses	76
Damage of substructure of the pucca houses	64
Damage of household goods	66
Damage of underground service lines	52
Water pollution	91
Water born diseases	86
Increase mosquito	88
Damage of trees and vegetation	40
Increase of construction and maintenance cost	60
Death of fish	55

Source: Field survey, 2018

CHAPTER-7

URBAN FLOOD MANAGEMENT IN DHAKA CITY

7.1 Introduction

This chapter starts with a quick background on urban floods in Dacca and its nature. It additionally provides a brief description of recent major flooding events of Dacca. this is often followed by a quick discussion on urban flood management practices in Dacca. A historical analysis of flood management interventions in Dacca and therefore the sequence within which they occurred is undertaken. The analysis shows however coming up with for flood management evolved historically; the drivers of call making; the importance and limitations of the measures undertaken, each infrastructural and non-infrastructural; and the way selections relating to flood vulnerability have knowledgeable spatial coming up with and sectionalization. This historical analysis is crucial for understanding options obtainable presently and charting pathways for the long run.

This Chapter also will specialize in institutional and structure capability assessment for urban coming up with and flood risk management in Dacca, Bangladesh. This includes analysis of relevant plans and policies, mandates, and capability of key organizations like RAJUK, the Dacca North town Corporation (DNCC), the Dacca South town Corporation (DSCC), the Asian nation water program Board (BWDB), and therefore the Dacca water and Sewerage Authority (DWASA) in shaping flood resilience.

7.2 History of Flood in Dhaka

The historic reason of flooding in capital of Bangladesh is that the rise in water levels of the rivers bordering town and serious seasonal rain. Dhaka City has knowledgeable two major floods, one in 1988 and therefore the alternative in 1998. The previous was primarily caused by excessive transboundary in flow and lack of any flood protection structure for town. The latter was primarily caused by serious rain everywhere the structure areas of the foremost rivers flowing through Bangladesh. Additionally, internal drain congestion evoked by serious rain, outflow through buried pipes, culverts and floodwalls, untimely gate operation, inadequate pumping and lack of institutional coordination have significantly contributed to worsening the flood state of affairs. (Faisal, Kabir, Nishar 1999)

Dhaka has experienced major floods often together with in 1954, 1955, 1962, 1966, 1974, 1987, 1988, 1998, 2004, 2007 and 2009. Traditionally, the key factors behind flooding are high water within the encompassing rivers and serious rain throughout the monsoon season (Faisal, Kabir, and Nishat 1999). In 1988 Flood there was no flood protection mound on the western aspect of capital of Bangladesh, and eighty five % of the world among capital of Bangladesh town was inundated (World Bank 2003). The 1988 floods peaked early and lasted for concerning 3 weeks, setting records for a few of the very best water levels.

1988 Flood

The 1988 flood was the biggest ever recorded and harmful. The 1988 flood inundated regarding eighty five p.c of national capital (water depths were in an exceedingly vary of zero.3–4.5 m), analytic the town from the remainder of the country for regarding period of time. Water provides were severely affected; and road, rail, transportation, and telecommunications were discontinuous .

This flood was primarily caused by inflows from the upstream areas, that caused an increase within the stream water levels (Faisal et al. 2003). The flood peaks were higher during this flood compared to the 1998 flood however the areas close national capital received but average rain (Faisal et al. 2003).

1998 Flood

The 1998 flood lasted quite 2 months, the longest within the city's history. Excessive rain over the construction areas of the GBM geographic area caused the 1998 flood. The rain was fortieth higher in Gregorian calendar month and thirty five in August compared to traditional rainfall within the July-August amount (Faisal et al. 2003). Most of the part of Dhaka was extensively flooded, and twenty percent of the western a part of the town, that had already been embanked at the time, was additionally flooded. Showing that despite flood mound within the west, the flooding drawback had not disappeared entirely (Faisal, Kabir, and Nishat 1999; cf. Hasnat 2006). In central Dhaka, close to sixty six kms of khals and eighty kms of storm water drains were impaired (Huq and Alam 2003; Dasgupta et al. 2015).

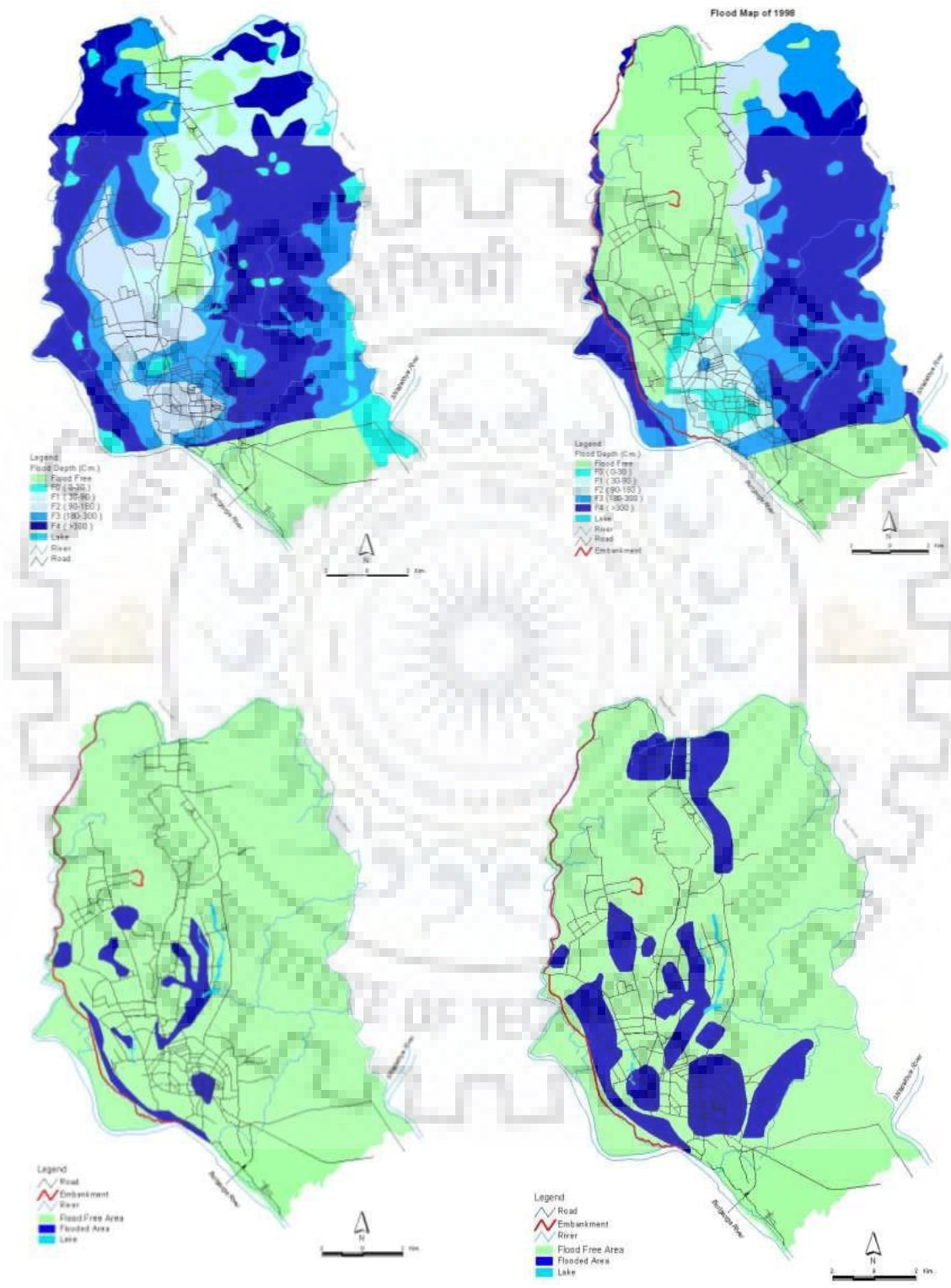


Figure 45 History of Urban Flood in Dhaka

2004 Flood

The 2004 flood event was another catastrophe for the Dhaka city, poignant nearly five million individuals. The city received virtually 315 metric linear unit of precipitation over a 24-hour amount. Residents faced a severe shortage of beverage, and also the sewerage system failing across a good space. Whereas the length of the 2004 floods was shorter than that of the 1988 and 1998floods, it took longer for the water to empty out. Of the city's 22 thanas,18 were inundated (Dasgupta et al. 2015). Whereas the west a part of the city was most affected, several elements of Dhaka west conjointly endured waterlogging. The recorded highest daily precipitation was 341mm compared to mean monthly rainfall of 264 metric linear unit in Gregorian calendar month (Rahman et al. 2005). around 40% of Dhaka west was inundated.

2007 Flood

The August 2007 flood exceeded the period of the 1988 and 2004 events; but, the magnitude of peak flow higher than the danger mark for all rivers close larger Dhaka was but 1988, 1998, and 2004 levels. Flooding of the Buriganga watercourse receded inside twenty four hours, however lasted over twenty days for different major rivers and canals. Eastern Dhaka was particularly laborious hit because of the absence of a flood-protection mound, with boats serving because the solely suggests that of transport. Sections of major roads and bridges were washed away, and diverse drowning deaths were reported. (Susmita Dasgupta, Asif Zaman, Subhendu Roy, Mainul Huq, Sarwar Jahan, and Ainun Nishat, 2015)

2009 Flood

The 2009 flood resulted from associate in nursing erratic rain pattern. Though the year's monsoons concerned twenty percent less rain than traditional (Flood report 2009), higher-than-normal rain on July 26–27 (76.57 millimetre and 324.75 mm) caused associate in nursing unprecedented flood. Although the water level of the encompassing 5 rivers was below the danger levels, excessive rain among a brief period, combined with associate in nursing inadequate system, caused the city's inundation. (CEGIS2009).

7.2.1 Recent Urban Flood in Dhaka

Many low-lying areas in the capital were waterlogged due to downpour coupled with storm on April 2018, causing immense sufferings for city people. Many areas in the capital, including Mirpur Section 14, Shewrapara, Ibrahimpur and Kuchkhet, were flooded with rain water. Roads in Dhanmondi, Testuri Bazar, Malibagh, Mouchak, Mirpur, Kazipara, Arambagh, Motijheel, Mohammadpur areas went under ankle-deep water due to the heavy shower.
The downpour created severe traffic congestion on many city roads, causing intense sufferings for commuters and pedestrians. Movement of passenger buses came to a halt on most of the busy city roads and passengers had to stuck in traffic. According to the Weather Office, the highest recorded wind speed during the storm was 73km/hr.
A total of 50mm of rain was recorded in Dhaka between 6am and 9am on 28th April, 2018.

Figure 46 Recent Urban Flood Scenario in Dhaka

Begum Rokeya Avenue in the area becomes inundated even after only 30 minutes of rain.With a significant portion of the Begum Rokeya Avenue being demarcated for the construction of Dhaka Mass Rapid Transit (DMRT), traffic congestion in this highly populated part of Dhaka city has become unbearable.

The rainy season has only just began but the Begum Rokeya Avenue floods after just 30 minutes of rain. It only increases the suffering of thousands of people like Farhana Alam, a service holder, who travels from Kazipara to Uttara on a regular basis.

