Dhaka City Urban Resilience Project

Strategic Environmental Assessment (SEA)

Revised Inception Report

2019, JUNE

“If humanity fails to counter the climate change in Bangladesh, it will also fail elsewhere!”

SEA Team

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ABBREVIATIONS

AQI	Air Quality Index
AQMP	Air Quality Management Planning
BAPA	Bangladesh Poribesh Andolon
BEDS	Bangladesh Environment and Development Society
BELA	Bangladesh Environmental Lawyers Association
BEP	Bangladesh Environment Project
BRAC	Bangladesh Rural Advancement Committee
BUFT	BGMEA University of Fashion & Technology
BWDB	Bangladesh Water Development Board
BYEI	Bangladesh Youth Environmental Initiative
C3ER	Centre for Climate Change and Environmental Research
CASE	Clean Air and Sustainable Environment
CCEC	Center for Coastal Environmental Conservation
CNG	Compressed Natural Gas
DAP	Development Area Plan
DCC	Dhaka City Corporation
DMA	Dhaka Metropolitan Area
DNCC	Dhaka North City Corporation
DoE	Department of Environment
DRM	Disaster Risk Management
DSCC	Dhaka South City Corporation
DWASA	Dhaka Water Supple and Sewerage Authority
ESDO	Environment and Social Development Organization
FAC	Flood Action Plan
FFWC	Flood Forecasting Warning Center
GDP	Gross Domestic Product
GoB	Government of Bangladesh
HEC-RAS	Hydrologic Engineering Center-River Analysis System
IED	Institute for Environment and Development
IUB	Independent University, Bangladesh
IUCN	International Union for Conservation of Nature
IUT	Islamic University of Technology

IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
JKKNIU	Jatiya Kabi Kazi Nazrul Islam University
JRC	Joint River Commission
LGED	Local Government Engineering Department
LIL	Learning and Innovation Loan
MoEF	Ministry of Environment, Forests & Climate Change
MoHPB	Ministry of Housing and Public Works
MoLGRDC	Ministry of Local Government, Rural Development & Co-operatives
MoWR	Ministry of Water Resources
NILG	National Institute of Local Government
NGO	Non-governmental Organization
NWRD	Natural Water Resources Database
OIC	Organization of Islamic Cooperation
PIU	Project Implementation Unit
PM	Particulate matter
PMCU	Project Monitoring and Coordination Unit
RAJUK	Raydhani Unnyan Katripakkha (Capital Development Authority of the Government of Bangladesh)
SA	Stakeholder Analysis
SCPT	Seismic Cone Penetration Test
SEA	Strategic Environment Assessment
SEHD	Society for Environment and Human Development
SESM	School of Environmental Science and Management
SOD	Sediment Oxygen Demand
SPT	Standard Penetration Test
ToR	Terms of Reference
UDD	Urban Development Directorate
URP	Urban Resilience Project
WARPO	Water Resource Planning Organization
WASA	Water Supple and Sewerage Authority
WB	World Bank
WHO	World Health Organization

I INTRODUCTION

1.1 Rationale for the Strategic Assessment Study[1]

Bangladesh is known as the most disaster prone country in the world. In order to reduce the disaster risk and minimize the damage caused by disasters, the Government of Bangladesh (GoB) has instituted a series of disaster risk reduction programs and invested a lot in infrastructure (especially in flood management) so far, which eventually turned Bangladesh into one of the fore-bearers of proactive Disaster Risk Management (DRM) approach globally. Yet, despite the tangible gains achieved through these efforts, the vulnerability of Bangladesh's urban areas is not as well understood, or addressed, in the country's DRM policy framework.

The Urban Resilience Project (URP) of Bangladesh supported by the World Bank has an objective to strengthen the capacity of the Government of Bangladesh to respond to emergency events and to strengthen systems to reduce the vulnerability of future building construction to disasters in Dhaka and Sylhet. URP is expected to serve as a new model to build capacity for emergency preparedness and response for both recurrent and large-scale events, as well as best practice in the construction industry in highly exposed, disaster-prone urban environments. The project is being implemented by Dhaka North City Corporation (DNCC), Rajdhani Unnayan Kortiphokkho (RAJUK) and Project Monitoring and Coordination Unit (PMCU) under Planning Commission.

The objective of component B of the URP is to develop the consensus-driven analytical foundation required for longer-term investments to reduce risk in the built environment of Dhaka, Sylhet and other cities in Bangladesh. It concentrates mainly on the following activities;

i) An assessment of the vulnerability of the built environment in Greater Dhaka to earthquakes and other major hazards, focusing on essential and critical facilities and infrastructure. The assessment will establish the patterns of vulnerability of the cities, understand the hotspots, and serve as a basis for a long-term vulnerability reduction in Greater Dhaka, and

ii) The development of risk-sensitive land use planning as a practice in Bangladesh informed by an understanding of the hazards, vulnerability and risk facing

[1] Compiled mainly from World Bank, 2015a, & Government of Bangladesh, 2015.

urban centers, and by clearly stated consensus disaster risk reduction objectives and policies.

Strategic Environmental Assessment (SEA) study for Dhaka City Urban Resilience Project-Component B is being carried out by Joint Venture of NKY–PROTEK–SHELTECH ("Consultants"). Terms of Reference (ToR) for this SEA study emphasizes that if the SEA is performed simultaneously and in parallel with the process of producing development plans it will bring many benefits for regions and cities including;

i) Informing decision makers and the community about the environmental impacts and sustainability of policies, plans and programs at the very early stages and, consequently, improving decision processes,

ii) Integrating environmental considerations at stage of developing the plan and, as a result, the elaboration and selection of an environmentally friendly option that includes sustainable development considerations in all respects, and

iii) Designing a program with environmental considerations and sustainability in non-environmental organizations.

1.2 Objectives of the Study

The objectives of the SEA have been defined in the ToR document as follows;

i) To incorporate environmental considerations and assess the likely significant environmental effects (risks and opportunities) of the implementation of the Urban Resiliency Project developed by RAJUK,

ii) To address the most important environmental, natural resource-related and climate change-related constraints bearing on the performance retrofitting and code, and,

iii) To identify the opportunities for the Urban Resiliency Project to contribute to enhancing the state of the environment, building climate resilience of the sector and the population, and promoting low carbon development and the transition to the green economy.

1.3 Approach and Methodology of SEA

In the first stage of the research, primary sources such as 2007 SEA Report, available area plans, development plans, environment-related regulations, and secondary sources such as relevant research articles, research reports and books will

be thoroughly reviewed and analyzed.

A stakeholder analysis will be conducted, and consultation meetings with relevant institutions, universities, and managers of industrial facilities will be organized to seek views and opinions of the stakeholders on the major environmental problems in Dhaka. In addition to these face-to-face meetings and interviews, online surveys (and, if possible, meetings) will be conducted with some relevant NGOs working in the field of environmental protection in Bangladesh.

In order to promote active participation of the stakeholders and to raise awareness of the people, a website and social media accounts will be set up. The team will also use location-specific targeted advertisements on relevant websites to reach more social media users from Bangladesh. All in all, interested local people will be informed about the content and intention of our project, and information about their ideas regarding the topic will be gathered directly through online interaction.

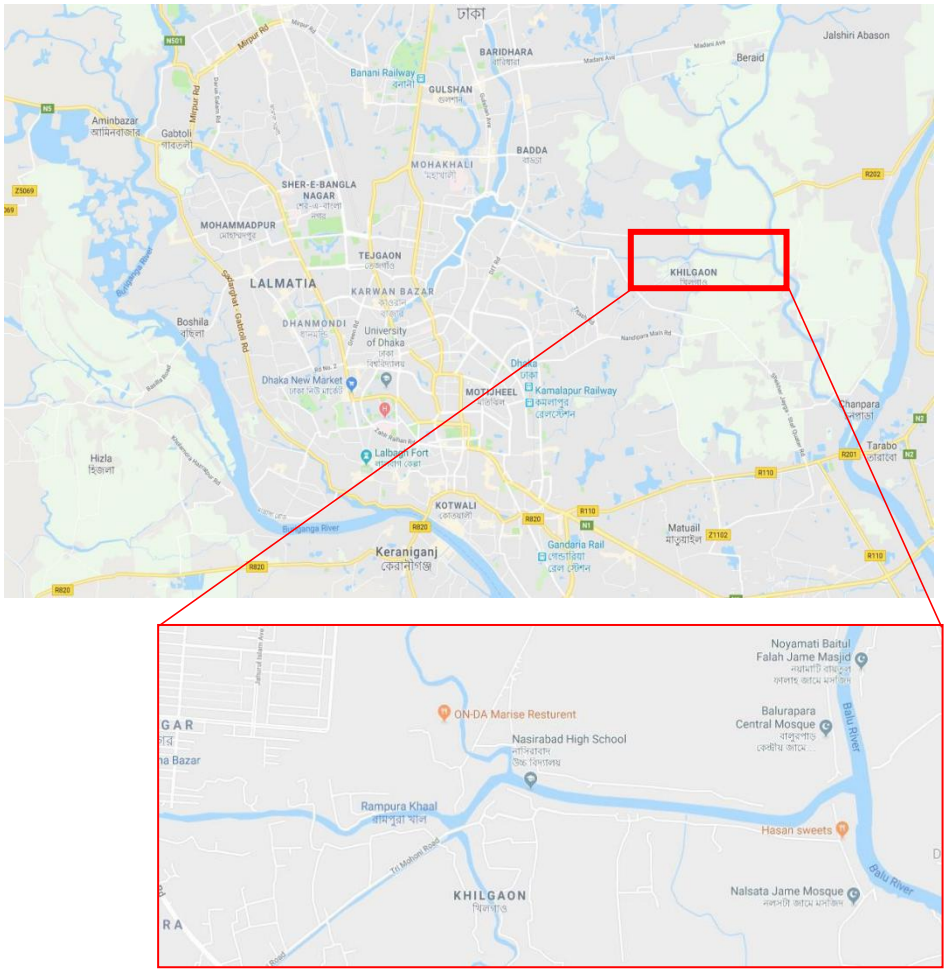


Figure 1.1. Study area where flood risk analysis will be conducted.

Our specialists will conduct fieldwork research in the sites that they will decide on in accordance with the outcomes of the literature review and initial stakeholder meetings, and to gather the information they need, they will visit relevant institutions and meet with relevant personnel. Flood risk analysis will be conducted for a portion of one of the tributaries of Balu River. Google Maps image showing the study area is given in Figure 1.1 above. Hydraulic modelling of the study river will performed by using 1-D hydraulic model HEC-RAS. Additionally, natural and critical habitats in Dhaka will also be visited and examined in order to improve the quality of -biodiversity analysis.

After the screening process will get completed, the draft inception report will be prepared on the basis of the opinions acquired from exchanges with stakeholders as well as the information gathered from fieldwork, and this will be uploaded to the website of the project, www.dhakaurpsea.org, to be put up for discussion.

All stakeholders will be invited to attend the SEA Stakeholders Consultation Workshop, and to ensure their active participation, they will be asked to share their proposed solutions for environmental problems, ideas about challenges for environmental management in Dhaka and thoughts on how these challenges might be surmounted. Participants' opinions will be gathered through holding an effective brainstorming session.

Inception report will be revised and enriched with the outputs of SEA stakeholder consultation workshop and preliminary SWOT analysis. Environmental impact assessments will be examined together with alternatives as a part of risk-sensitive land use planning.

Findings of all conducted research will be collaboratively evaluated by our team of specialists, and technical calculations and cumulative assessments about environmental stress reduction factors will be carried out carefully to be presented in the interim report (For the list of the team, their professions and specific roles in the project, see Appendix I).

Additionally, a SWOT Analysis will be undertaken by our specialists from different backgrounds of expertise once the draft chapters of the report are submitted. Finally, draft final report, which will also include strategy and policy recommendations, will be issued.