(Source: Dhaka Tribune, 22th April, 2019)

Figure 47 Office-goers start walking in knee to waist-deep water, after failing to get on buses

Photo: Prabir Das, Source: The Daily Star, April 2018

7.3 Urban Flood Management: Aims and Approaches

Flooding may be a phenomenon, that can't be prevented. Complete control is not within the interests of Asian nation Flood management approach. The flood management in Dhaka focuses on cut back the damages of properties, infrastructure and saving lives from watercourse flood. Another necessary half in its management is to improvement of voidance khal to cut back injury from storm water flooding. There are 2 styles of flood management approaches in Dhaka, Bangladesh. The measures are principally physical in nature.

7.3.1 Structural Measures

Structural flood management measures are measures, which are taken to protect people and property, that counteracts the flood event in order to reduce the hazard or to influence the course or probability of occurrence of the event.

- Flood protection – over 10,000 km flood protection embankment
- Flood and Cyclone Shelters.
- Approximately 37 km of raised road and floodwall.
- A total number of 11 regulators at the outfall of canals to the surrounding rivers along the embankment.
- One regulator and 12 sluice gates on the canals at the crossing with Biswa Road, DIT road, Pragati Sarani, Mymensingh road and railway line at Uttar Khan.
- Three pump stations.

DWASA is responsible to provide drainage facility in Dhaka city which covers almost 150 sq km area. Which is only the 40% of the whole Dhaka city.

- 22 open canals having width of 10 to 30 m and total length of approximately 65 km.
- 185 km. of underground pipes having diameter ranging between 450 to 3000 mm.
- 6.5 km. of box culvert of sizes between 2.5 m * 3.4 m to 6 m * 4.1 m.
- 2 storm water-pumping stations, of capacity of 9.6 m^3/s and 10 m^3/s at Narinda and Kallyanpur respectively.

- Recently DCC has constructed one storm-water pumping station, having capacity of 22 m^3/s at the confluence of river Buriganga and Dholai khal. Dhaka WASA has taken over the operation and maintenance of the pumping station.

Besides that, the Dhaka town Corporation (DCC) has made and maintains approx. 2,460 km surface drains, that carry storm water to the most sewer lines. Rajdhani Unnayan Katripakkhya (RAJUK) conjointly constructs margin underground drain lines throughout the development of latest roads.

7.3.2 Non-Structural Measures

An alternative strategy of Flood hazard mitigation, a concept of social adjustment known as non structural measures. These measures include:

- dissemination of meteorological/flood forecasts to help speedy evacuation.
- land management for reduction of runoff;
- land use change and enactment of building codes, diversification of agricultural production;
- floodplain zoning involving land use zoning to control zoning to control development and restrictive development regulations;
- disaster relief during and post flood situation forms an important part of flood loss recovery.

The non-structural measure are employed to improve the capacity to manage the consequences of floods and reduce the vulnerability of the flood affected people and their property. This includes: Flood Forecasting and Warning (FFW), Flood Plain management measures like flood proofing, flood-plain zoning, Retention ponds and the drainage network, Land use planning etc.

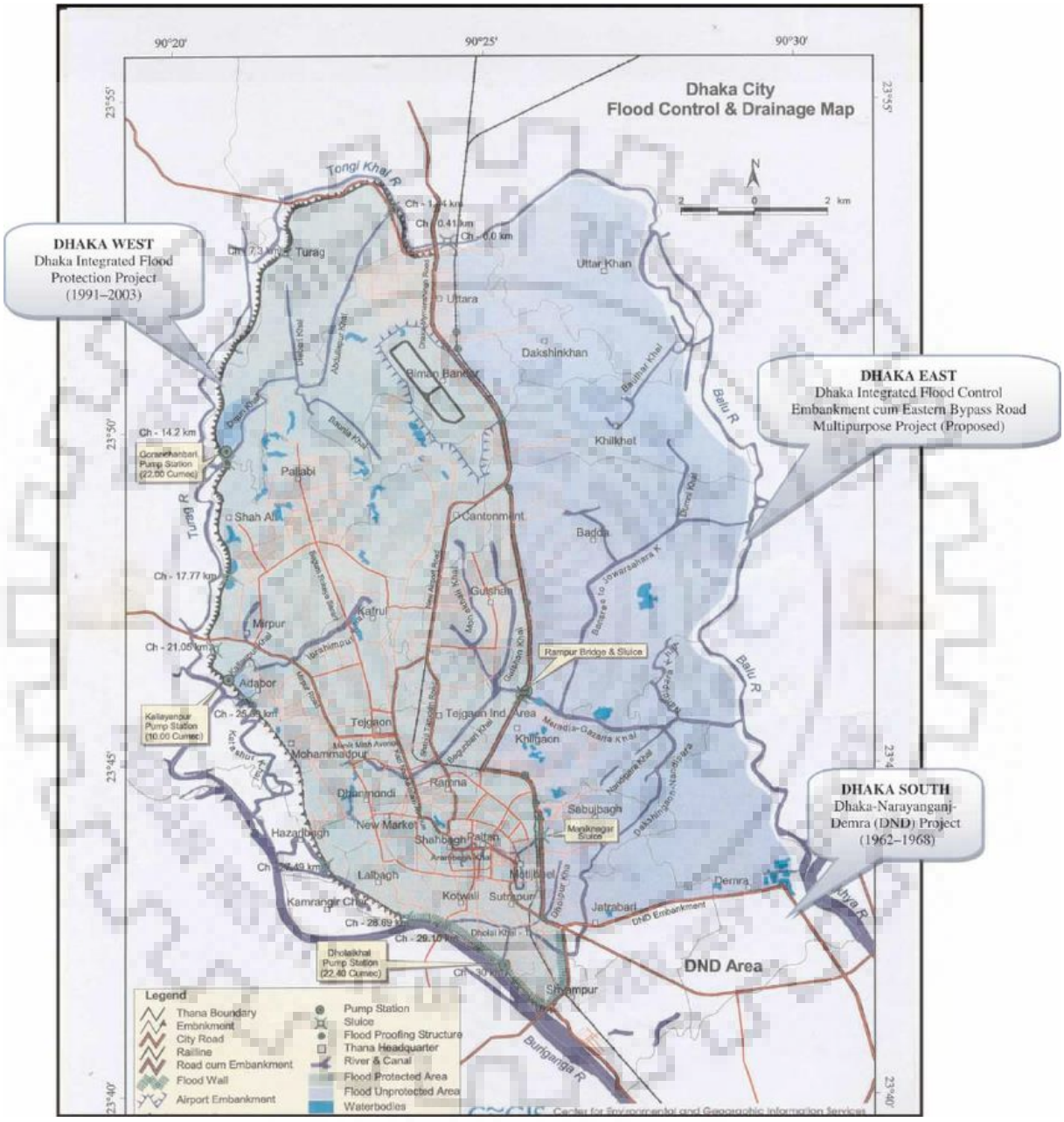


Figure 48 Dhaka city flood control & drainage map, Source: CEGIS 2008

(a) Forecasting and warning

Flood statement and warning is that the responsibility of FFWC of BWDB in cooperation with Surface Water Modeling Center (SWMC), Bangladesh meteorological Department (BMD) and house analysis and Remote Sensing Organization (SPARRSO). FFWC was established as a part of FAP activities with the assistance of the international organization and therefore the Government of Bangladesh (GOB). Fig. 7.3.2 (a) shows the procedure followed by FFWC.

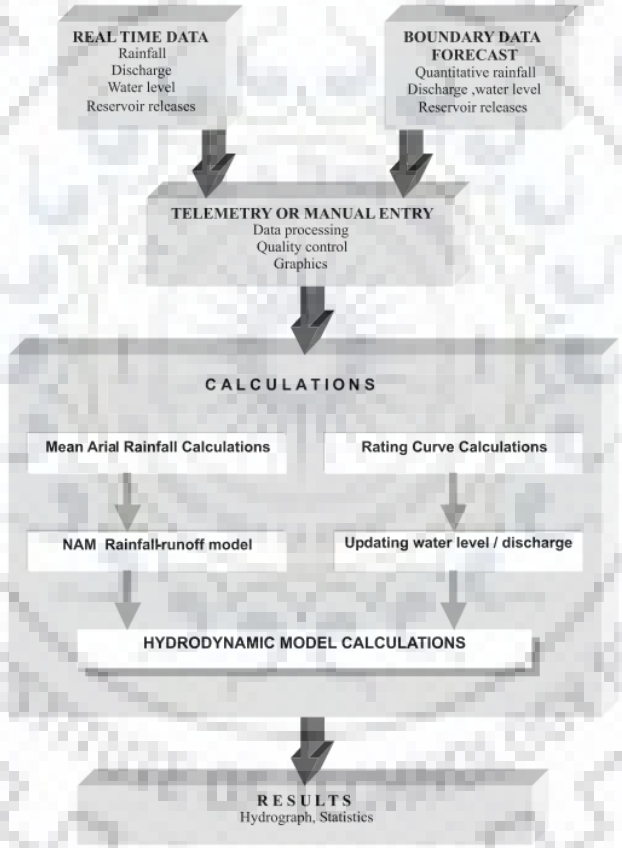


Figure 49 Flood forecasting and warning procedure of FFWC.

FFWC could be a permanent facility, that operates a Flood info centre from one could to thirty Sep. If necessary, its operation continues through Oct. 3 hydrologic foretelling techniques are utilized by FFWC, namely, MIKE11 Simulation Model, Muskingum/Cunge Flood Routing and Gage-to-gage correlation. FFWC provides Flood and watercourse forecasts for sixteen locations for 24-h and 48-h periods. in addition, it

conjointly provides daily watercourse level and precipitation outline for fifty rivers and forty nine rainfall locations. of these info are free as Flood Bulletin
(Kachic,1998).

(b) Retention ponds and the drainage network

Dhaka town contains a range of lakes and natural depressions, that function retention ponds once a significant storm and stop water-logging within the town. Several of those retention ponds are being encroached by developers resulting in severe emptying congestion within the town. Presently the entire space of retention at intervals the urbanized a part of DCC is regarding 365 hour angle. This space is a smaller amount than four of the western a part of Dacca. In line with town development authority, 12-tone music of the geographic area ought to be engaged as retention ponds (RAJUK, 1995). Since the western a part of town has already been urbanized, RAJUK ought to make sure that this recommendation is followed through within the eastern part of the city. One economically possible approach of doing this may be to buy non-public land during this space and develop the retention ponds as Fisheries-cum-recreational spots.
(I.M. Faisal, M.R. Kabir, A. Nishat, 2000)
An important reason for internal Flooding of town in 1998 was that the emptying network in several components of the city was silted up (to the maximum amount as 70%) and was unable to hold the look discharge. This was because of indiscriminate disposal of solid waste in each the surface and sub-surface drains and runoff from construction sites heavily loaded with sediments. Solely public awareness and active public participation will facilitate eliminate this drawback in future. (I.M. Faisal, M.R. Kabir, A. Nishat, 2000)

(c) Land use Planning

Land use coming up with is dispensed to optimize the employment of land supported its geographical, geographic, climatically and soil characteristics. Within the context of town development, it means that delineating land for residential, business, industrial and natural uses. Developed countries like the USA have introduced the idea of flood division wherever land is categorized supported risk of inundation. This can be followed by acceptable rules to make sure that extremely flood prone square measures square measure spared from intensive capital investments and dwellers of that space are coated through

flood insurance.

In the context of national capital town, RAJUK will build 2 necessary contributions through land use coming up with. One, RAJUK, with the assistance of BWDB, will find and shield the potential sites for retention ponds within the eastern part of Dhaka city. RAJUK has already ready the rules for minimum ground level elevation of the lowland and development starting from four.5 to 6.0 m (PWD datum).

Activity	Description	Participants	Remarks
Emergency Services	Medical care (water born diseases, snake bite, etc.), potable water, food, candle, fuel, clothing, temporary housing, shelter.	Hospitals, DWASA, Red Crescent, GOB, NGOs, Defense forces, Political groups and general public.	Widely practiced. Usually limited to accessible places.
Flood Proofing	Raising the plinth level of the house, building on tall pillars, Flood walls along properties, raising important roads and some power stations above the 1988 Flood level, special embankment for the international airport.	Individuals and some businesses and industries, GOB.	RAJUK has proposed minimum ground elevations for the eastern part of Dhaka City.
Flood Fighting	Temporary Flood wall (brick or sandbags), pumping, moving assets to upper Floors, roof or dry places such as high roads and embankments.	Individuals and some businesses and industries.	People try to fight floods till they are forced to evacuate.

Flood Shelter	Community centers, schools, colleges, public buildings, roads, embankments	Flood victims, community volunteers, emergency service providers.	Facilities used as shelters are not designed as such and do not have sufficient capacity.
Recovery and Reconstruction	Vulnerable group feeding, food for work, building materials, soft or interest-free loans for business and agriculture.	GOB, NGOs, banks and private initiatives.	Affected group have very limited access to such help. Pilferage of relief and rehabilitation material or fund.

7.3.3 Flood Management Strategies in Bangladesh

Flood Management Strategy has been below continuous amendment since early sixties of the last century. Flood Management methods will be divided into 3 distinct phases of its development, that are as follow:

i) Phase-I: 1960 to 1978

ii) Phase-II: 1978 to 1996

iii) section III: 1996 to 2000 ahead

Phase-I:

The first section (1955-1971) was supported solely post disaster recovery methods, the main target was on large-scale flood interference and irrigation schemes. Once unfortunate floods of 1954, 1955 and 1956 international organizations and agencies gave attention on the importance and also the want for control and water management in East Pakistan (the then East Pakistan). International organization fashioned a mission that was crystal rectifier by Krugg. Aim of the mission was to seem into the issues of arrive East Pakistan and to counsel some effective measures.

In 1956 the Krugg Mission finalized its Report and submitted it to the then Government of West Pakistan and conjointly gave some recommendations. The report emphasized on water resources development as a result of it had been essential for higher agricultural production and control as central issue. Principal recommendations of Krugg Mission were following:

i) Develop a programme for Water and Power Development;

ii) kind a statutory body to cope with water and power development;

iii) Conduct a hydrological survey and investigations additionally.

This report conjointly centered on 'self-sufficiency in food'. 'Self-sufficiency in food' was the milestone of the govt policy. As a result, a exploitation programme was ready in 1964 and on it plan structural choices having giant project portfolios got priority. The programme known ninety one comes to deal with flood issues of what was then Bangladesh. Review of development policies once the 1962 floods conjointly crystal rectifier to some efforts to integrate infrastructure development comes with flood-control efforts. some such vital control comes were (1) Kurigram hill project, (2) previous Brahmaputra River clinical test and eleven, (3) Belkuchi, Chalan Bill and Bogra comes, (4) Dhaleshwari and Bangshi Channel Improvement comes, (5) Ganga-Kaputakkhya Project, (6) Faridpur-Barisal Project, additionally as varied different comes together with Southern Rajshahi, national capital Southwest, Chandpur, Gorai, Aria1 Khan, Boral, Haor schemes, Kushiyara, Meghna- Dhangoda, Titas, Gumti, Khowai, Mono and Matamohori (Tarafder, 1974). Krug Mission conjointly prompt, a national scale control and Drainage(FCD) to develop. Implementation of huge and medium FCD comes were too time intense and through the implementation of those projects some medium scale flood occurred specially one in 1968 that caused many suffering and social issues to the folks. As a result the govt. completed that solely through structural measures flood issues couldn't be resolved or mitigated it conjointly wants some non structural solutions. In 1972 the govt. determined to travel for non-structural measures like flood statement and warning system to mitigate flood issues. (Source: APFM, Sept 2003).

Table 7.3.2 Non Structural Measures Practiced by various Agencies in Dhaka

Phase-II:

By the late Nineteen Sixties it absolutely was accomplished that the proportion of prices to advantages in giant scale comes was terribly high. Maintenance became a large task, and rent realization from major irrigation comes was slow and in some cases unsuccessful. Since the implementation of large-scale comes needed for much longer time, the stress on the support of large-scale development comes by public sector teams lost their momentum and significance over time. The priority for the restrictions of economic viability of large-scale comes led to a amendment high management and irrigation methods when the independence of Asian country. Within the early Seventies, World Bank review studies of the land and water sector of Asian country suggested changes within the strategy, that diode the govt. to shift to small-scale, low cost, and quick-return comes high management, drainage, and irrigation development (IBRDDDA, 1970; 1972). With the appearance of low-lift pumps, tube wells, and diffusion of dry-season cropping, a shift of policy from major control works to a lot of small-scale, quick-yielding comes predominated starting in 1971. Then government detected the National Water arrange (NWP). The Government took initiative in 1982 to formulate a NWP trying into varied aspects of water connected with its use and also the demand and interest of various stakeholders concerned within the water sector. NWP was finalized in 1986 however wasn't approved by Government . when unfortunate floods of 1987 , government once more took NWP seriously. All the international Development Partners voted for a project entitled Flood Action arrange (FAP). FAP (1990 to 1996) developed a national Flood and Water Management Strategy. FAP was primarily a study project partaking twenty six parts. On the idea of FAP activities the Government developed Asian country Flood and Water Management Strategy (BWFMS) in 1996. In BFWMS some policy tips for water resources development and management were fanciful i.e. Peoples Participation, Environmental Impact Assessment (EIA), Multi-Criteria Analysis throughout coming up with method were created required altogether future water sector comes.

Phase-III:

At the tip of FAP studies, Government found that each one the problems regarding the water resources development and utilization haven't been self-addressed properly and people weren't integrated with Water Resources Management (WRM). Then the Government once more boarded on formulating a National Water Management arrange (NWMP) through an endeavor and error method. Completely different sectors of economic system within the lightweight of IWRM were enclosed in 1998. To guide the preparation of NWMP, the Government additionally developed a National Water Policy (NWPo) in 1999. NWMP was ready in 2001 with twenty five period projection. Whole Program amount was divided into 3 phases e.g. short term for five yrs., medium term with ten years and future with twenty five years amount. Program approach was followed to formulate that. It absolutely was a shift within the Government policy. It recognized varied conflicting water desires and to make sure unbiased water use and balanced economic process. NWMP has eighty four programs cross cutting eleven completely different sectors of economy. Access to Safe drink and Sanitation was on the highest priority. Within the NWMP the difficulty of economic condition reduction has not been self-addressed clearly, however the Government needs to place emphasize considering economic goal. NWMP is currently anticipating Governments approval. A number of flood mitigation structures: embankments, flood walls, sluice gates and storm water emptying structures: pump stations, emptying pipes, retarding ponds ar projected in FAP 8A Study. Total summery of all the proposals are shown in **Table 7.3.3**

Table 7.3.3 Proposals that are mentioned in FAP 8A Study

Area	Flood mitigation	Stormwater drainage
1. Greater Dhaka		
a) West	a)embankment (R): 16.7 km	a)pump station o: 73.2m3/sec(2)
	b)flood wall (R): 4.7 km	b)khal improvement: 42.7 km
	c)embankment: 6.3 km	c)drainage pipe: 8.1 km
	d)flood wall:3.0 km	d)retarding pond: 770.0 ha
	e)sluice gate:11plcs	e)land acquisition: 43.7 ha
	f)land acquisition:37.0 ha	
b) East	a)embankment: 26.7 km	a)pump station no: 179 m^3/s(3)
	b)sub embankment: 11.3 km	b)khal improvement: 72.4 km
	c)sluice gate: 5plcs	c)drainage pipe: 8.9 km
	d)land acquisition: 317.4 ha	d)retarding pond: 1884.0 ha
		e)land acquisition: 168.0 ha
2.Narayanganj		
a) DND area	a)flood wall(R):20.2 km	a)pump station no:50.2 m^3/s(1)
	b)flood wall:10.0 km	b)khal improvement:38.0 km

	c)sluice gate:2 plcs	c)retarding pond:681.0 ha
	d)land acquisition:5.8 ha	d)land acquisition:90.8 ha
b) West	a)embankment:6.1 km	a)pump station:16.2 m^3/s(3)
	b)road cum embankment:4.3 km	b)khal improvement:6.4 km
	c)flood wall:10.5 km	c)retarding pond:170.0 ha
	d)sluice gate:7 plcs	d)land acquisition:12.2 ha
	e)land acquisition:61.5 ha	
	%evacuation facilities 1 LS	
c) East	a)embankment :6.6 km	a)pump station no:12.5 m3/s(4)
	b)road cum embankment:6.5 km	b)khal improvement:7.4 km
	c)flood wall:26.0 km	c)retarding pond:130.0ha
	d)sluice gate:12 plcs	d)land acquisition:14.1 ha
	e)land acquisition:99.2 ha	
3. Tongi		
a) Tongi	a)embankment:13.0 km	a)pump station no:25.2 m3/s(2)
	b)road cum embankment:6.2 km	b)khal improvement:22.0km
	c)flood wall:2.2 km	c)retarding pond:265.0 ha
	d)sluice gate:7 plcs	d)land acquisition:42.5 ha
	e)land acquisition:100.9 ha	
	% evacuation facilities:1 LS	
4. Savar		
a) Savar	a)embankment:9.3 km	a)khal improvement:30.0 km
	b)sluice gate:3 plcs	b)land acquisition:66.2 ha
	c)land acquisition:62.3 ha	
	%evacuation facilities:1 LS	
5. Keranigonj		
a) Keranigonj	a)embankment:23.3 km	a)pump station:27.7 m3/s(1)
	b)flood wall:3.7 km	b)khal improvement:22.5 km
	c)sluice gate:10 plcs	c)retarding pond:292.0 ha
	d)land acquisition:163.7 ha	d)land acquisition:50.6 ha
	% evacuation facilities:1 LS	

7.3.4 Flood and water management instruments

Since ancient time for flood management in the country legal instruments were used. Many important acts and rules for flood management were introduced, e.g. Embankment Act, Drainage Act and Canal Act, etc during the latter part of 19th Century. From the early sixties some more acts to manage floods has introduced by Government. Actually there are some irregularities found in these laws it has been decided to disseminate a unified law and work is now going on in framing a National Water Code. An integrated hydrological database and a good hydrological data collection system has developed through all over the country. Real-time water level and rainfall data collection system is another important tool because all these data are used for planning and design of different types of hydraulic structures, construction of different infrastructures, etc. Government has invested approximately USD 4 billion during the last 40 years in the water sector, mainly for FCDI projects. For water and flood management annually about USD 200 million are disbursed.

7.4 Institutional Framework for Urban Flood Management

In Bangladesh about 53 central government organizations and 13 ministries are working to mage flood and water. Principal national institution for flood management in Bangladesh is the Bangladesh Water Development Board (BWDB). Besides BWDB, many organizations are working in the flood management activities involved at different stages of flood management. Organizations and their respective responsibilities regards flood management is given below:

Bangladesh Water Development Board

Bangladesh exploitation Board is that the leading organization for water resources management and development. BWDB is to blame for flood protection and mitigation for the complete country together with Dhaka. It constructs and maintains embankments and flood walls, operates regulators and pump stations.