In the final Stakeholder Evaluation Workshop that will be held after the submission of draft final report, all the findings of SEA process, mitigation options

and strategy recommendations will be evaluated by all stakeholders, and in the light of feedback from workshop participants, final report will be restructured and finalized (see, Figure 1.2).

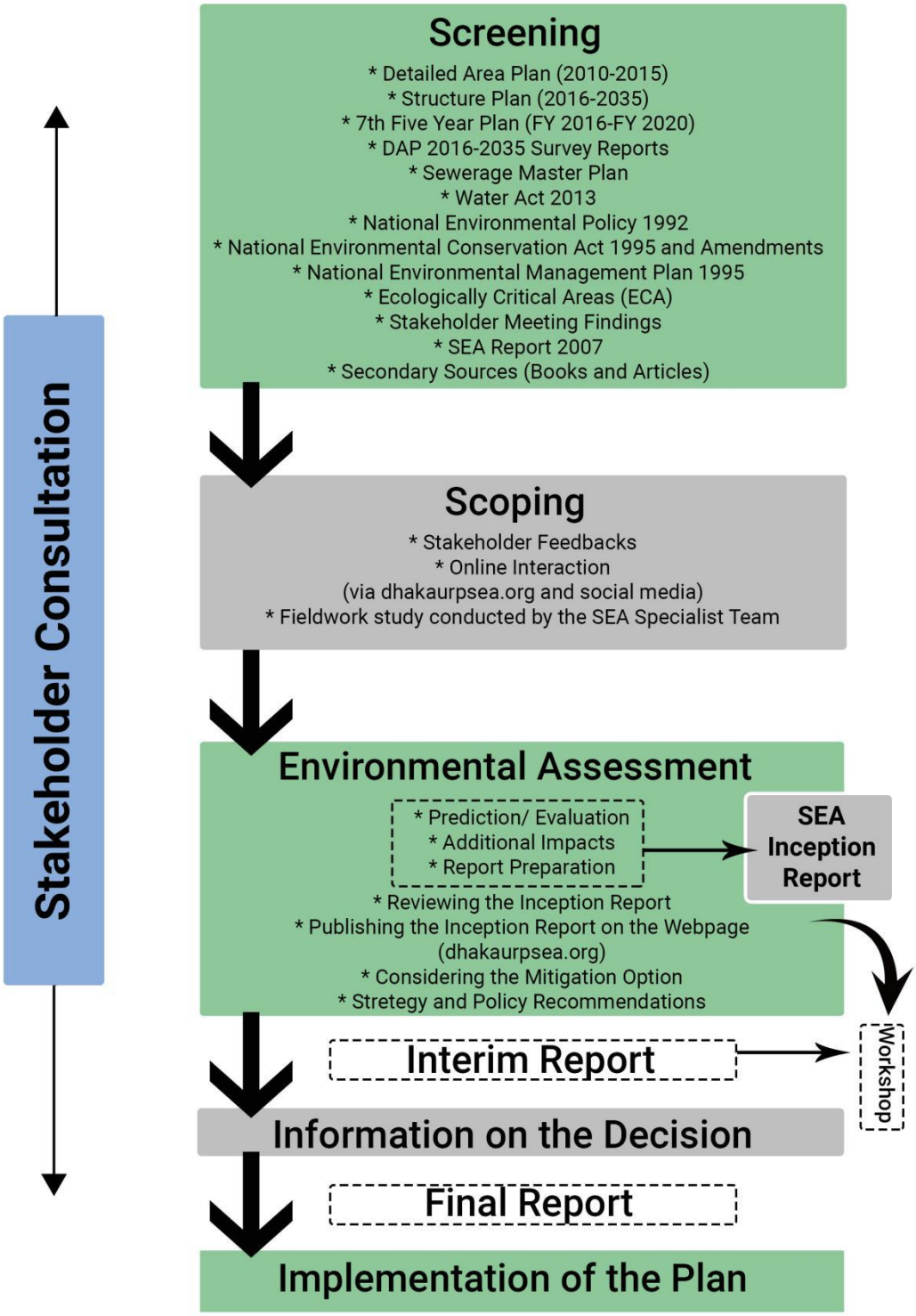


Figure 1.2 Methodology and design of the study.

1.4 Initiating the Study

A work plan including stakeholder meetings and site visits was developed by the SEA team, and the project was mobilized immediately afterwards.

Table 1.1 SEA Working Plan

SEA-Strategic Environmental Assessment Component B of Dhaka's Urban Resiliency Project	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Task and Accomplishment	***Dec. 2018***	***Jan. 2019***	***Feb. 2019***	***Mar. 2019***	***Apr. 2019***	***May 2019***	***June 2019***	***July 2019***
Mobilization								
Inception Report & Revised Inception Report (10.06.2019)								
Interim report								
Final report								

At first, a joint meeting between the Consultants and Project Implementation Unit (PIU) of RAJUK was held on December 2nd, 2018. The work plan prepared by the Consultants was approved by PIU, and Consultants agreed to submit three separate but interrelated reports (i.e., Inception, Interim, and Final reports) in the course of the research project.

Figure 1.3 PIU meeting (02.12.2018)

After the joint meeting, literature review and data collection process was initiated and the duties were distributed among the research team.

Outcomes of the fieldwork research and stakeholder meetings will be thoroughly discussed in interim and final reports of the project.

II ENVIRONMENTAL SITUATION ANALYSIS FOR DHAKA CITY

The aim of this chapter is to provide an overall analysis of the environmental situation in the study area. The section will identify factors that influence the environment and social fabric of the area including human-induced and natural ones (for example, climate change and flooding); determine the quality and quantity of natural variability of environment where adequate data is available or can be sourced; and describe the extent to which the general environment and ecosystems are already stressed by natural and anthropogenic effects (MOEE et al., 2017).

2.1 Historical and Cultural Heritage of Dhaka City

Although it is "not completely clear when and how a settlement was first formed at the site where the old core of Dhaka stands today", it is known that Dhaka City has a very long, rich and complex history, which can be traced back to more than a thousand years ago (Ahmed, Nahiduzzaman, & Bramlay, 2014: 24). Throughout its history, the city came under the rule of various dominators from different cultural backgrounds including Hindus, independent Sultans of Bengal, Mughals (Turco-Mongols), British and Pakistani, before Bangladesh eventually gained its independence in 1971 (Siddiqui et al., 2010: 3-6) (see, Figure 2.1). Therefore, it is most accurate to state that "Dhaka reached its present status through a series of dynamic changes it underwent during different phases of history" (RAJUK, 2015: 35).

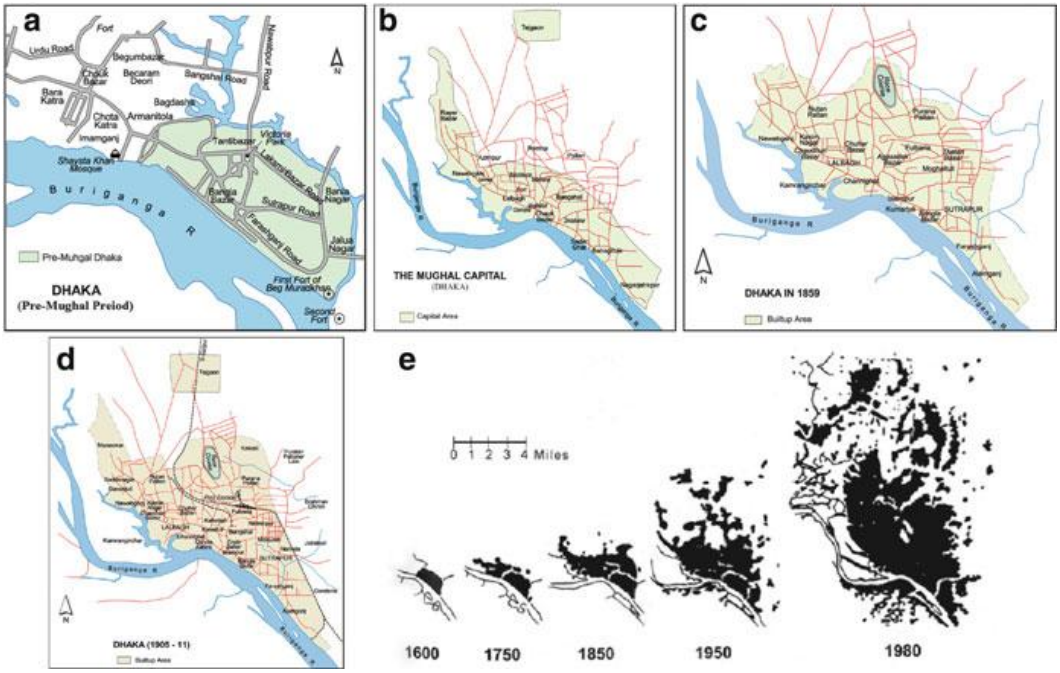


Figure 2.1 Evolution of Dhaka: (a) Pre-Mughal period, (b) Mughal period, (c) British period, (d) capital of East Bengal and Assam, and (e) evolution of Dhaka at a glance, 1600–1980.

Source: Ahmed, Nahiduzzaman, & Bramley: 2014: 26.

Since Dhaka has experienced "several rulers having different perspectives on city development and expansion" throughout its transformation from a small rural settlement to a "Third World Megacity" particularly in the last 400 years (Kabir, & Parolin, 2012: 7; Siddiqui et al., 2010), today, the city is rich with many different architectural styles such as Hindu, Mughal/Indo-Islamic, British colonial and so on, making it an important tourist attraction in the Southern Asia.

Figure 2.2 Lalbag Kella (Lalbagh Fort), one of the most popular historical places in Dhaka.

The most prominent historical heritage sites of the city that should be protected and preserved for the coming generations at any cost can be listed as follows ("Historical places...", 2017):

- ***Choto Katra:*** Mughal-era building constructed between 1663-64 and 1671.
- ***Lalkuthi (Northbrook Hall):*** British colonial era building near the bank of Buriganga built between 1872 and 1876; an excellent fusion of European Renaissance and Mughal architectural styles.
- ***Lalbag Kella***: Unfinished Mughal-era fort started to be constructed in 1678 under the direction of the titular Mughal Emperor Azam Shah. (Figure 2.2)
- ***Ahsan Monjil:*** Former palace of the Nawab of Dhaka constructed on the site of an old French factory by the British in Neo-Mughal style; a true architectural beauty.
- ***Boro Katra:*** Mughal-era structure constructed in 1644; once a monumental building, Boro Katra is almost in ruins today due to lack of repair and maintenance.
- ***Hosainy Dalan:*** Prayer hall for Shia Muslim community of Dhaka originally built during the late Mughal-era, and reconstructed several times afterwards.
- ***Star Mosque:*** A gem of Mughal-era architecture constructed in early 19^{th} century.
- ***Sat Gambuj Mosque:*** 17^{th} century Mughal-era mosque used to look mesmerizing, but looks quite dim today with a lot of ugly buildings around.

2.2 Socio-economic Conditions and Land Use

Dhaka is considered one of the ten mega cities in the world and is currently growing at an alarming rate. The population density is one of the highest in the world, at 23,333 people per km^2. Furthermore, it is estimated that about 4.2 million people live in slum areas and about 55% of Dhaka residents live below the poverty line. Therefore, it is an irrefutable necessity for Bangladeshi authorities to properly plan the future expansion of Dhaka.

Table 2.1 Demographic characteristics of Dhaka mega city.