BWDB conjointly deals with irrigation; stream ban and city protection; flood foretelling and warning services; hydro-meteorological information management; land reclamation; protection against periodic event surge. BWDB collects and maintains information on surface water (water level, discharge, sediment information, and water quality), groundwater (level activity, quality), morphology (river cross section) and meteorology (rainfall, evaporation, climatologically station).

Flood Forecasting and Warning Center (FFWC)

Flood foretelling and Warning Center (FFWC) was established in 1972. It works underneath designing Wing of BWDB headed by chief engineer geophysics. FFWC has established hydrological observation stations on rivers across the country. The product of this centre area unit satellite image, rain distribution map, Daily bulletin outline, Forecast bulletin & Hydrograph, Inundation Map, stream scenario map, Thana standing map. The circulate the information via net, email, fax, telephone, radio and tv to President's workplace, prime Minister's workplace, Ministry of Water Resources, Disaster Management Bureau, Public info Department, news agencies, NGO'S administration. Their major limitations embrace short Forecast time interval, Forecast in major rivers solely, Weak dissemination up to village level, lack of Review and Response.

Water Resources Planning Organization (WARPO)

Water Resources designing Organization (WARPO) a key organization below the Ministry of Water Resources engaged in nation-wide macro-level water resources designing and management. In 1983 the government created the program Organization (MPO) with a mandate to arrange a National Water arrange. MPO became WARPO below Act variety XII of 1992.The Water Resources designing Organization (WARPO) is an establishment below the Ministry of Water Resources. It provides body, technical and legal support to ECNWRC, and advises them on policy designing and restrictive matters of water resources and surroundings. The core tasks of WARPO includes: observance, implementation of the NWMP and its impacts, observance the applying of pointers of democratic Management and update it etc. The periodic functions of WARPO embrace periodic update of NWMP, spontaneous recommendation on policy, strategy, institutional and legal problems assist different agencies in designing, monitoring, studies and investigations etc.

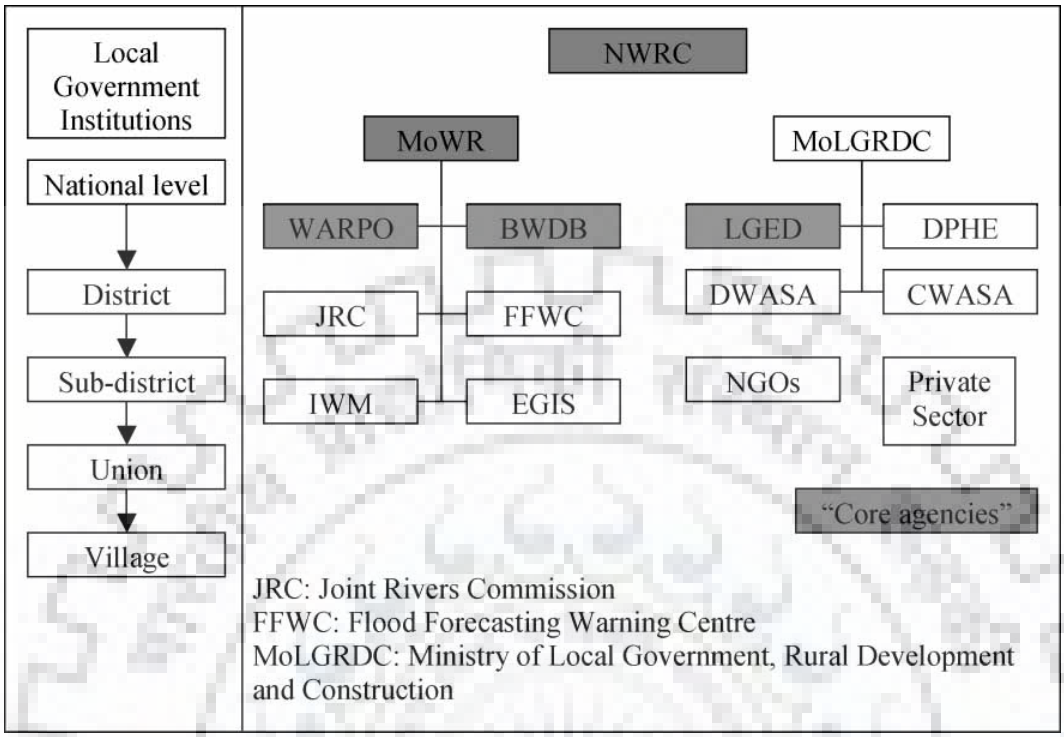


Figure 50 Institutional framework in the water sector in Bangladesh

Dhaka Water Supply and Sewerage Authority (DWASA)

Dhaka water and Sewerage Authority (DWASA) manage the water and Sewerage network of national capital. DWASA was established in 1963. per the water and Sewerage Authority Act 1996, the most functions of DWASA are: construct, improve and maintain water works for assembling, purifying, pumping, storing & distributing potable water, construct, improve and maintain sewerage works for assembling, pumping, treating and confiscating hygienically waste product and industrial wastes, construct and maintain voidance works for voidance facilities together with storm water voidance and levy water, sewer and storm water rates. The voidance circle of DWASA is that the key role player keep the town free from voidance congestion. they're liable for voidance and operation of the pumping stations. They conjointly construct, maintain voidance infrastructures like deep drains, box culverts.

Table 7.4 Institutional Framework for Flood Management in Bangladesh

SL No.	Ministry	Organizations/ Agencies	Scope of Work
1.	**Ministry of Water Resources (MoWR)**	**Water Resources Planning Organization**	Macro planning of water resources management
2.	**Ministry of Water Resources (MoWR)**	**Bangladesh Water Development Board**	Implementation, Feasibility Studies, Operation and Maintenance of Flood Management Projects, Real Time Data Collection for Flood Forecasting and Warning Services, Dissemination of Flood information at national and regional levels.
3.	**Ministry of Water Resources (MoWR)**	**Flood Forecasting and Warning Center (FFWC)**	Generates and forecasts floods in Bangladesh
4.	**Ministry of Local Government, Rural Development and Co-operatives**	**Dhaka Water and Sewerage Authority (DWASA)**	Administrate Water supply, Drainage and Sanitation system in Bangladesh
	Ministry of Local Government,		

5.	**Rural Development and Co-operatives**	**Dhaka City Corporation (DCC)**	To run municipal affairs of Dhaka City.
6.	**Ministry of Housing and Public Works**	**Dhaka Capital Development Authority (RAJUK)**	Responsible for coordinating urban development in Dhaka, Bangladesh
7.	**Ministry of Defense**	**Bangladesh Space Research and Remote Sensing Organization (SPARRSO)**	Responsible for astronomical research and the application of space technology in Bangladesh
8.	**Ministry of Defense**	**Bangladesh Meteorological Department (BMD)**	Long, medium and short range weather forecasting and dissemination
9.	**Ministry of Local Government, Rural Development and Co-operatives**	**Local Government Engineering Department**	Implementation. O&M of Small Scale FCD projects
10.	**Ministry of Disaster and Relief**	**Directorate of Relief**	Conducting Relief and Rehabilitation operation in flood hit areas
11.	**Ministry of Local**	**Local Government Institutions (LGI)**	Implementation and O&M of small scale

	Government, Rural Development and Co-operatives		flood management project, Flood Information Dissemination, Relief and Rehabilitation of flood victims.
12.		**Non-Government Organizations (NGO)**	Advocacy for flood management, Relief and Rehabilitation of flood victims

Dhaka City Corporation (DCC)

In 1990 national capital Municipal Corporation was renamed to Dhaka City Corporation (DCC). DCC is that the key organization liable for keeping the atmosphere of national capital town healthy and comfy. Electoral civil authority and ninety town Councilors administer DCC. The executive set-up is redistributed into 10 zonal offices. There are sixteen departments headed by Chief officer (CEO). the opposite functions of DCC performs big selection of functions like public heath, public safety, urban designing, welfare, education, public areas (parks, gardens, forests, trees), facility and voidance, street lighting, culture, development etc. DCC is additionally liable for removal, assortment and disposal of solid wastes, offer public drains, control, regulate and examine surface drains and construction and maintains roads.

Dhaka Capital Development Authority (RAJUK)

Dhaka Capital Development Authority (RAJUK) is indirectly concerned overflowing management. RAJUK is a crucial agency underneath Ministry of Housing and construction who is primarily answerable for the design and development of the bigger national capital and encompassing areas, a complete of 1528 sq. km. within the year 1987 RAJUK was established by commutation national capital Improvement Trust (DIT).

RAJUK is answerable for dominant all development connected activities of national capital town underneath the provisions of city Improvement Acts, Building Construction Rules and Land Use laws among the realm underneath its jurisdiction .RAJUK is that the principal actor to guide and management urban growth through the detail area set up. RAJUK is additionally obligated to preserve the natural depressions and water bodies in urban areas.

7.5 Policies, Acts and Regulations

Bangladesh has varied national policies for various key sectors to accelerate the balanced means of development. There are many policies and acts for formulating the foundations and laws on general usage on water and to manage Flood. The ministry of Water Resources and Ministry of authorities, Rural Development and Co-operatives have mounted some policies and set up that act as pointers to completely different organizations operating within the field of water resources below the administration of relevant ministries.

7.5.1 Water Sector Policies and Plans

The table 7.5.1 presents the lists of water and flood related policies and plans.

Table 7.5.1 Water and Flood Related Policies and Plans

Ministry	Policies & Plan	Year
Ministry of Water Resources	Master Plan	1964
	National Water Plan	1986
	National Water Policy	1999
	National Water Management Plan	2001
	Integrated Coastal Zone Management	2005
Ministry of Local Government, Rural Development and Co-operatives	National Policy for Safe Drinking Water Supply and Sanitation	1998
	National Arsenic Mitigation Policy	2004
	Drainage Master Plan	2006

Source: Haque, 2008

National Water Policy

The Ministry of Water Resources revealed the National Water Policy to confirm best development and utilization of water. it's a tenet for all involved ministries, agencies, departments, and native bodies that square measure accountable for the event, maintenance and delivery of water and water connected services likewise because the

non-public users and developers of water resources.

The key focus areas of the policy are follows:

- River Basin Management
- Water and Fisheries and Wildlife
- Planning and Management of Water Resources
- Water for Preservation of Haors, Baors and Beels.
- Water Rights and Allocation
- Public and Private involvement
- Public Water Investment
- Economic and Financial Management
- Water Supply and Sanitation
- Water and Agriculture
- Water and Industry
- Water for Hydropower and Recreation.
- Water for the Environment
- Water and Navigation

The National Water Management arrange has been ready to supply a framework at national and regional level among that line agencies, regime and different stakeholders might arrange and implement their own activities and comes in an exceedingly synchronous manner, in keeping with overall national and sectoral objectives. The Water Resources coming up with Organization (WARPO) ready the arrange in 2001. In March 2004 this arrange was adopted by the govt. The NWMP may be a framework, spanning twenty five years through that water connected programs are going to be implementing varied programs and comes in an exceedingly coordinated manner by varied organization. The arrange has 3 phases: within the short term (2000-05), within the medium- term (2006-10) and within the future (2011-25). The key objectives of NWMP area unit given bellow:

• Rational Management and correct utilization of Bangladesh's water resources.

• To guarantee a property resolution and to create peoples life simpler and cozy by the just, safe and reliable access to water for production, health and hygiene.

• Clean water in adequate quantity for utile use and preservation of the aquatic and water dependent eco-systems.

7.5.2 Water Sector Legislations

There are several acts and rules in Bangladesh related to water sector. The table 5.4 provides the water sector legislations are in place in Bangladesh.

Table 7.5.2 Water Sector Legislations

Ministry	Legislations	Year
Ministry of Water Resources	The Canals Act	1864
	The Irrigation Act	1876
	The Embankment & Drainage Act	1952
	The Irrigation Water Rate Ordinance	1963
	The River Research Institute Act	1990
	The Bangladesh Irrigation Water Rate Act	1992
	The Irrigation Water Rate Rules	1992
	The Water Resources Planning Act	1992
	Bangladesh Water Development Board Act	2000
	The Irrigation Service Charges Rules	2003
Ministry of Local Government, Rural Development and Co-operatives	Water Supply & Sewerage Authority Act	1996
	The City Public Lands Protection Act	2000

7.6 FAP-8A Study

Most of the major flood control facilities have been constructed after the 1988 flood. The storm water drainage plan of Greater Dhaka city was prepared by GOB. The Greater Flood Control Committee with the planning minister as its chairman was established to protect the greater Dhaka area from flooding after 1988 flood. For the nearby towns of Savar, Tongi and Narayanganj flood mitigation facility projects were proposed by the institute of Diploma Engineers. No flood mitigation plan for Keraniganj was prepared. The committee's plan with a phasing of activities is given below:

Proposed Facilities

A number of flood mitigation structures: embankments, flood walls, sluice gates and storm water drainage structures: pump stations, drainage pipes, retarding ponds are proposed in this study. Summary of the proposal is shown in **Table 7.6.1**

Table 7.6.1 Summary of the proposal

Area	Flood mitigation	Storm water drainage
1. Greater Dhaka		
a) West	a)embankment (R): 16.7 km	a) pump station o: 73.2m3/sec(2)
	b)flood wall (R): 4.7 km	b) khal improvement: 42.7 km
	c)embankment: 6.3 km	c) drainage pipe: 8.1 km
	d)flood wall:3.0 km	d) retarding pond: 770.0 ha
	e)sluice gate:11plcs	e) land acquisition: 43.7 ha
	f)land acquisition:37.0 ha	
b) East	a)embankment: 26.7 km	a) pump station no: 179 m^3/s(3)
	b)sub embankment: 11.3 km	b) khal improvement: 72.4 km
	c)sluice gate: 5plcs	c) drainage pipe: 8.9 km
	d)land acquisition: 317.4 ha	d) retarding pond: 1884.0 ha
		e) land acquisition: 168.0 ha
2.Narayanganj		
a) DND area	a)flood wall(R):20.2 km	a) pump station no:50.2 m^3/s(1)
	b)flood wall:10.0 km	b) khal improvement:38.0 km
	c)sluice gate:2 plcs	c) retarding pond:681.0 ha
	d)land acquisition:5.8 ha	d) land acquisition:90.8 ha
b) West	a)embankment:6.1 km	a) pump station:16.2 m^3/s(3)
	b)road cum embankment:4.3 km	b) khal improvement:6.4 km
	c)flood wall:10.5 km	c) retarding pond:170.0 ha
	d)sluice gate:7 plcs	d) land acquisition:12.2 ha
	e)land acquisition:61.5 ha	
	%evacuation facilities 1 LS	
c) East	a)embankment :6.6 km	a)pump station no:12.5 m3/s(4)
	b)road cum embankment:6.5 km	b)khal improvement:7.4 km
	c)flood wall:26.0 km	c)retarding pond:130.0ha
	d)sluice gate:12 plcs	d)land acquisition:14.1 ha
	e)land acquisition:99.2 ha	
3. Tongi		
a) Tongi	a)embankment:13.0 km	a)pump station no:25.2 m3/s(2)
	b)road cum embankment:6.2 km	b)khal improvement:22.0km
	c)flood wall:2.2 km	c)retarding pond:265.0 ha
	d)sluice gate:7 plcs	d)land acquisition:42.5 ha
	e)land acquisition:100.9 ha	
	% evacuation facilities:1 LS	
4. Savar		
a) Savar	a)embankment:9.3 km	a)khal improvement:30.0 km
	b)sluice gate:3 plcs	b)land acquisition:66.2 ha
	c)land acquisition:62.3 ha	
	%evacuation facilities:1 LS	
5. Keranigonj		
a) Keranigonj	a)embankment:23.3 km	a)pump station:27.7 m3/s(1)
	b)flood wall:3.7 km	b)khal improvement:22.5 km
	c)sluice gate:10 plcs	c)retarding pond:292.0 ha
	d)land acquisition:163.7 ha	d)land acquisition:50.6 ha

Scope of FAP-8B Study

Dhaka Integrated Flood Protection Project FAP 8B was a priority component of the Bangladesh Flood Action Plan (FAP). The underlying rationale for the Project was to provide flood security in Dhaka City to improve the urban efficiencies and environmental conditions, particularly for the urban poor, and to promote stainable long term economic development. A number of project enlisted in **Table 7.6.2**, indicated the proposed agencies to carry out the development works.

Government Agency	Scope of Work
1. BWDB	• Foundation stabilization on 7.8 km of the existing embankment; • Erosion control and slope protection over 11.5 km; • Minor remedial works and slope protection over 24,2 km; • Repair and stabilization of parts of 5.3 km of existing concrete flood wall; • Construction of 1.6 km of new flood wall/embankment; • Construction of 5 additional sluices along the existing embankment; • Establishment of a maintenance program and supply of maintenance equipment to safeguard the flood protection investment.
2. DWASA	• Rehabilitation and upgrading of 21 existing priority khals (including completion of the crash program initiated by the government), for a total length 78.6 km; • Rehabilitation and construction of 50.7 km of pipe drains. • Establishment of a maintenance program and supply of maintenance equipment to safeguard the drainage improvement investment

3. DCC	• Slum and squatter area improvements covering about 8,725 beneficiary families; • Solid waste management, including the supply of 30 new trucks and complementary waste handling equipment; • Sanitation improvements, including 30 public toilets and 5 mobile toilets, 5,500 low cost sanitary latrines for low income residents, and 2 septic tank desludging trucks • 1,000 public water standpipes for low income communities; Rehabilitation and extension of 131 km of minor local drains, and supply of 1 drain cleaning truck.
1. Others	A Project Implementation Office, headed by the BWDB, staffed by representatives of each participating GOB agency, and strengthened by consulting and training services, was planned to provide the following support: • Planning, detailed design, construction supervision, monitoring and evaluation; • Coordination and management of Project activities; • Equipment and logistical facilities; • Quality assurance and control (including establishment of a materials testing laboratory, to complement and work in cooperation with existing laboratories).

7.7 Review JICA Study

Table 7.7 A short review on JICA Study

Code	Drainage zone	Area(km^2)	Priority	Remarks
A	Buriganga river zone	7.25	Second Priority	1) drainage pipe 2) khal improvement 3) sluice gate
B	Dholaikhal zone	7.24	Highest Priority	1) drainage pipe 2) khal improvement 3) pump station
C	Segunbagicha khal zone	10.92	Highest Priority	1) drainage pipe 2) khal improvement
D	Bashabo zone	7.46	Second Priority	1) drainage pipe 2) khal improvement
E	North east edge zone	13.93	Second Priority	1) khal improvement
F	Begunbari khal zone	13.70	Highest Priority	1) drainage pipe 2) khal improvement
G	Gulshan Banani zone	17.64	Second Priority	1) khal improvement 2) pump station 3) sluice gate
H	Kallyanpur zone	17.60	Highest Priority	1) khal improvement 2) pump station 3) sluice gate
I	North zone	31.42	Second Priority	1) khal improvement 2) pump station 3) sluice gate
J	Turag river bank zone	7.69	Second Priority	

CHAPTER -8

RECOMMENDATION

After analysis part in this chapter we will prescribe some efficient recommendation to mitigate urban flood in study area. For overall study area Structural and Non Structural measure will be describes. And Some planning strategies will also be suggested for betterment of the whole Dhaka city.

8.1 Structural Measures

- Kallayanpur Main Khal, Ramchandrapur Khal, katasur Khal, Kallayanpur Kha Khal, Kallayanpur Gha Khal, Kallayanpur Uma Khal all are silted up with sludge. Immediate cleaning and realignment works necessary for this khals.
- To construct 2.35-km long new pipe line from Mirpur-10 to Kallyanpur Kha Khal along new road. (project Id: 2nd phase-10)
- Another 7.14 km pipe line needs to construct from Mirpur-1 to Kallayanpur Branch Kha through Technical moar and Gabtoli. (project Id: 2nd phase-11)
- Retention area about 1.929 sq. km is proposed of which 1.33 sq. km of retention pond at area of Gantoli in this zone need to be acquired/ managed.
- At Sheorapara and Kazipara (partly falls within the zone) water logging problem is very much severe due to the absence of adequate drains. DWASA needs to construct some secondary drain / pipe drain within this zone immediately.
- At Rayerbaazar a temporary pump station needs to be installed along with some arrangement of retention pond.

8.2 Non-Structural Measures

- Rainwater Harvesting should be included in building law.
- Formulation of a separate drainage management zonal authority
- To formulate and enforce legislation for protecting the khal, waterbodies etc. from illegal encroachment.
- All the illegal encroachment and structure over the water bodies and low lying areas need to be immediately removed.
- Establishment of Right of Way for the natural channels.

- DWASA needs to recover the proposed amount of retention areas for Kallaynpur pump station in FAP study immediately. DWASA may adopt both legal enforcement and land acquisition approach in this context.
- Proper Landuse planning.
- Proper guided solid waste management is another prerequisite to achieve a sustainable stormwater drainage management.
- & M works along with proper monitoring system must be introduced that the ward dwellers as well as the cleaners and relevant personnel could not neglect their duties.
- Create public awareness.