Year	Total HH	Population	Density	Sex Ratio (M/F)	Literacy Rate	HH Size	Growth Rate (%)
1951	NA	411,279	4815	165	–	6.4	–
1961	127,710	718,766	5796	154	–	5.6	–
1974	341,167	2,068,353	6156	137	–	6.1	11.15
1981	527,311	3,440,147	8547	139	48.1	6	5.22
1991	1,088,378	6,487,459	4795	126	57	5.4	6.55
2001	1,920,682	9,672,763	7055	125	65.1	4.6	4.08
2011 [a]	3,232,683	14,509,100	10,484	113	67.3	4.1	–
2016	4,550,000 *	18,200,000	11,910	-	-	4.0	-

Note: HH = Households [32]; [a] Derived from BBS [33]; * Estimated from UN [9].

Source: Swapan et al., 2017.

As incisively pointed out in a 2015 World Bank document:

"Bangladesh is the most disaster prone country in the world, and is highly exposed to a variety of hazards such as floods, cyclones and earthquakes. The Government of Bangladesh (GoB) has instituted disaster risk reduction policies and invested in infrastructure along coastal areas to mitigate the risk from floods and cyclones, primarily after the catastrophic cyclones of 1970 and 1991. Over the years, the GoB has demonstrated that investments in flood management and cyclone preparedness saves lives, reduces economic losses, and protects development gains. As a result, the Government's actions are often cited in the argument for proactively investing in Disaster Risk Management (DRM) globally.

With seven million people living in Dhaka City, and 15 million people living in the wider metropolitan area, Dhaka is particularly at risk. Approximately 28 percent of the population is already classified as poor, and an estimated 300,000 to 400,000 poor migrants arrive in the city on a yearly basis. Land use planning regulations, and public service delivery in the urban areas of Bangladesh have failed to keep up with the pace of growth. The current regulatory environment is somewhat opaque and the enforcement mechanisms for urban development control do not address structural safety, creating an environment that lacks practical enforcement capability and accountability. In this context, physical and social vulnerabilities keep increasing and any hazards, such as floods, fires, building collapses, or earthquakes, present a formidable threat to life and prosperity" (World Bank, 2015b)

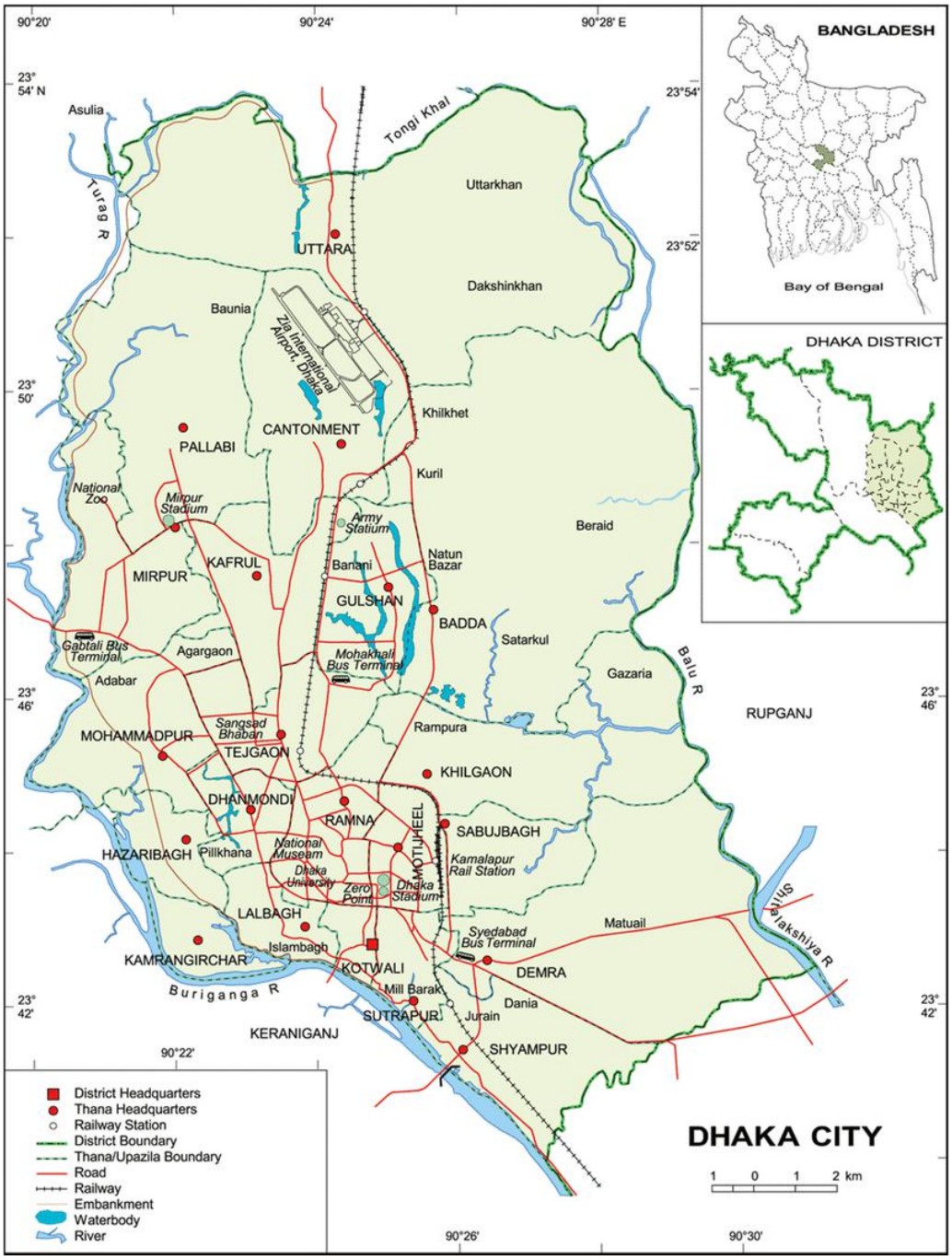


Figure 2.3 Location and administrative map of Dhaka city.
Source: Swapan et al., 2017.

In their seminal article that discusses the present and future of the urban development of Dhaka, Swapan et al. (2017: 5) give the following information concerning the urban expansion dynamics of the city:

"The urban sector in Bangladesh is the main thrust of the economy, which contributes more than 60% of the GDP. Dhaka is the prime urban agglomeration and economic hub of the country, having a current GDP of US$ 10 billion. The city offers 43.6% of the total formal employment in the country consisting of office jobs, business, and manufacturing industries. The city hosts five key manufacturing

industries namely: apparel, textiles, furniture, food and beverage, and leather. Dhaka also provides a large scale of informal jobs, including rickshaw operation, street vending, and household services run by the urban poor. The socio-economic profile of the residents shows extreme inequality between the rich and poor in Dhaka. Only 3% of the total population belongs to the rich cohorts who enjoy a high standard of living. The rest of the population belongs to either the middle or the lower-middle income groups, who have to struggle to sustain their life. Corner and Dewan record that 45% of the city's population is defined as urban poor, of which 25% are classified as 'extremely poor'. The urban poor are mostly located in slum areas of Dhaka city, characterized by a degraded built environment and unhealthy sanitation conditions. Slums accommodate newly arrived environmentally displaced and regular migrants from rural areas. Social clustering based on kinships, district of origin, profession and religion is a very common feature within communities living in slums. Such clusters and social networks provide initial income support, information, accommodation, and access to jobs for newly arrived people."

Some further details and information are provided in "National Plan for Disaster Management, 2010-2015" prepared by the Government of the People's Republic of Bangladesh:

"Around 52% of the civilian labor force of the country is engaged in agriculture and 14% is engaged in industry. Per capita GDP for 2002-2003 was US$418. Since independence in 1971, Bangladesh has achieved substantial improvements in some social indicators like a decrease in infant and maternal mortality as well as illiteracy, and an increase in life expectancy, access to safe water and sanitation. However, approximately 40% of the population still continue to live below the poverty line. The economic performance of the country has been relatively strong since 1990, with an annual 5% average GDP growth rate. Although half of the GDP is generated through the service sector, nearly two thirds of Bangladeshis are employed in the agriculture sector with paddy as the single most important product. The geographical location, land characteristics, multiplicity of rivers and the monsoon climate render Bangladesh highly vulnerable to natural hazards. The coastal morphology of Bangladesh influences the impact of natural hazards on the area. Especially in the south western area, natural hazards increase the vulnerability of the coastal dwellers and slow down the process of social and economic development. Significant country features include:

- A vast network of rivers and channels
- An enormous discharge of water heavily laden with sediments
- A large number of islands in between the channels
- A shallow northern Bay of Bengal and funneling to the coastal area of Bangladesh
- Strong tidal and wind action" (Disaster Management Bureau, 2010).

As regards to land use, data mainly comes from land use surveys. Land use survey basically records the use of land by its functional activity and classifies the land as residential, industrial, commercial, agricultural etc. In various land use surveys conducted for Bangladeshi authorities by different teams of specialists, the categories of land use in Bangladesh are listed as follows:

Table 2.2 Categories of land use in Bangladesh.

Residential	Planned Residential Area, Govt. Quarters, Private Housing, Rest/Guest/Circuit House, Banglow, Mess, Orphanage/Old Home, Rural Homestead, Slum, Squatters.
Commercial	Residential Hotel/ Hotel & Restaurant, Wholesale Rice Market, Wholesale Vegetables Market, Wholesale Fish Market, Wholesale Paper Market, Wholesale Grocery Goods Market, Wholesale Fruit Market, Book Stall, Cloths Shop, Paper & Magazine, Stationery Shop, Shoe Shop, Bag & Leather Goods, Cosmetics, Spectacles, Electronic Goods, Audio Video Cassette, Utensils/Crockery, Sports Goods, Computer Goods, Motor Car Parts, Jewelry shops, Show Room, Furniture Shop, Department Store, Mobile Sales Center, Hardware Goods, Sweet Shop, Bakery Shop, Gift Shop, Press & Printing, Grocery Shop, Gun Shop, Iron & Steel Shops, Shopping Center/Mall, Shopping Mall, Super Market, Rubber Stamps, Phone-Fax-Photocopy, Cycle Store, Studio/Colour Lab, Drug/Pharmacy, Pottery shop, Electronics, Sports and Athletics, Kitchen Market, Katcha Bazar, Beauty Parlor/Hair dresser, Govt. Food Godown, Cold Storage, Others Godown.
Mixed Use	Commercial – Residential, Office – Residential, Commercial – Industrial, Two or More categories. More use.
Transport Facilities	RHD Road/LGED Road, Primary Road/ Major Through fare, Secondary Road (Pucca), Secondary Road (Katcha), Local Road (Pucca), Local Road (Katcha), Access Road (Pucca), Access Road (Katcha), Footpath (Paved), Footpath (Unpaved), Walkway, Embankment cum Road, Airport / Bus terminal / Truck terminal / BRTC bus Depot / Tempo stand / Rickshaw stand / Railway station / BIWTA Terminal/ Launch Terminal etc, Broad gauge, Meter gauge, River, Ferry Ghat, Filling Station, Garage, Passenger shed, telephone exchange, ticket counter, transport Office etc.
Institutional Area	Deputy Commissioner's Office, ZilaParishad Office, SP Office/Police Headquarter, Civil Surgeon Office, LGED Office, Upazila Headquarter, Paurashava Office, Union Parishad Office, Settlement Office, Post office, Bank, Public Works Department Office, R&H Office, DPHE Office, Police Station, Ansar Camp, Jailkhana, Statistical Bureau Office, PDB Office, BWDB Office, DoE Office, All types of Government Office, Private Bank/ Insurance Company, Mercantile & Cooperatives, Money Exchange Center, Private company/Different types of NGO/CBO/Club, Construction Office, Commercial Group Office, Trading Corporation Office, Security Service Office, Law Chamber, Doctor's Chamber, Political Party Office, Professional's Association, Labor Union.
General Industry	Green and Orange A categories as per The Environment Conservation Rules, 1997, Other toxic and pollutions Industries (Orange B and Red categories as per The Environment Conservation Rules, 1997)
Agricultural	Single crop land, Double crop land, Triple crop land, Barren land, Mango garden/Litchi/Jackfruit/Banana/Lemon/others, fruits garden etc., Different types of flower garden, Tree cultivation, Hatchery/Gher, Livestock / Poultry Farm / Diary Farm, Agricultural Research Area.