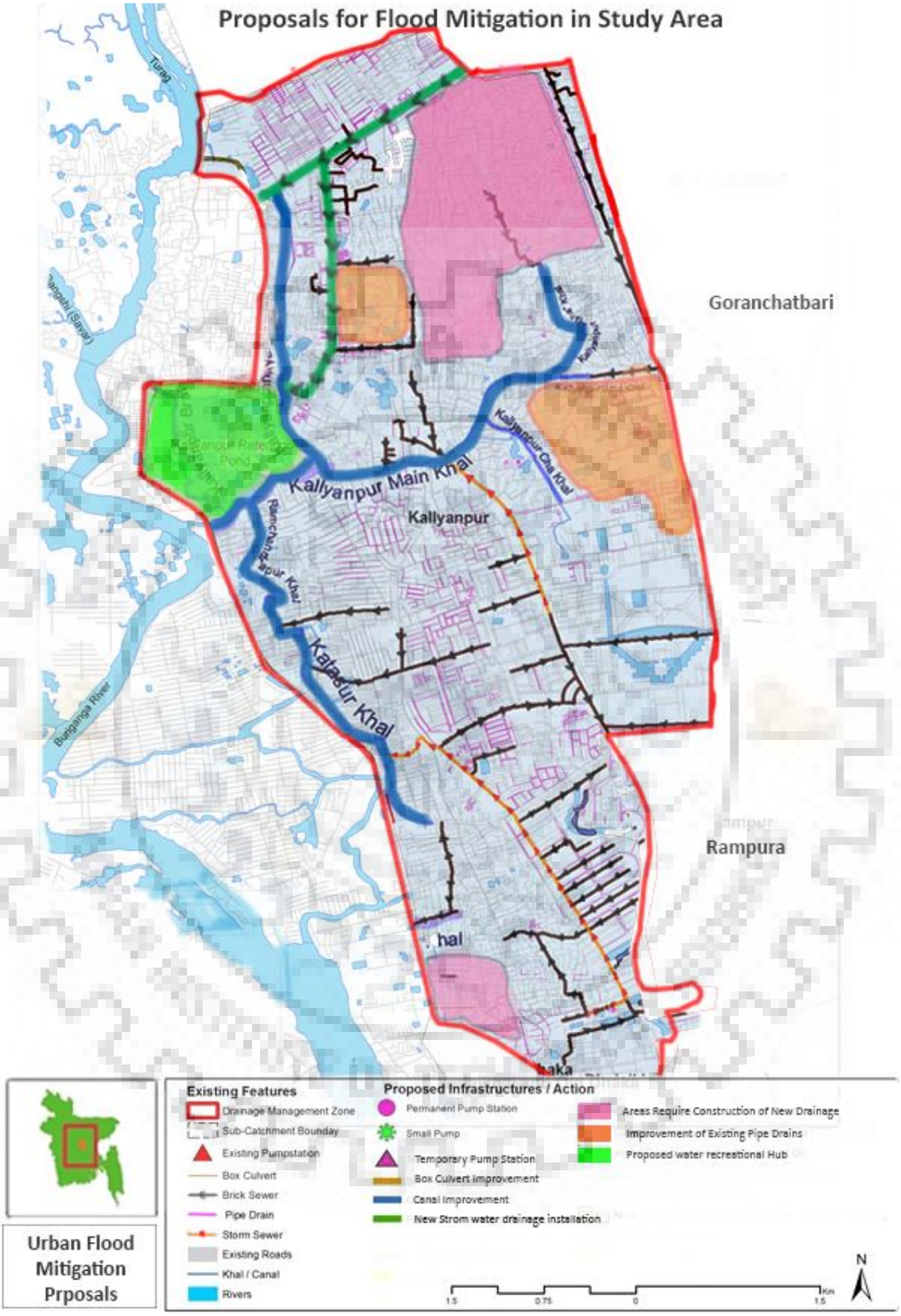


Figure 51 Proposed Urban Flood Mitigation Plan

8.3 Some Planning Strategies to Mitigate Urban Flood Problem

8.3.1 Blue Green Approach

The Blue-Green approach aims to reintroduce a more natural water cycle into urban environments and provide measures to manage the risk of flooding while backing the concept of multi-functional land use to generate benefits for the environment, society and the economy.

- It is an integrated approach to create a network that prevents floods and draughts
- It can ensure good water quality. The water quality provides a lot of ecosystem services.
- This approach can help to decrease coefficient runoff in stormwater drainage.
- This process helps to increase permeable surface.

Blue Green Infrastructure

- Bio retention systems
- Swales and buffer strips
- Storage ponds, lakes and reservoirs
- Controlled storage areas, e.g. car parks, recreational areas, minor roads, playing fields, parkland and hard standing in school playgrounds and industrial areas
- Permeable paving
- Rain gardens
- Constructed wetlands
- Open green space, parks, pocket parks and gardens designed for strategic water retention and infiltration
- Street trees
- Green Roof

Infiltration

Infiltration facilities (sumps, trenches, porous pavements and basins) area unit suggested to capture a volume of stormwater runoff, retain it, and infiltrate all or a part of that volume into

the bottom and therefore the excess to overflow to the conveyance system. The system is to be designed and created to stay practical for an extended amount. the boundaries of the utmost contributive structure areas for infiltration sump, trench and basin area unit suggested as five hundred money supply, four hour angle and fifteen hour angle, severally. Saturated soil infiltration rate of the projected infiltration facility web site ought to have a minimum price of twenty mm/hr. the bottom of all facilities ought to be placed a minimum of zero.5 m on top of the seasonal status water level and/or any water-resistant layer.

Bio-retention System

Bio-retention systems use infiltration and vegetation to get rid of pollutants from stormwater. These area unit projected to accommodates excavated basins or trenches that area unit full of porous media and planted with vegetation. If the infiltration rate and nutrient content of the unmoved soil area unit appropriate, it's not necessary to use soil foreign from alternative areas. Larger areas ought to be divided into smaller sub- areas with individual bio-retention systems. Specific style of a bio-retention facility could vary significantly, reckoning on web site constraints or preferences of the designer or community.

Swales

Swales area unit wide however shallow channels designed to store and/or convey runoff at a non-erosive speed, yet on enhance stormwater quality through infiltration, geological phenomenon and filtration. Swales area unit projected among open house areas, parklands and on roadways. A swale is meant to convey the height flows while not prodigious the utmost permissible speed. Wherever this is often not sensible or the house is proscribed, designer ought to think about dividing the flow into surface and submersed elements, wherever underground pipeline or emptying blocks area unit suggested as submersed drains.

Green Roof

Green roofs contribute to reducing and delaying runoff and shaving peak flow. An inexperienced roof system is associate degree extension of the present roof that involves, at a minimum, top quality water-proofing, root repellent system, system, filter fabric, a light-weight growing medium, and plants. Inexperienced roof systems could also be standard, with emptying layers, filter fabric, growing media, and plants already ready in movable, typically interlocking grids, or loose laid/built-up whereby every element of the system could also be put in on an individual basis. Inexperienced roof development involves the creation of "contained" inexperienced house on high of a human-made structure. This inexperienced house may be below, at, or on top of grade, however altogether cases it exists cut loose the bottom.

Inexperienced roofs will give a good vary of public and personal edges and are with success put in in countries round the world. for instance, MacMillan (2004) found that storm-size ranges of 10–19 metric linear unit, 20–29 mm, 30–39 mm, and forty metric linear unit had average peak-flow reductions of eighty five, 82, 68, and forty six p.c, severally. it's expected that inflated storm size can cause peak-flow reduction to drop dramatically.

Clearly, in Dhaka's worst-case situation (396 metric linear unit of precipitation in twenty four hours), a garden would be of very little use as a complete system. However, in response to smaller sized storm events, inexperienced roofs may be quite helpful. Green Roof in Storm water Management

- With green roofs, water is stored by the substrate and then taken up by the plants from where it is returned to the atmosphere through transpiration and evaporation
- In summer, green roofs can retain 70-90% of the precipitation that falls on them
- In winter, green roofs can retain between 25-40% of the precipitation that falls on them
- Green Roofs not only retain rainwater, but also moderate the temperature of the water and act as natural filters for any of the water that happens to run off
- Green roofs reduce the amount of storm water runoff and also delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods.

8.3.2 Kallyanpur Retention Pond Integrated Project

Kallyanpur Retention Pond integrated project is nothing but just a multi functional project what can be developed by Bangladesh government adopting Blue Green Approach.

It can be compared with another similar Hatijheel Integrated project which was inaugurated in 2013. To rejuvenate kallyanpur khal, and to acquire the suggested amount retention area this kind of project can act like game changer.

This project will be multifunctional project what will integrated green and blue infrastructure ensuring a better and sustainable environment for city people. Conceptual master plan is showing (in figure 8.3.2) some recreational element like wet land park, boating area, urban forest, fish museum etc. This types of function will help to perform as a water based recreational hub and to conserve the whole retention area for further encroachment as well.