Educational and Research	Kindergarten and Nursery, Primary School, High School, College, Public. University, Private University, Public Medical College, Private Medical College, Homeopathic Medical College, Engineering College/University, Law College, Social Research, Health Research, Economic Research, Vocational Training Institute, Physical Training Institute, Nursing Training Institute, Teachers Training College, Computer Training Institute, Dakhil Madrasa, Alim Madrasa, Fazil. Madrasa, Kamil Madrasa, Hafezia Madrasa, Tutorial/ Coaching Center, Government Training Institute, Library, Museum, Social Welfare Institution
Health Facilities	Govt. Hospital / Pvt Hospital / Mental Hospital/ Maternity/ Children Hospital / Clinic/ Diagnostic Center, Veterinary Hospital
Community Facilities	Mosque, Eidgah / Mazar/ Dargha, Temple, Church, Pagoda, Graveyard, Cemetery, Cremation place, Community Center, Social Club, Slaughter House, Monument, Shahid Minar etc. which will provide service to the community, Utility services include Overhead Tank, Power Office/Control Room, Public Toilet, Sewerage Office, Waste Disposal, Fire Service, WaterPump House, Water Reservoir, Water Treatment Plant, etc.,
Restricted Facilities	Cantonment/BDR/Navy, TV Station, Radio Station, T&T Board, Power Supply Station.
Recreational Facilities	Cinema Hall, Theater Hall, Museum & Art gallery, Auditorium /Community Center/Town Hall, Park/Playground/Amusement Park/Theme Park, Stadium/ Gymnasium/Swimming Pool, Tennis Complex. Historic Sites, National Park/Botanical Garden, Zoological Park, Forest. Land/Urban Green, Ecological park/sites, River Bank
Water bodies	Pond, Ditch, Marshy Lands, Beels, Lakes, River, Khals, Streams.

Source: Compiled by various researchers working in cooperation with RAJUK, PIU, UDD, and so on. The same list can also be found in a number of research reports submitted to Bangladeshi authorities.

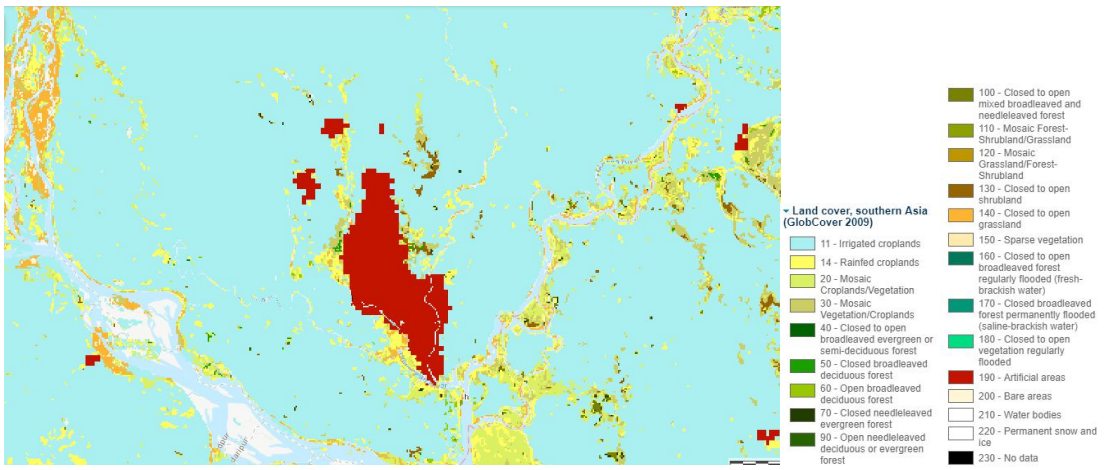


Figure 2.4 Land cover of Dhaka and its surroundings.
Source: Datasets by www.databasin.org

Agriculture remains the most important sector of Bangladeshi economy. Despite its relatively high level of industrial development, Dhaka also does not seem to be an exception in this sense (see, Table 2.3 below). Yet, non-farm income has also been gaining importance as a livelihood diversification strategy in not only urban, but also rural parts of Bangladesh, partially due to very small and declining farm sizes. Roughly a third of the rural population is functionally landless, and unable to participate in agricultural value chains as producers. Persistent poverty and an inability to participate meaningfully in commercial agriculture drives many to pursue other economic options, either finding off-farm employment in rural areas or migrating to urban areas. A 2013 study estimated that approximately 53 percent of Dhaka slum residents were domestic migrants (Feed the Future, 2018). This almost unchained massive population movement towards Dhaka is apparently one of the most important reasons behind excessive and rapid population growth in the city, and in this sense, it also contributes to environmental degradation in Bangladesh

Table 2.3 Land use composition in Central, Northern, Eastern, Southern and Western Regions of Dhaka.

Central Region

Land Use Type	Ha	%
Agriculture	7,104.9	23.6
Industrial Area	541.4	1.8
Commercial	694.2	2.3
Mixed Use area	611.9	2.0
Residential Area	12,987.9	43.2
Purbachal RA	6.3	0.02
Public Facilities	1,293.6	4.3
Recreational Area	289.0	0.96
Restricted Area	2,030.0	6.8
Road/Railways	1,858.8	6.2
Waterbody	2,643.4	8.8
Total	3,0061.4	100.00

Northern Region

Land Use Type	Ha	%
Agriculture	16,560.0	46.6
Industrial Area	931.0	2.6
Commercial	291.5	0.8
Mixed Use area	127.7	0.4
Residential Area	14,247.8	40.1
Public Facilities	780.3	2.2
Recreational Area	4.1	0.01
Restricted Area	863.5	2.4
Road/Railways	552.8	1.6
Waterbody	1,203.1	3.4
Total	35,561.8	100.0

Eastern Region

Land Use Type	Ha	%
Agriculture	9,813.5	45.6
Industrial Area	557.3	2.6
Commercial	134.3	0.6
Mixed Use area	3.9	0.02
Residential Area	7,022.3	32.6
Purbachal RA	2,391.5	11.1
Public Facilities	89.8	0.4
Restricted Area	30.2	0.1
Road/Railways	212.1	1.0
Waterbody	1,273.5	5.9
Total	21,528.5	100.0

Southern Region

Land Use Type	Ha	%
Agriculture	8,094.6	37.4
Industrial Area	909.1	4.2
Commercial	242.1	1.1
Mixed Use area	123.7	0.6
Residential Area	8,758.8	40.5
Public Facilities	336.9	1.6
Recreational Area	9.4	0.04
Restricted Area	321.1	1.5
Road/Railways	423.1	2.0
Waterbody	2,416.5	11.2
Total	21,635.4	100.0

Western Region

Land Use Type	Ha	%
Agriculture	11,156.2	44.1
Industrial Area	727.2	2.9
Commercial	138.8	0.6
Mixed Use area	82.4	0.3
Residential Area	8,852.0	35.0
Public Facilities	1,177.8	4.7
Recreational Area	87.3	0.4
Restricted Area	753.7	3.0
Road/Railways	418.4	1.7
Waterbody	1,901.8	7.5
Total	25,295.5	100.0

Source: JICA, 2018.

2.3 Environmental Conditions

2.3.1 Air Management

In 2007, two Air Quality consultants, Richard Baldwin and David Calkins, prepared a report regarding urban air quality management in Bangladesh for the World Bank. This report concisely describes how the problem of air pollution worsened and the World Bank-supported air pollution management strategy was developed in Bangladesh from 1990s to mid-2000s:

"In the mid 1990's air quality in Dhaka started deteriorating visibly and became an issue of public concern. The main air pollutant of concern was identified as particulate matter (PM). To address

growing concern over air pollution, in 2000 the Government of Bangladesh (GoB), with assistance from the World Bank, launched the Air Quality Management Project (AQMP) with primary focus on Dhaka.

The AQMP was conceived as part of the Bangladesh Environment Project (BEP) in 1998. The initial BEP concept was for an umbrella project with multiple implementing agencies corresponding to several of the country's highest environmental priorities as expressed in its just-completed National Environmental Management Action Plan. After the review of the project concept, it was decided that the BEP should be 'unbundled' and split into several smaller interventions, most of which became sub-components of other projects in the pipeline. The AQMP remained as the stand-alone environmental intervention and was formulated as a Learning and Innovation Loan (LIL) supported by the World Bank.

It was agreed that (i) this project was suitable as a LIL because of its short term nature and the ability to have maximum flexibility providing grants to perform the identified tasks; (ii) it was reasonable to focus on transport emissions, but analytical work on other sources of air pollution should also be conducted; (iii) success of this LIL would be judged on the basis of institutional capacity building, greater information and understanding of air pollution, more effective enforcement of rules, and appropriate participation of the private sector – but not on the basis of actual improvement in ambient air quality, given the short life-span and learning nature of the project.

The primary objective of this LIL was to learn about options and develop components of urban air quality management by means of pilot activities and institutional support, with the ultimate goal of reducing human exposure to vehicular air pollution in a cost-effective manner. The components were designed to promote learning, develop institutional capacity for air quality management, test technical options for financial, environmental and social viability, and raise stakeholder awareness of the issues and options related to vehicular air pollution. The project was negotiated in July 2000 and consisted of two main components: (i) Vehicle Emissions Reduction: Enforcement, Standards and Control and (ii) Air Quality Monitoring and Management.

The AQMP has developed an air quality database for PM in Dhaka, developed a limited database for gaseous criteria pollutants in Dhaka, and is beginning to develop a PM and gaseous criteria pollutant database in Chittagong. The AQMP has also developed an on-road profile of vehicle exhaust emissions for Dhaka, and has created an enforcement program to cite excessively polluting vehicles in Dhaka.

The first set of ambient air quality standards for Bangladesh was defined in the Environment Conservation Rules of 1997. The 1997 standards were replaced by a new set of standards in July 2005 based on a proposal of the World Bank-funded AQMP which reviewed the old standards. The new standards for Particulate Matter (PM_{10}, $PM_{2.5}$), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and ozone (O_3) are almost the same as the ambient air quality standards set by US EPA, and the standard for lead (Pb) is equivalent to the guideline value set by WHO. Bangladesh is the only country in South Asia which set a $PM_{2.5}$ standard in its National Ambient Air Quality Standards (NAAQS). Some of the standards for CO, NO_2, SO_2, and O_3 are seen to be more lenient than the guidelines set by the World Health Organization (WHO)" (Baldwin, & Calkins, 2007).