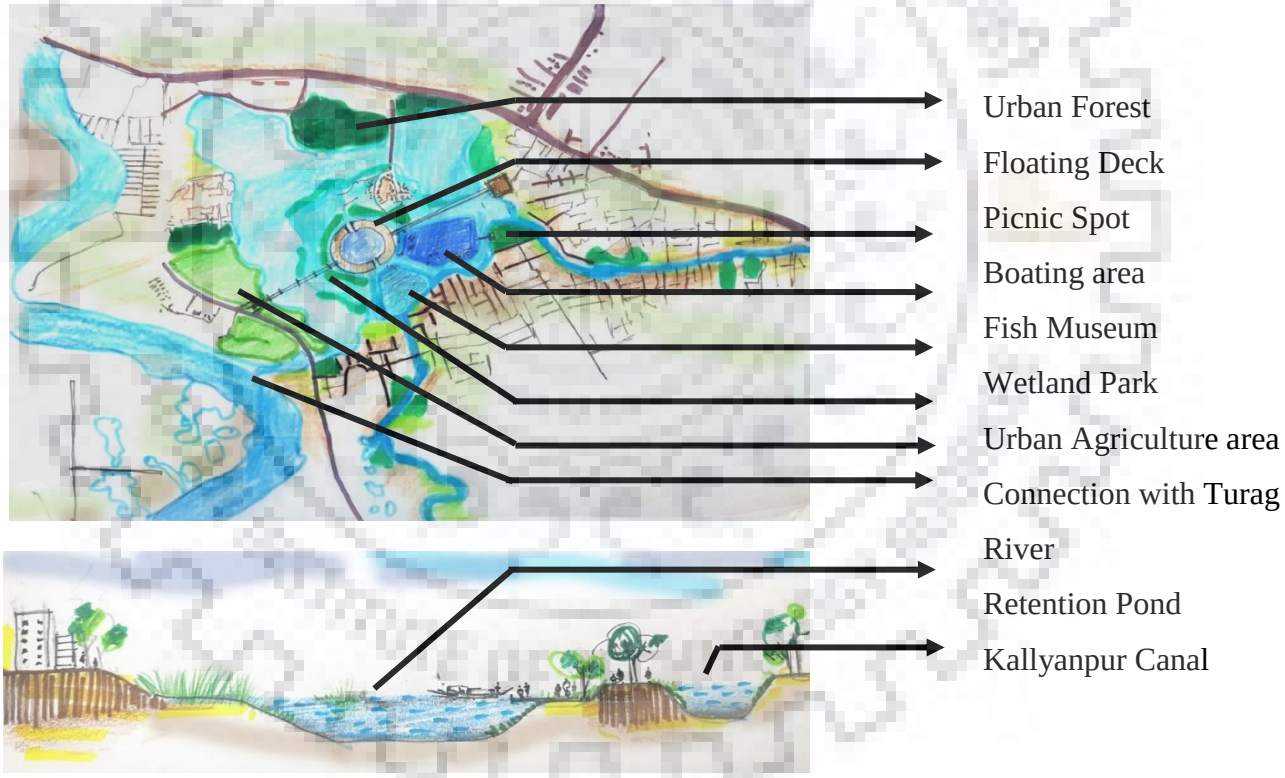


Figure 52 Conceptual Master Plan and Section

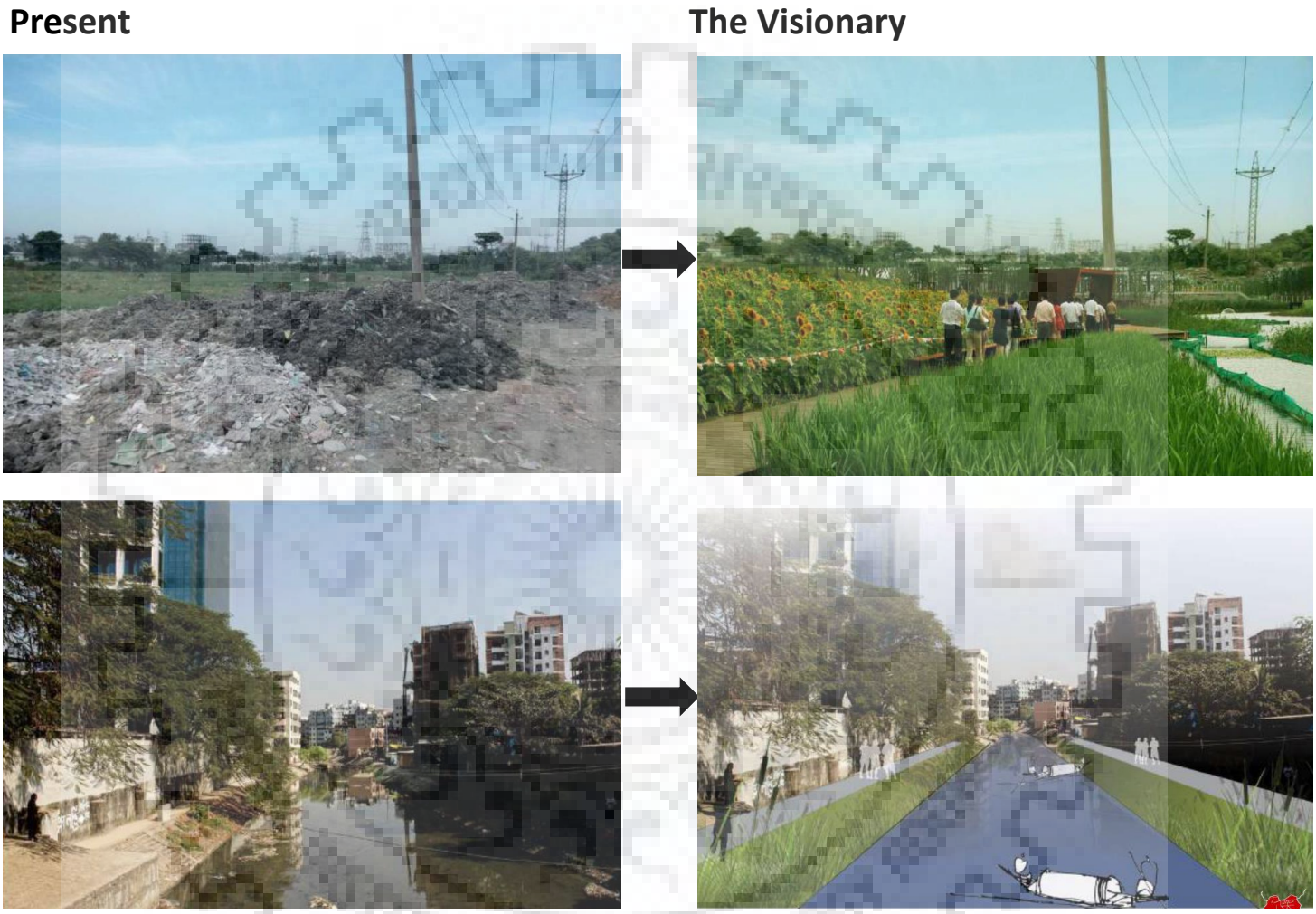


Figure 53 Kallyanpur Retention Pond Integrated Project

8.3.3 Rainwater Harvesting in Ward 13 and Ward 14

RWH is a decentralised, environmentally sound solution, which can avoid many environmental problems often caused in centralised conventional large-scale water supply projects.

Advantages of Rainwater Harvesting

- Promotes adequacy of underneath ground water
- Mitigates the result of drought
- Reduces erosion as surface run-off is reduced
- Decreases load on storm water disposal system
- Reduces flood hazards
- Improves well water quality / decreases salinity (by dilution).
- Prevents ingress of ocean water in undersea aquifers in coastal areas.
- Improves spring water table, therefore saving energy(to elevate water).
- The price of recharging subterranean geological formation is lower than surface reservoirs.
- The subsurface aquifer additionally is storage and distribution system.
- No land is wasted for storage purpose and no population displacement is involved.
- Storing water underground is surroundings friendly.

Rainwater Harvesting in Context of Dhaka

Rainwater gather is another supply to scale back water scarceness further as the water work drawback of Dhaka town. Rain gather is a easy and straightforward technique used for collection and storing rain for human use. For hundreds of years, the planet has relied upon rain gather as a supply of water for home and agricultural functions. It empowers individual and communities to manage their water and use it in the dry season as well as at times of their would like. There are multiple unit edges of rain gather, like the improvement of the amount and quality of water, mitigating the result of drought and recharging the groundwater table, reducing the soil erosion as surface runoff decreases and making certain a property water management system. It is the “least cost” kind of water provide, mostly in comparison with the high value of different sources. Though the potentiality of

rain gather is tremendous many folks aren't conscious of it. They're tormented by a severe installation drawback and wish a permanent answer to the present drawback.

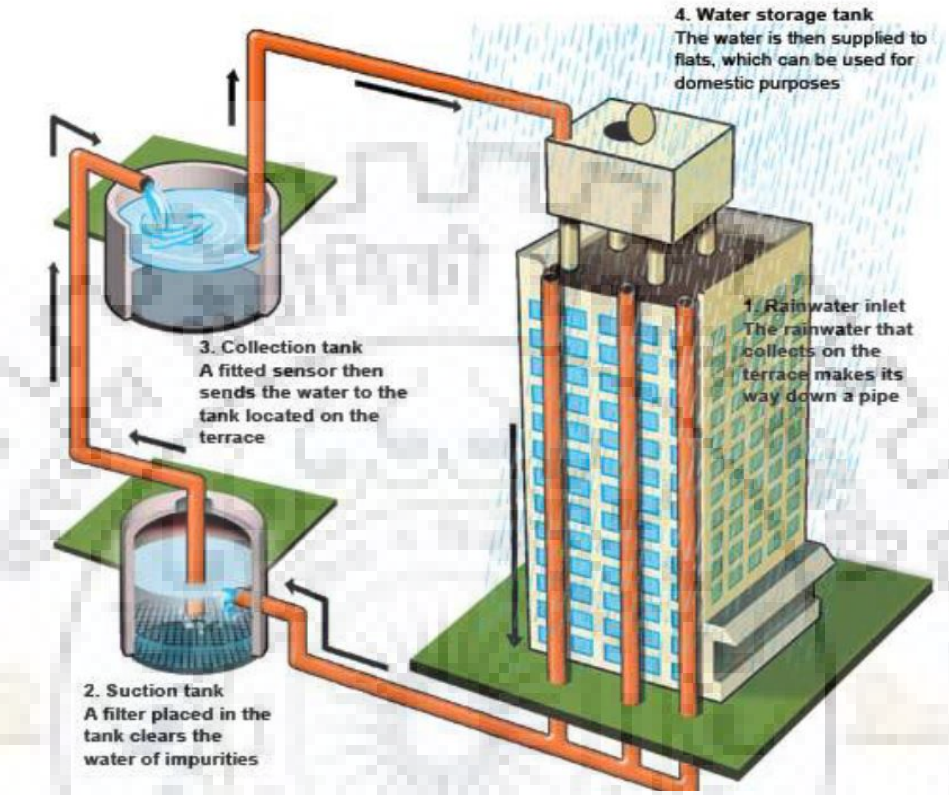


Figure 54 Rainwater Harvesting

Rainwater Harvesting Potentialities in Ward 13 and Ward 14

Ward 13, 14 that means a part of Mirpur area is densely inhabited areas of Dhaka city. A water deficiency downside in season may be a common situation per annum during this area. The ground water level is declining each year in Kazipara and it becomes troublesome for Dhaka City. Water offer and Sewerage Authority (DWASA) to offer the needed quantity of water to the native individuals. The water level of that area in 2008 was hundred sixty feet however in 2012 the amount was a hundred and eighty feet. Therefore in four years twenty feet has been declined. Among numerous reasons, groundwater withdrawal from the geological formation is that the major reason. speedy urbanization as well as construction of roads, buildings, alternative engineering structures, flood protection dams, and embankments area unit incessantly obstructive the natural groundwater recharges from precipitation and perennial water sources existing in and around the town. amerceable encroachment conjointly causes the ground water level to fall off. Not solely water deficiency however conjointly

water work throughout the monsoon season creates vast inconveniences for the inhabitants of the Mirpur area. Through rain gathering system, the inflated demand of water may be partly consummated and can conjointly cut back water work issues of the Mirpur area.

In questionnaire survey it was found that average area of the building roof of that particular area is 127 sq km.

The potential of rainwater harvesting of that building

= A x R x C

A= Catchment area of each building (Area of roof top).

R= Average Annual Rainfall of Dhaka city (2,100 mm).

C= Coefficient (0.8).

= 127.53*2,100*0.8 = 2,14,340 litre/year (approximately)

Water consumption is 1,10,000 litres per month in a building of that area.

So, water consumption in a year will be = 110000 x 12

= 13,20,000/litre

For toilet flush water consumption rate is 22% (Source: Water requirement for different purposes according to the Center for Science and Environment (CSE)

So, 13,20,000 x 22% = 2,90,400 litre/year.

The total demand for water per year for toilet flushing and cleaning purposes of Kazipara is 60, 43, 67,000 litres per year or 6, 04,367 cubic meters per year.

On the other hand, the potential of rainwater harvesting in the Kazipara area is 4, 02,096 cubic meter water per year. Through rainwater harvesting, a 66.53% demand of water for toilet flushing and cleaning purpose can be served. (Source: DWASA)

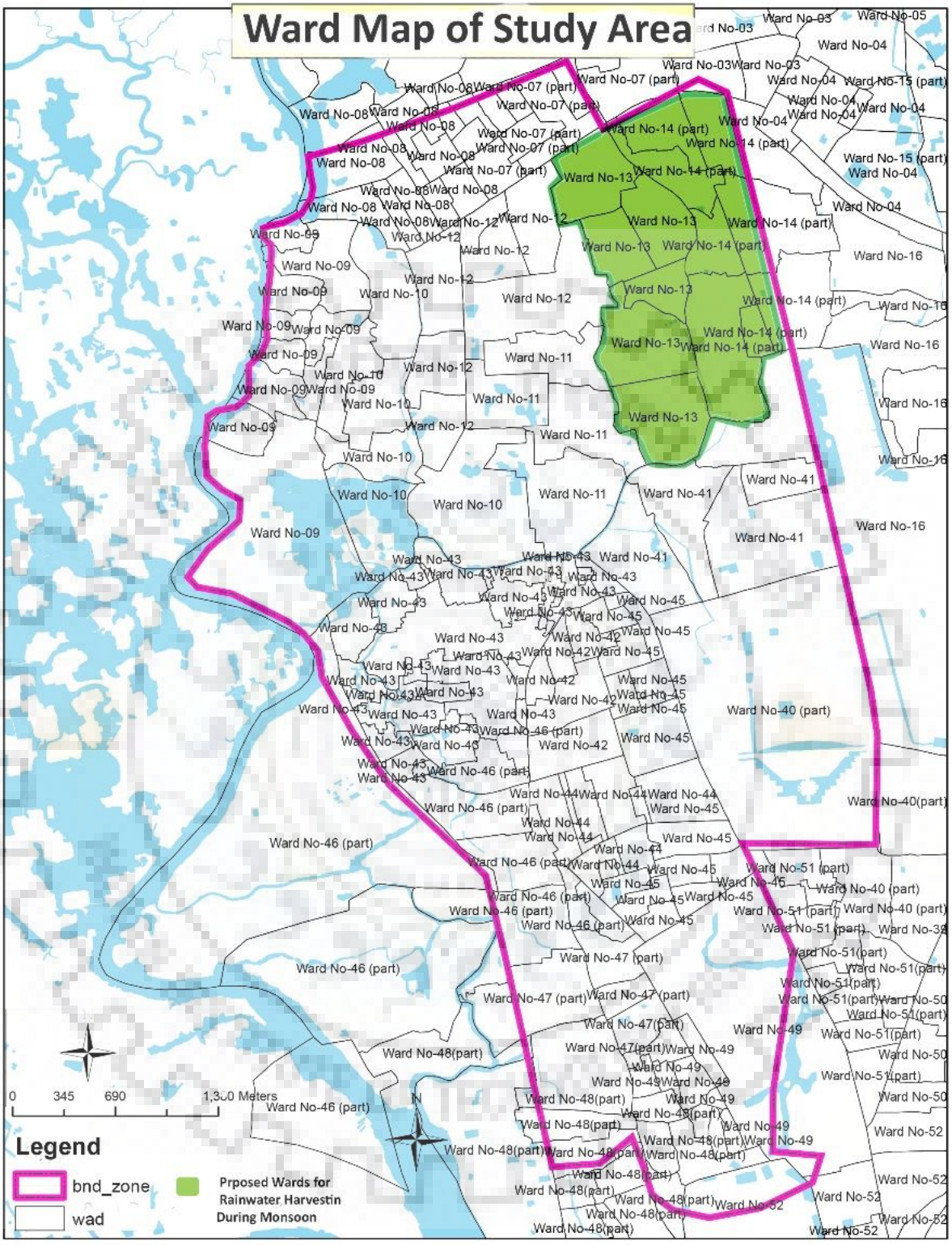


Figure 55 Proposed Wards for Rainwater Harvesting

8.3.4 Increasing Permeable Surfaces and Detention Area

Parks, wet lands, open fields can serve as detention ponds if these are preserved and designed properly. Discourage developers to pave whole plots on which they construct buildings to prevent the runoff situation.