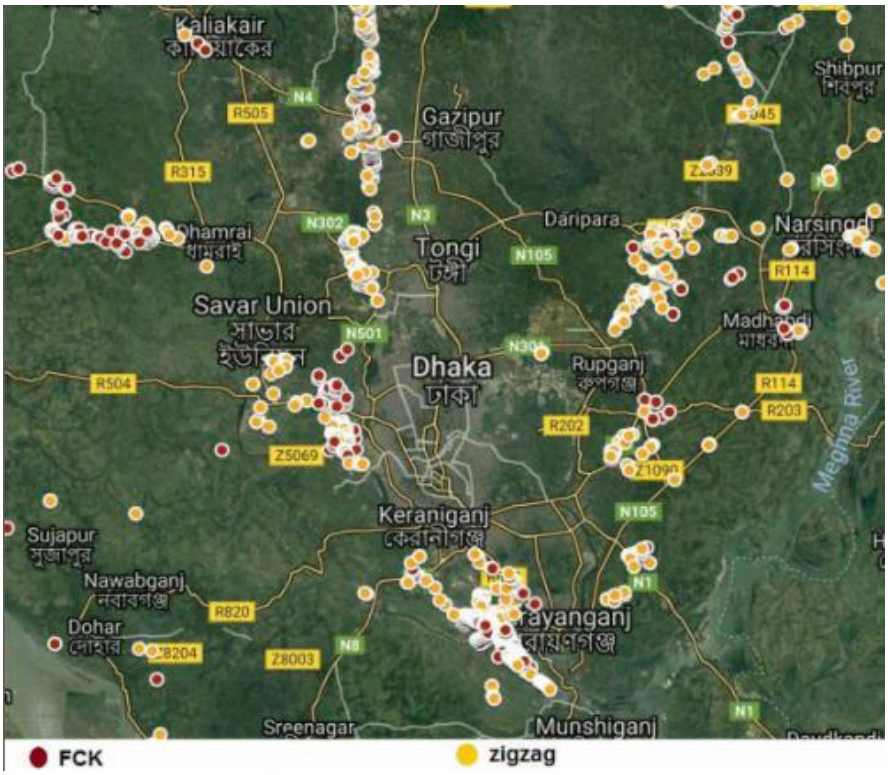


Figure 2.5 Brick kilns in and around Dhaka
Source: Department of Environment, 2019

Despite all the precautions taken, since this 2007 report was submitted, the quality of air in Bangladesh (and particularly in Dhaka) has deteriorated even more. As many news reports frequently point out, Dhaka continuously ranks among the world's most polluted cities (and even 'the most' sometimes), and Air Quality Index (AQI) of the city is usually at "hazardous" levels ("Dhaka Air...", 2019). In 2018, Dhaka had 83 days with its AQI over 301 (severely unhealthy) (Alam, 2019) (See, Box 2.1). It seems clear that Dhaka has very serious urban and indoor air quality problems that need to be resolved at any cost, but existing institutional mechanisms are not effective enough to handle these. So much so that, according to 2018 World Bank report, fine particulate matter ($PM_{2.5}$) air pollution, both ambient and indoor, remains to be the most significant environmental risk in Bangladesh, causing about 21% of all deaths (World Bank, 2018).

One of the most important reasons of severe air pollution in Dhaka is the vast brick industry. According to official statistics, there are 2487 brick kilns located in Dhaka (Department of Environment, 2019). These factories usually employ migrant domestic workers who fill up shanty towns in the city, and work in miserable

conditions. While exact numbers are hard to come by, estimates suggest the industry here employs more than one million people who churn out 17 billion bricks each year at some 7,000 kilns (Shachi, 2018).

Although brick kiln industry is seasonal and these factories rarely operate during the monsoon season (or wet season), yet, it is still an important source of carbon emission. This is also the reason why air pollution is much more severe during 'dry season' in Dhaka. "During the dry season, when brick making is going full tilt, dust and smoke from wood and coal-fired kilns mingle with clouds of pollution rising from trash fires and vehicle engines, hanging over the city like fog. The kiln operations alone generate nearly 60 percent of the particulate pollution in Dhaka, according to Bangladesh's Department of Environment (DOE). Many of those kiln operations including some 530 sites producing more than 2 billion bricks annually in northern Dhaka are so-called fixed-chimney kilns, which use inefficient technology with little to no pollution controls" (Shachi, 2018).

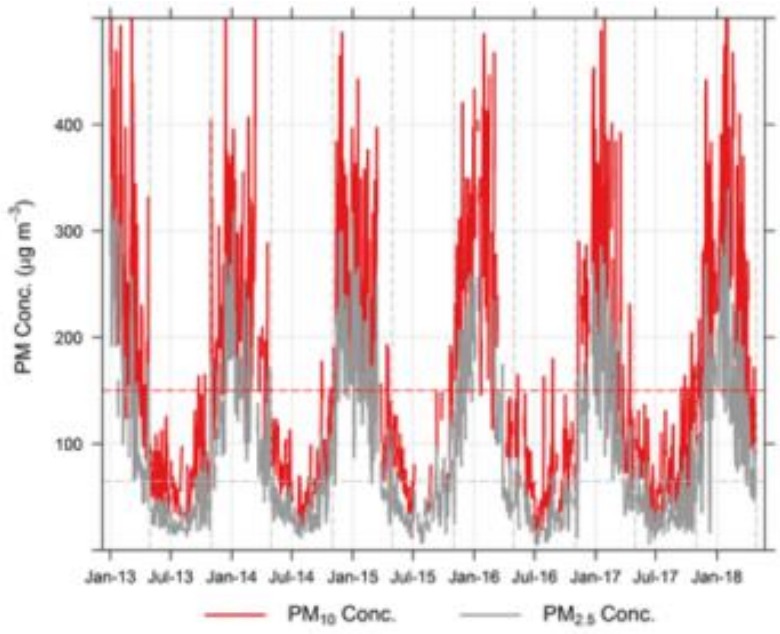


Figure 2.6 Trends in daily-averaged PM concentration (data threshold 80%) in Dhaka. The red and grey horizontal lines are standards for PM_{10} and $PM_{2.5}$ respectively.
Source: Department of Environment, 2019

Temporal trends in PM concentrations demonstrate seasonal variations sharply; PM_{10} and $PM_{2.5}$ concentrations in air remain higher than the standards of Bangladesh during November to April, and during the time from May to October the PM levels

satisfy the limit values. The month of January is found to be the most polluted month, followed by December and February. Winter season (December–January) is also characterized with higher fraction of fine particles to PM10 mass concentrations and the summer time (February–April) is typified with coarse particles in air (see, Figure 2.6).

In Bangladesh the AQI is based on 5 criteria pollutants; Particulate Matter (PM_{10} and $PM_{2.5}$), NO_2, CO, SO_2 and Ozone (O_3). The Department of Environment (DoE) has also set national ambient air quality standards for these pollutants. These standards aim to protect against adverse human health impacts. The AQI standard for Bangladesh is given as under.

Approved Air Quality Index (AQI) for Bangladesh

Air quality index (AQI) Range	Category	Colour
0-50	Good	Green
51-100	Moderate	Yellow Green
101-150	Caution	Yellow
151-200	Unhealthy	Orange
201-300	Very Unhealthy	Red
301-500	Extremely Unhealthy	Purple

Box 2.1 Approved AQI for Bangladesh
***Source*:** CASE, 2019.

The Government of Bangladesh with the financial assistance from the World Bank has been implementing the Clean Air and Sustainable Environment (CASE) project with a perspective to improve the air quality in the urban areas of the country. The project has worked on all of the components during its period from 2010 to 2019. Air quality screening in two big cities (Dhaka and Chattogram) has been done, and a countrywide air quality monitoring network has been established. Three of the eleven fixed Continuous Air Monitoring Stations in Bangladesh have been established in Dhaka (Department of Environment, 2019). "The Department of Environment monitors and reports findings daily for six common pollutants, including $PM_{2.5}$, PM10, nitrous oxide, sulfur dioxide, carbon monoxide, and ozone. According to air quality data from 2017, nearly half of Dhaka's available hourly readings were at or above

unhealthy levels and brick kilns contribute significantly to $PM_{2.5}$ concentrations in the cities close to where they operate. The U.S. Environmental Protection Agency considers the daily concentration of $PM_{2.5}$ to be unhealthy for anyone at levels above 55.4 micrometers per cubic meter of air and readings well above this are common. Since 1990, annual average population-weighted $PM_{2.5}$ levels in Bangladesh have increased from around 65 micrometers per cubic meter in 1990 to 101 in 2016, according to the State of Global Air report" (Shachi, 2018).

According to a Department of Environment report, 4,390 kilns in the country were using modern technology as of 2017, and about 65% of the facilities had been converted to environmentally-friendly versions. "The department also reported that it fined 605 illegal brick kilns between 2013 and 2017 and closed or dismantled. But with only vague wording to describe its updates, the state of the country's 'modern' or 'environmentally-friendly' kilns is far from clear" (Shachi, 2018).

Rapid industrialization is yet another factor contributes massively to air pollution in Dhaka. Since its independence in 1971, Bangladesh has achieved a tremendous growth rate in its industrial production. Today, Bangladesh is not only importing industrial products from other countries, but also exporting a substantial amount of product to over 100 countries of the world and shows an impressive growth in industrial sectors. Undoubtedly, rapid industrial growth often offers a huge burden of environmental pollution and associated risks. (Ahaduzzaman, 2017).

"The number of automobiles has been increasing in Dhaka city at the rate of at least 10 to 20% annually, which has been contributing to air pollution on the one hand and traffic congestion on the other" (Islam, 2014). "This critical state is largely due to inadequate road space, unplanned road network configuration and archaic traffic management system. Among the existing public transport system, bus transit operations in particular are characterized as the least desirable mobility option for people, especially in terms of reliability, comfort, speed and safety." (Alam, 2018).

"The exponential growth of vehicles over the last decade has forced Bangladesh's authorities to set new transport emission standards to curb increasing air pollution, in a country of more than two million vehicles and little effective monitoring. The Department of Environment has devised separate emission standards for vehicles powered by diesel, petrol and compressed natural gas (CNG), partly in line with its 2012 study on air pollution by the transport sector" (Chowdhury, 2017).

Cumulative assessment of air quality will be examined in details in the interim

and final reports.

2.3.2 Waste Management

2.3.2.1 Solid Waste

The ever-increasing population and changing living standards make it difficult to control and manage both waste volume and waste composition. Solid waste management is becoming increasingly important and complex today due to the pollution caused by solid wastes, increase in the size of existing and potential risks that this pollution generates, the economic damage that it wreaks, and the role that it plays in terms of resource depletion. Therefore, all components of an integrated solid waste management that includes all stages from waste generation to final disposal and their relations with each other must be studied and absorbed.

Waste management aims at minimizing the impact on the environment and economy in the disposal of waste generated within the waste management system. The shortest way to achieve this goal is to reduce the amount of waste naturally.

Integrated waste management can be defined as the selection and implementation of appropriate methods, technology and management programs for a specific waste management objective. Integrated waste management also includes the monitoring of the provisions stipulated in the relevant legislation. Steps of the integrated waste management is as follows:

1) Waste prevention,

2) Waste reduction,

3) Reuse,

4) Recycling,

5) Final Disposal.

The following figure describes the waste hierarchy adopted by the authorities in charge of targeted waste management.

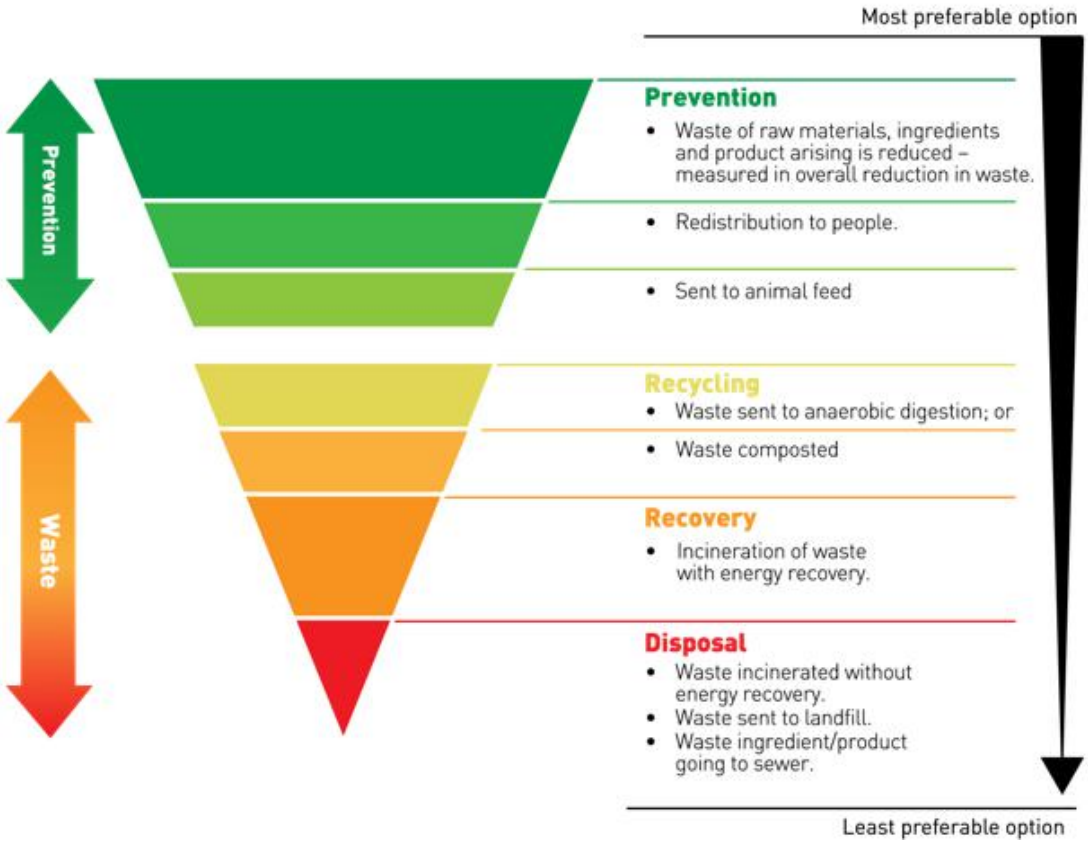
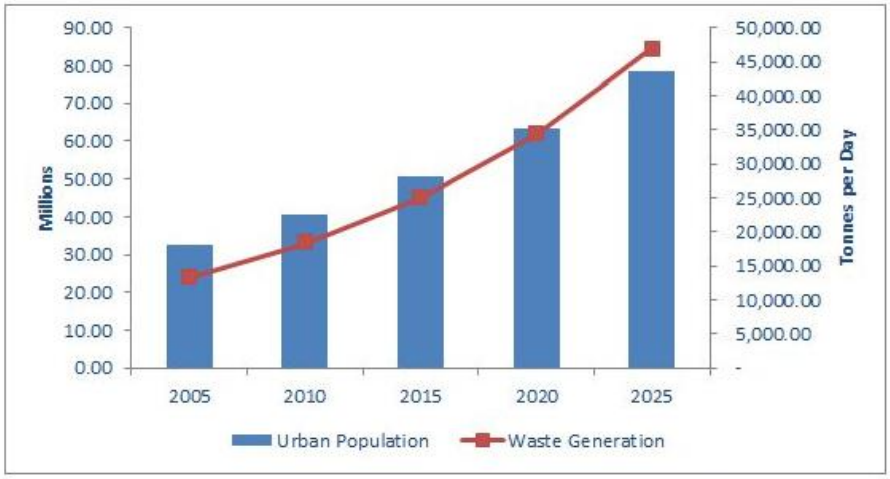


Figure 2.7 Waste hierarchy for targeted waste management

The issue of poor solid waste management (SWM) has become a challenge for governments of developing Asian and African countries since it is critical for the protection of public health, safety and the environment. In Bangladesh, due to lack of motivation, awareness, commitment, expertise as well as funds, a considerable portion of wastes, 40-60%, are not properly stored, collected or disposed in the designated places for ultimate disposal. Many experts from developing countries have expressed serious concerns about improper waste treatment and disposal in these countries especially Bangladesh. "World Health Organization (WHO) termed termed Dhaka as one of the mostly polluted cities, Municipal Solid Waste are being generated at a faster pace, posing a serious management threat. Rapid growth of industries, lack of financial resources, inadequate trained manpower, inappropriate technology and lack of awareness of the community are the major constraints of solid waste management for the fast growing metropolis of Dhaka. Both quantity and volume of this waste have increased rapidly as the city population" (Yasmin, & Rahman, 2017).



Source: World Bank, Waste Concern, and Frost & Sullivan Analysis

Figure 2.8 Municipal Solid Waste Management in Urban Bangladesh.

"The waste generation rate generally varies between the dry and the wet season in Dhaka. In the rainy season, organic and perishable wastes contain more moisture so the bulk of waste contains more weight than in the dry season. The contributions of different sectors to the total generation of Dhaka city, where nearly 76% of generated waste came from the residential sector, 22% came from the commercial sector, 1% from the institutional sector and rest from other sectors" (Yasmin, & Rahman, 2017).

An overall 23,688 tonnes of waste is produced every day in Bangladesh, and %70 of it is generated in Dhaka City (16,581 tonnes/day). Daily production of solid waste in Dhaka City is more than 4000 tonnes of which 200 tonnes hospital and clinical waste contains toxic chemicals, radioactive elements and pathological substances (Yasmin, & Rahman, 2017). "Solid wastes are being generated at a faster pace, posing a serious management threat. Rapid growth of industries, lack of financial resources, inadequate trained manpower, inappropriate technology and lack of awareness of the community are the major constraints of solid waste management for the fast growing metropolis of Dhaka" (Zahur, 2007)

"Municipal Corporation is unable to impose rules on the public. On the institutional side, rules and regulations are not clear. The role and responsibilities of waste generators are not clearly defined i.e., the present law does not provide penalties for illegal disposal of waste or littering. Lacks scientific approaches for problem solving and DCC has shortages of skilled human resources and finances. The accumulating waste is dumped by the residents in the city's streets, open storm water

and wastewater drains or open water bodies where and whenever the collection service is inexistent or dysfunctional. In particular, slum or periphery areas are affected by such a situation. During the annual monsoon rains wastewater and storm water drains which are clogged by solid waste overflow, creating an acute sanitary and hygienic threat in low-lying slum areas particularly" (Parvin, & Begum, 2017).

2.3.3 Water Management

In each basin, there are water resources such as rivers, lakes, groundwater, ponds, dams, reservoirs, and so on. In order to implement an effective water management mechanism in the basin, these water bodies should be split into smaller streams or units. Different perspectives should be utilized for surface and groundwater administration, since these two possess different characteristics. And during general health examinations, each community group should be considered as unique since the water source that they use usually differ.

Some key concepts regarding water management can be described as follows (Şıltu, 2015):

A) Water Quality and Pollution:

i) *Water Quality:* The composition of water expressed in terms of both measurable quantities and narrative statements;

ii) *Water Pollution (contamination, nuisance)*, Faulty condition of surface and ground waters.

B) Physical, Chemical or Biological Factors Affecting Water Quality

i) *Physical Parameters:* flow, temperature, electrical conductivity, turbidity, color, odor etc.

ii) *Chemical Parameters*: biodegradable organics, dissolved oxygen and sediment demand (SOD), nutrients (nitrogen and phosphorus), toxic pollutants, salinity (dissolved solids), pH, suspended solids etc.

iii) *Biological parameters*: macroinvertebrates, coliform bacteria, indicator parameters like chlorophyll a etc.

Agricultural activities, urbanization, industrial activities, domestic wastewaters, accidental spills are some of the factors that exert pressure on water quality and quantity (See Figure XX).

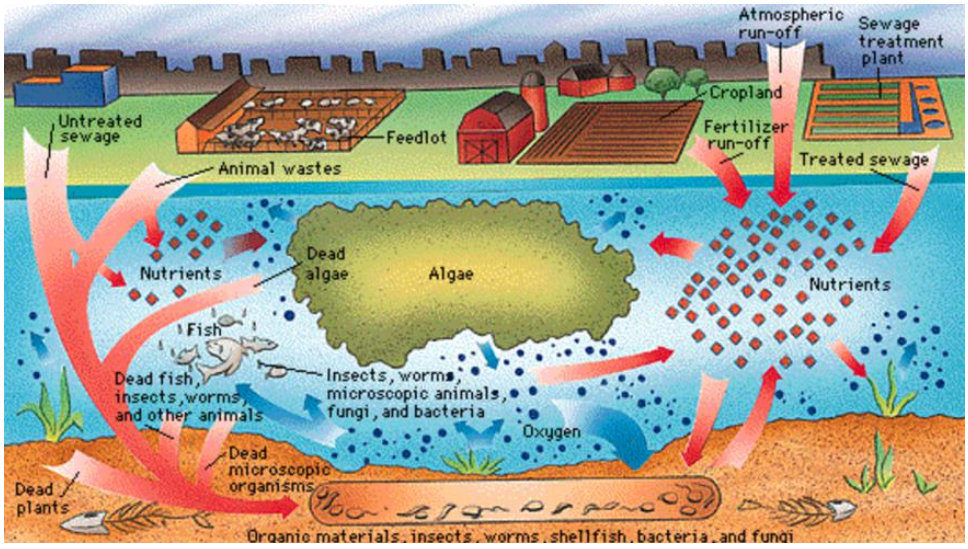


Figure 2.9 Sources of Water Pollution

As Yayan (2015) puts forward, although the concept, "Water Safety," is mostly utilized in Drinking Water Safety Plans, it is also used to define whether the quality of water intended for human consumption is wholesome and clean, and whether it meets the required microbiological, chemical, radioactive, physical and aesthetic parameters. "Water Security", on the other hand, is rather a strategic concept, which basically refers to "reliable access to water of sufficient quantity and quality for basic human needs, small-scale livelihoods and local ecosystem services, coupled with a well managed risk of water-related disasters" (WaterAid, 2012).

In this sense, drinking water safety also includes identification of physical, chemical and biological hazards in the whole distribution network (water supply system) from the source to the end users (consumers), and improving the monitoring, evaluation and surveillance of water quality standards to prevent drinking water to do harm on public health.

Dhaka city is dependent mainly on groundwater resources, which is now seriously depleting. As of June 2014, DWASA had approximately 672 production wells, which provided 88% of the city's total water supply through a 3,040 km long pipeline network (Shams et al., 2016). Excessive usage of groundwater in Dhaka has, of course, many negative effects on the environment. Any project aiming at solving this problem should:

a) "provide details of the groundwater and surface water in the area. This shall include an overview along with relevant data of important chemical and physical characteristics of surface waters and groundwater within the area. The section shall describe seasonal changes in water quality across a range of spatial and temporal scales (e.g. different periods during the year and different sections of the

catchment. Physical and chemical parameters shall include but not be limited to pH, dissolved oxygen, temperature, turbidity, conductivity, total dissolved gases, suspended solids, nutrients including nitrogen and other nitrates, phosphates, potassium, ammonia etc (dissolved and in solution), metals etc. These shall be collected from riffles, runs and pools as appropriate. Where relevant, the projects submitted before the desired applications shall assess marine water intrusion into groundwater where projects are being undertaken in coastal locations."

b) "describe with appropriate modelling and mapping, the baseline hydrological characteristics of the area of influence. This shall include but not be limited to seasonal flows and extreme events including velocity, volumes and any current impediments to flow. Details on all flooding including the average recurrence interval of large events shall be discussed. Stream gauges shall be used to measure these variables over spatial and temporal scales and up to date data (within previous five years) shall be used in the development of all calculations and modelling. It shall describe the watershed/catchment including size, slope and shape of the catchment area and the soils and groundwater infiltration. The hydrology shall include all surface water flowing in any streams and tributaries feeding into the main river from the catchment and how those matter vary depending upon the rainfall events measured historically in order to understand the variability in the annual flows (e.g. the differences between very wet and very dry years), and the seasonal patterns of flow. The any projects submitted before the desired applications shall also describe existing flood risk for a range of annual exceedance probabilities for the project area of influence" (MOEE et al., 2017).

The provision of drinking water in Bangladesh's capital city Dhaka has been particularly challenging. Dhaka's population has been growing at 3.6% per annum since 2005, much higher than the national average of 1.1%, leading to increasing demand for drinking water supply (DWASA, 2016).