A policy can be introduced where it will be stated that non-permeable surface is allowable only on the constructed area of the plot and that paving over vacant portions will incur tax for generating stormwater runoff.

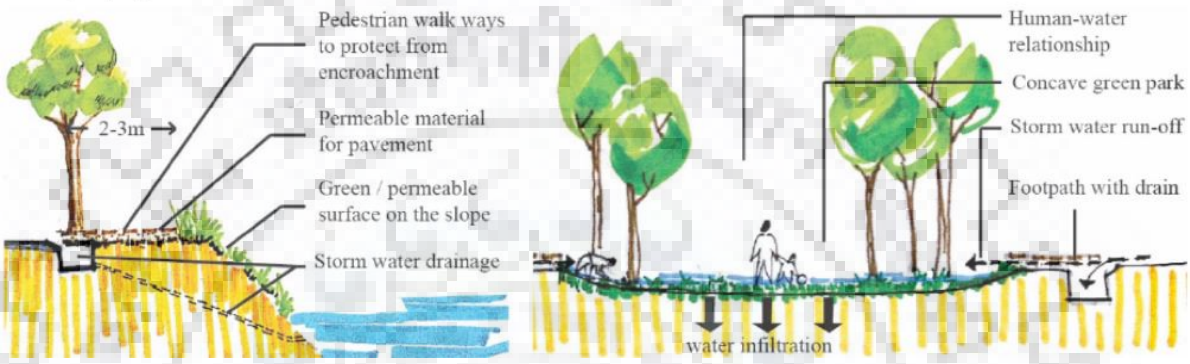


Figure 56 Detention area can be used to decrease surface runoff

8.3.5 Management of Impervious Surfaces

Discourage developers to pave whole plots on which they construct buildings to prevent the runoff situation.

A policy can be introduced where it will be stated that non-permeable surface is allowable only on the constructed area of the plot and that paving over vacant portions will incur tax for generating stormwater runoff.

8.3.6 Proper Solid Waste Management

In Dhaka, the responsibility for solid waste disposal currently lies with the DCCs. Dhaka South generates an estimated 3,300 tons of solid waste per day, of which only two-thirds (2,200 tons) are collected; of this collected amount, 1,900 tons are processed in landfills, while the remaining 300 tons are recycled. SO, DCCs should improve their man power, equipment's and management capacity. Recycling strategy to reduce the need for primary and secondary solid waste collection.

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ANNEX 1 INTERVIEW QUESTIONNAIRE

Questionnaire Survey

Zone……Ward No……..Locality…….Road No…….HouseNo……

Demographic and Socio Economic Profile

1. Name of the Respondent:
2. Gender: a) Male b) Female
3. Age: a)
4. Religion: a) Muslim b) Hindu c) Christian d) Buddhist e) Other (specify)
5. Resident: a) Original b) Migrated
6. If migrated:

Year of Migration	Migrated From	Purpose of Migration
	Other area/ Other village/ Other city/ Other country	Education/Occupation/Social/ Political/Marriage/Other (Specify)

7. Years of residence in present address : a) <5 years b) 5-10 years c) 10-20 years d) > 20 years
8. Ownership of house: a) Owner b) Rented c) Rented by other family member
9. Type of house: a) Kacha b) Semi Pacca c) Built up concrete structure d) Multi Storied e) Flat
10. Number of family members: a) 2 b) 3 c) 4 d) 5 e) more than 5
11. Level of education:

Categories	Male	Female	Total
Illiterate			
Up to primary level			
Up to secondary level			
Up to higher secondary level			
Graduate			
Post graduate			
Other			

12. Occupation: a) Govt. sector b) Private sector c) Business d) Other
13. Designation:
14. Type of employment: a) permanent b) temporary c) seasonal d) daily

Those who are employed in industry

15. Type of industry employed in:
16. Commodities produced in industry:
17. Clients for the commodities produced: local, regional, national, global
18. Other sources of employment:
19. Income of Respondent:

a) less than 1000 per month b)2000-5000 c) 5000-10,000 d) 10,000-20,000 e) more than 20000 (in Taka.)

20. Average monthly income of the family:

a) <5000 b) 5000-10,000 c) 10,000-20,000 d) 20,000-50,000 e) more than 50,000 (in Taka)

Transportation

- Condition of the road: Kutcha/ Pucca
- Maintenance of the road: Good/ Bad/ Worse/ Not any
- Vehicles owned (No.): Cycle ___; 2 wheeler___; 4-wheeler___; Any other___
- Movement Chart:

Activity	Mode of Transportation(public/private)	Distance in Kms.	Frequency in a week
Shopping			
Recreation			
Work			
Religious			
Other(Specify)			

Water Supply

- Supply System: Public supply/ Own source/ Both
- Time of supply (in hours):_____
- Use of equipment: Filter/ Zeero B/ Aquaguard

Electricity:

- Available / Unavailable Metered/ Non-metered
- Overhead Poles/ Under Ground Cables Voltage fluctuations
- Tariff: Monthly/ Flat Rate

Drainage/ Sewerage:

- Availability of: Septic Tank/ Soak pit/ Sewer/ No Facility
- Drains: Open/ Covered/ No drains
- Problems: Overflow/ Clogging/ Bad odour/ No problem
- Over flow of drains during rainy season (Yes/ No)
- Distance from nearest water body –
- Type of water body

Waste Disposal

- Method of collection at house:
  a) Storage container b) Dust bin/ PVC bag c) Burning d) Throwing out
- Frequency of collection from the area:
  a) Everyday b) Alternate days c) 3 days d) 4 days e)weekly
- Agency for collection: a) Nagar Nigam b) Private agency c) NGO

1. Environmental Characteristics

- Water Quality : Very Good/ Good/ Moderate/ Poor
- Air Quality: Very Good/ Good/ Moderate/ Poor
- Land Quality: Very Good/ Good/ Moderate/ Poor
- Noise Pollution: Very High/ High/ Moderate/ Low
- Quality of Living: Excellent/ Good/ Bad

Drainage System

21. Type of sewage disposal system: a) non existent b) open drains c) concrete drains constructed by municipal authorities.
22. Distance from water body, type of water body
23. Source of water: for drinking, household work

Flood Vulnerability

18. Do you face Urban flooding/ Water logging problem in your locality?

    a) Yes b) No

19. What is the main reason of Urban flood?
    a) Heavy rainfall b) Congestion in drainage c) Illegal encroachment d) Lack of awareness e) All of the above.

20. When do you face urban flood?
    a) June- July b) August- September c) October- November d) Other.

21. How long water remains stagnate in your area?
    a) Less than 1 hour b) 1-3 hours c) 3-5 hours d) more than 5 hours

22. Last when did you face urban flood/ water logging in your area?
    a) One month ago b) 3 months ago c) 6 months ago d) 1 year ago

23. Does water enter your house during monsoon season?
    a) Yes b) No

24. What types of problem you used to face during urban flood?
    a) Traffic in road b) Water pollution c) Water born diseases d) Physical Damages e) All of the above

25. Level of water inside the house during urban flood? (In feet)
    a) 1 feet b) 2 feet c) 3 feet d) more than 4 feet

Flood Impacts

26. What does road condition remain during urban flood?
    a) Very poor b) Bad c) Good d) Excellent

27. What does drainage condition remain during urban flood?
    b) Very poor b) Bad c) Good d) Excellent

28. What does water condition remain during urban flood?
    c) Very poor b) Bad c) Good d) Excellent

29. Does electricity supply hamper during urban flood?
    a) Yes b) No

30. Does internet connection hamper during urban flood?
    a) Yes b) No

31. Availibility of emergency services?
    a) Health b) Fire service c) Police station d)

Flood Loss

32. What types of direct losses do floods incur in monsoon season?
    a) Property b) Means of transport c) House assets d) Soil and garden products
    e) Domestic animals

33. What types of indirect losses from floods?
    (a) difficult to get daily wage jobs b) Difficult to reach at work place c) health disorders
    d) loss of convenience as shops and convenience stores

34. Is there any loss due to wind damage?
    a) Yes b) No

35. Do floods lead to contamination from pollutants or infestations from animals? Snake or insect bites? Oil?
    a) Yes b) No

36. Does urban flood hamper daily life?
    a) Yes b) No

Mitigation & Recovery

18. In case of flood, where do you take shelter? Why?

19. Is the shelter assigned? Is it accessible?

20. What type of risks does the shelter have from floods?

21. What belongings do you carry with yourself?

22. Do you pack important things up during monsoon season? If not why?

23. Do you save money for such incidents?

24. What methods do you adopt to stop water from getting inside your house?

25. What are the immediate steps you take when you see the water rising?

26. Do you have anyone to help you keep water out of your house?

27. Do other households in the neighborhood follow similar methods to avoid Floodwater?

28. New relationships that have developed while recovering from floods? Do social boundaries get permeable during and immediately after floods?

29. What should be done to make the mitigation process more effective? What are you willing to do to make it more effective?

30. Do you have knowledge about Waste segregation?

31. Have you heard of Rain water harvesting?

ANNEX 2 STAKEHOLDER'S INTERVIEW

Questionnaire for the concerned development organizations

Name of the organization:
2. Name of the respondent:
3. Designation of the respondent:
4. What are role of your organization for the management of Dhaka City?
5. What are the main reasons for water logging in Dhaka City?
6. Does your organization have any activities related to water logging?
   i) If yes, which activities?
7. Is your organization able to perform/manage all these activities properly?
8. What is the lacking of your organization to manage the activities related to water logging?
9. What is your suggestion to enhance the management system of water logging related activities that can help to reduce the problem?

Questionnaire for Informal discussion with the experts in different field

Name:
2. Expertise Field:
3. Working Place:
4. What are the main reasons for water logging in Dhaka City?
5. What are the effects of water logging on city life?
6. What type of measures/actions are needs that can help to solve or reduce the water logging problem for long term?