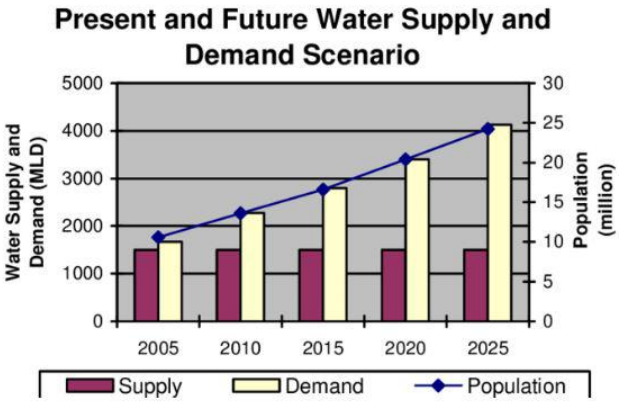


Figure 2.10 Present and future water supply and demand scenario for Dhaka City.

Dhaka Water Supply and Sewerage Authority (DWASA) provides water across a service area of about 400 square kilometers in Dhaka City and its surroundings. It has been relying heavily on groundwater as a source of water supply, but current ground water is drastically decreasing with increasing population. Moreover, excessive water pollution also threatens already shrinking water resources of the city. Such that,

research studies put forward that a total of 41% of all improved water sources in Bangladesh have been contaminated with E. coli bacteria, 13% of Bangladesh's water sources contain arsenic levels above a safe threshold, and major drinking water source of Dhaka city is endangered by the chromium pollution from approximately 150 tanneries in Hazaribagh area, in the western side of the capital (Nabi, 2018; Khan, & Schüth, 2011).

As Amin (2015) summarizes, the main reasons for water pollution in rivers of Bangladesh, especially the rivers which stands in the neighborhood of the Dhaka city are;

- "Rapid and unplanned urbanization and industrialization, brick-field development, dying factories, tanneries, grabbing up the river.
- The slum dwellers use unhygienic open latrines, wash clothes; take bath even cows and goats bathe in the river.
- Untreated wastes are thrown into the river as most of the industries have no effluent Treatment Plant.
- Some rivers are used to rot jute plants by the farmers.
- Oil spills of boats and different water vessel.
- Using agro-chemicals in agricultural land."

Effects of this water pollution are;

- "The dissolved oxygen level of many of the rivers' water has reached at lethal level.
- Due to over spilling of pollutants during the rainy season, the agricultural lands are contaminated that they have lost their crop growing capacity and hence remain unused all the year round.
- Sometimes the pollutants enter food chain eventually killing birds, fish, and mammals.
- The scientists in a recent research on the Karnaphuli found traces of radioactivity 'very close to risk level' on the soil. If radioactivity of the river soil goes up it will hamper the natural breeding of fish as well as growth of fishes. If the people eat the affected fish it may spread to their body.
- Pollution is so acute that hardly any hydro-organisms can tolerate it and eventually, fish of many species are found floating dead in the river water. These

dead fishes gradually get rotten and highly add to the further pollution of the river water.

- Due to rotting jute in the river (Chitra River in South West of Bangladesh) the water quality of the river is in an inferior position as aquatic creatures are dying for lack of oxygen.
- The river pollution has also hit the local fishermen hard. Life has become difficult for them as they lost their income source.
- This also results in the alteration of geomorphic features which can then change in the geometry and sedimentary characteristics of river channels, flood plains and deltas.
- Industrial pollutants such as lead, cadmium, iron, copper and organic wastes from leaking sewage systems can accumulate in rivers."

2.3.4. Soil Quality

As pointed out in a 2018 World Bank report, in Dhaka, "[u]rbanization and industrialization have increased the amount of waste generated. Without proper collection and disposal, solid waste clogs channels, leading to urban floods. Unsafe recycling of hazardous waste, including of used lead-acid batteries on a growing number of sites and waste from shipbreaking, poses a growing public health hazard" (World Bank, 2018: 12).

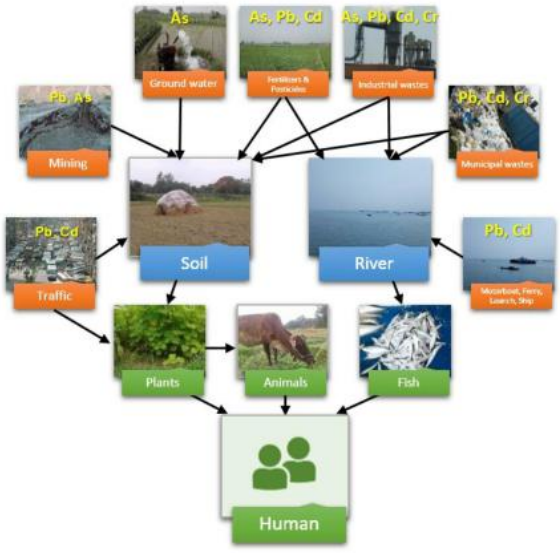


Figure 2.11 Major pathways of heavy metal and metalloid dispersion and human exposure in Bangladesh.
***Source**:* Islam et al., 2018.

Dhaka is abundant of water resources, and most industries in the city are located near the bank of rivers or lakes where industries can dump their waste with almost no treatment. This, of course, makes the soil near the water bodies particularly polluted in Dhaka. A recent case study about soil pollution near Hatirjheel Lake located at the center of Dhaka city clearly shows how terrible the level of soil pollution in the city is. As the authors reveal, the soil in and around the study area has been contaminated heavily with iron, manganese, chromium, arsenic and lead since the waste water from the industries (which is, apparently, rich of heavy metals) is discharged without accomplishing any recovery/reuse system (Hashem et al., 2017). In a similar vein, Islam et al. (2018) also point out that "rivers surrounding Dhaka and Chittagong such, as the Buriganga, Turag, Shitalakhya, and Karnaphuli rivers are highly polluted by cadmium, lead, and chromium," which make all kinds of food grown in and around Dhaka contain extremely high level of heavy metals and metalloids going much beyond the safe limits.

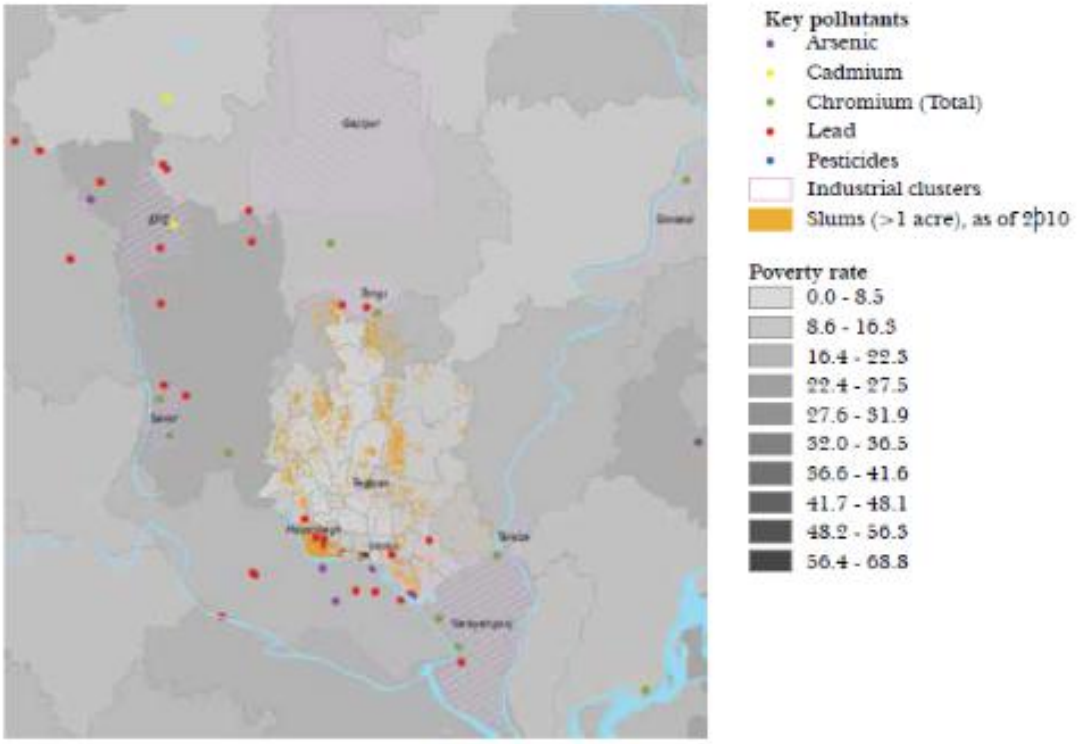


Figure 2.13 Land contamination hotspots in Dhaka.

Source: World Bank, 2018.

On the basis of a study that they conducted in Tangail district of Dhaka, Proshad et al. (2018) suggest to carry out a long-term risk assessment on the leach ability and migration potential of the the hazardous elements at the contaminated sites, and take different remediation measures (phyto-remediation or bio-remediation) to remove or reduce existing metal contamination in Dhaka, given the fact that the soils of the study area are moderately to highly contaminated by various hazardous elements (Cr, Ni, Cu, As, Cd and Pb).

2.3.5 Climate Change and Effects

"Bangkok, Dhaka, Guangzhou, Ho Chi Minh City, Kolkata, Manila, Mumbai, Shanghai, and Yangon have one thing in common. These low-lying or coastal cities are all highly vulnerable to rising sea levels, floods, and other impacts of climate change" (ADB, 2015). Climate change is often considered as; sea level rise, global warming, ocean acidification, etc when discussing the impacts of climate change. But the repercussions of global climate change in Bangladesh are not limited to these; rather, it has a complex adverse impact on the socio-economic conditions of its people. Bangladesh is one of the worst victims of global climate change (Al Mamun, 2019). As Rabbani, Rahman, & Islam (2011) warn, "immediate measures addressing climate induced vulnerabilities are necessary to the long-term sustainability of Dhaka."

Bangladesh is already experiencing the adverse effects of global warming and climate change. Summers are becoming hotter, monsoon irregular, untimely rainfall, heavy rainfall over short period causing water logging and landslides, very little rainfall in dry period, increased river flow and inundation during monsoon, increased frequency, intensity and recurrence of floods, crop damage due to flash floods and monsoon floods, crop failure due to drought, prolonged cold spell, salinity intrusion along the coast leading to scarcity of potable water and redundancy of prevailing crop practices, coastal erosion, riverbank erosion, deaths due to extreme heat and extreme cold, increasing mortality, morbidity, prevalence and outbreak of dengue, malaria, cholera and diarrhea, etc. The climate change in Bangladesh creates insecurities for food, water, life, property, settlement, livelihood assets, livelihoods and others. Climatic impacts reduce securities directly and indirectly. Environmental degradation, degradation of land resources ultimately reduces food securities, health securities etc and at the same time

increases conflicts over resources and livelihood persuasions (Department of Environment, 2009).

Among estimated impacts of the climate change on Dhaka, on the other hand, there are decrease in GDP, further increase in temperature, changes in rainfall patterns, increase in the frequency and severity of natural disasters (floods, drought, storms, heat waves, cyclones, prolonged dry season etc.), changes in water quality and quantity, loss of corps, sea-level rise, loss of property and life (land, house, cattle etc.), and displacement of millions of people.

2.4 Disaster Management

2.4.1 Seismicity

2.4.1.1 General Overview

Bangladesh has long been one of the most seismically active regions in the world, and the record of approximately 150 years shows that Bangladesh and the surrounding regions experienced seven major earthquakes since the mid-19th century (Disaster Management Bureau, 2010: 14-16). *World Risk Report 2018* also identifies Bangladesh as the ninth most natural disaster-prone country (out of 172 countries) in the world (IFHV, 2018).

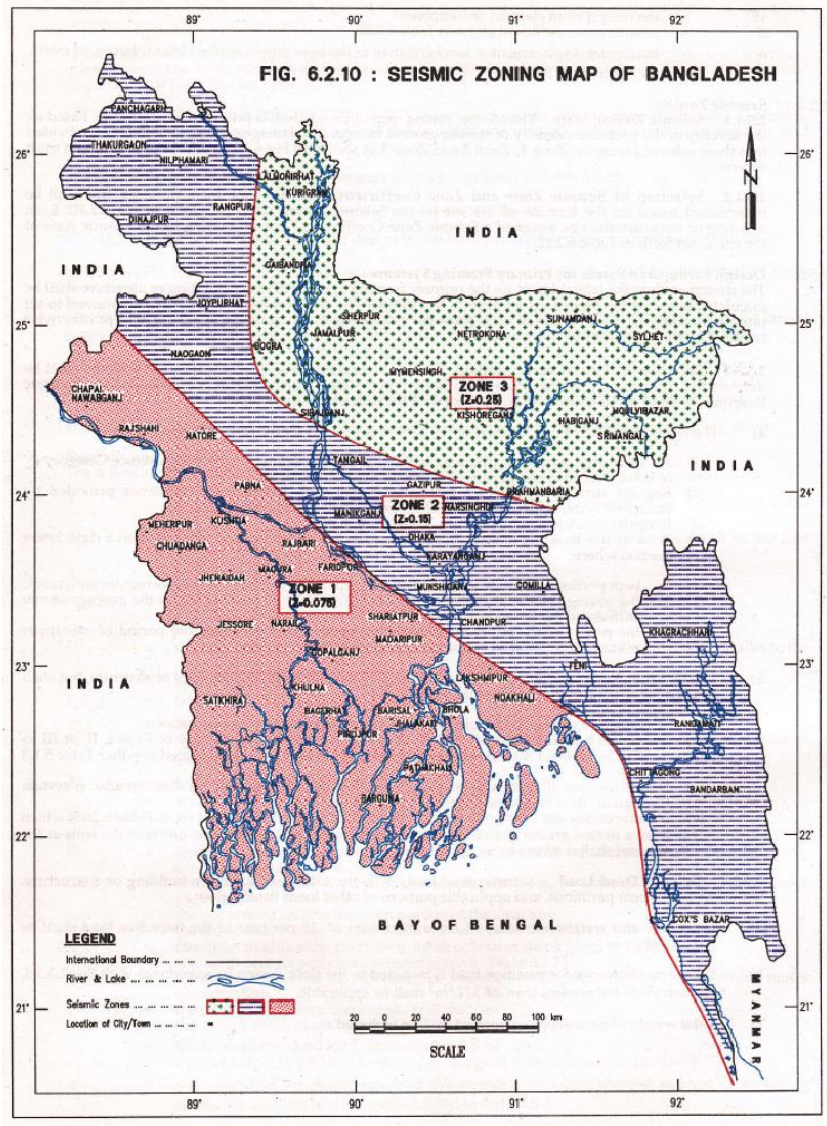
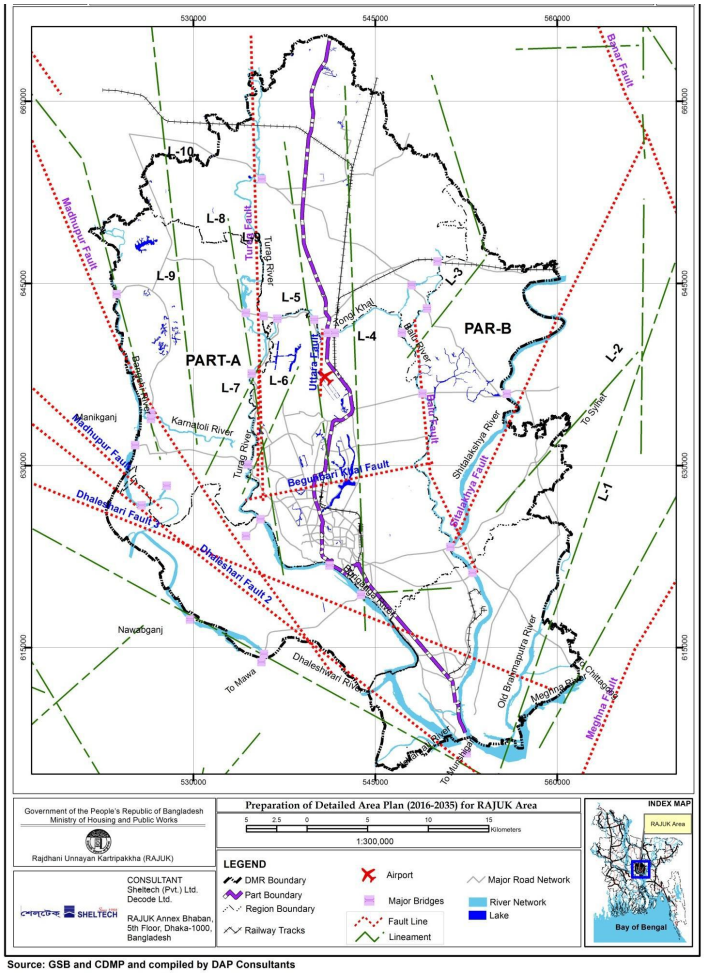


Figure 2.13 Seismic zoning map of Bangladesh
Source: Al-Hussaini, Hossain, & Al-Noman, 2012.

As can be seen in Figure 2.13 above, Dhaka city is located in the moderate risk area ("Zone 2") in the seismic zoning map of Bangladesh. As addressed in Detailed Area Plans (DAPs), Dhaka Metropolitan area is intersected by many geological faults making it particularly prone to seismic activities.



Source: GSB and CDMP and compiled by DAP Consultants

Figure 2.14 Faults and lineaments in Dhaka.
Source: RAJUK, 2018.

It has been more than a century since Dhaka was hit by a major earthquake. Yet, many scientists predict a major earthquake in the region in near future, and seismic experts suspect that if an earthquake with a magnitude 7.0 on the Richter scale occurs in large cities of Bangladesh (above all, Dhaka, where the population density is very high and millions of people live in poorly made, unsafe buildings or high-rise apartments), there would be a major human tragedy and economic disaster due to the structural failure of many buildings built in these urban centers without the use of proper construction materials and in violation of building codes. It is reported that although a set of construction codes, which include guidelines for earthquake resistant design of concrete and steel structure, has already been develop by the Bangladeshi government, these codes are not officially enforced (Islam, Islam, & Islam, 2016). Such that, by 2010, only around 38% of the buildings in the the Dhaka Metropolitan area are considered vulnerable to strong earthquakes (RAJUK, 2018).

According to EMI's (2014) prediction, expected losses from a postulated magnitude 7.5 earthquake on the Madhupur Fault running under the city are;

- US$ 5.7 billion,
- Over 200.000 injured,
- 50.000 fatalities, and
- 180.000 damaged buildings.

Moreover, a recent study also "reveals the existence of subduction zone of about 250 kilometers that can produce an earthquake of magnitude 8.2-9.0" on the Richter scale. As Al-Zaman and Monira (2017: 2-3) point out:

"After setting two dozen ground-positioning (GPS) instruments linked to satellites, capable of tracking tiny ground motions and analyzing the ten years of data the scientists have shown that eastern Bangladesh and a bit of eastern India are pushing diagonally into western Myanmar at a rapid clip -46 millimeters per year or about 1.8 inches. After combining with the existing GPS data from India and Myanmar, the measurements show that much of the resulting strain has been taken up by several known, slowly moving surface faults in Myanmar and India. But the rest of the movement-about 17 millimeters, or two-thirds of an inch per year is shortening the distance from Myanmar to Bangladesh which is inferred as a subduction process going on. This shortening of distance is building pressure and that also a few kilometers below the surface and this process is going for a long time. The most uncomfortable reason is Dhaka, one the most densely populated territories and also the capital of Bangladesh is also under the range of this zone."

2.4.1.2 Geo-technical Studies

In order to evaluate seismicity of the study area, the following methods will be applied as a part of the project:

i) Standard Penetration Test (SPT): Total 15,000 meter test will be conducted. Length of each will be at least 30 m and total 500 SPT test will be conducted. So, for Dhaka city with area approximately 1500 km^2, One (01) SPT test will be conducted for each 3 km^2.

Following test will be conducted from collected soil sample;

- Atterberg Limit Test
- Specific Gravity
- Grain Size Distribution
- Shrinkage and Swelling
- Consolidation Test
- Shear Test

- Triaxial Shear Test
- Unconfined Compressive Test

ii) Cone Penetration Test (CPT): Total 5,000 meter test will be conducted. Length of each will be at least 20 m and total 250 CPT test will be conducted. So, for Dhaka city with area approximately 1500 km^2, One (01) CPT test will be conducted for each 6 km^2.

Following test will be conducted from collected soil sample;

- Atterberg Limit Test
- Specific Gravity
- Grain Size Distribution
- Shrinkage and Swelling
- Consolidation Test
- Shear Test
- Triaxial Shear Test
- Unconfined Compressive Test

iii) *Seismic Cone Penetration Test (SCPT):* Total 400 number of test will be conducted. So, for Dhaka city with area approximately 1500 km^2, One (01) CPT test will be conducted for each 37.5 km^2.

Following data will be collected from SCPT test;

- Shear Wave Velocity

iv) *Seismic Downhole Tests:* Total 400 number of test will be conducted. So, for Dhaka city with area approximately 1500 km^2, One (01) Seismic Downhole test will be conducted for each 37.5 km^2.

Following data will be collected from Seismic Downhole test;

- Shear Wave Velocity

iv) *Measuring Shear Wave Velocity by Non-Invasive Techniques:* Total 400 number of test will be conducted. So, for Dhaka city with area approximately 1500 km^2, One (01) Seismic Non-Invasive techniques will be used for measuring shear wave velocity of soil for each 37.5 km^2.

2.4.2 Flood

2.4.2.1 General Overview

Dhaka, the capital of Bangladesh, is the most populated city in Bangladesh and the tenth largest city in the world (Gain et al., 2015). Being one of the world's fastest

growing megacities, Dhaka is projected to grow from its current population of around 14 million to nearly 25 million by 2035 (Bird and Venables, 2019). The city lies in the lower reaches of the Ganges delta (Bird and Venables, 2019) in the subtropical monsoon zone and receives approximately 2000 mm of rainfall annually, of which more than 80% occurs during the monsoon season (from June to September) (Dewan et al., 2007a; Dewan and Yamaguchi, 2009a). Topographically, the city sits on flat land, 2-13 m above mean sea level, with most of the urbanized areas at elevations of 6-8 m (Huq and Alam, 2003; Alam and Rabbani, 2007).

Flood are among the most destructive and pervasive natural disasters in Bangladesh and Dhaka city has been affected by seasonal flooding almost every year (Dewan et al., 2004) and the severity of these events is increasing gradually (Parvin and Shaw, 2011; Haque et al., 2010). Dhaka is surrounded by Buriganga River to the south, Balu River to the east, Tongi Khal (canal) to the north and Turag River to the west. The river network within the detailed area plan (DAP) is given in Figure 2.15. Turag and Balu are connected by Tongi Khal. Due to its low-lying lands and the rivers and canals surrounding them, wide areas of the city are prone to flooding (Bird and Venables, 2019; Barua et al., 2016). To the west the city is bounded by a dike but the eastern side remains largely unprotected (Bird and Venables, 2019). Historical flooding in Dhaka City before 1988 together with rivers surrounding the city are shown in Figure 2.16.

Two recent catastrophic examples are 1988 and 1998 flood that inundated 61 % (Paul, 1997) and more than 70 % (Chowdhury, 2000) of the total area of Bangladesh. 1988 flood was severe due to the lack of flood protection in the city center together with transboundary flow of major rivers (Dewan et al., 2004) while the 1998 flood was caused by heavy downpour in the upstream that was drained out through the major rivers in Bangladesh (Chowdhury, 2000). Although structural measures have been taken into consideration right after the 1988 floods, they could not help ameliorate flood induced damage during
the 1998 events (Dewan at al., 2004).

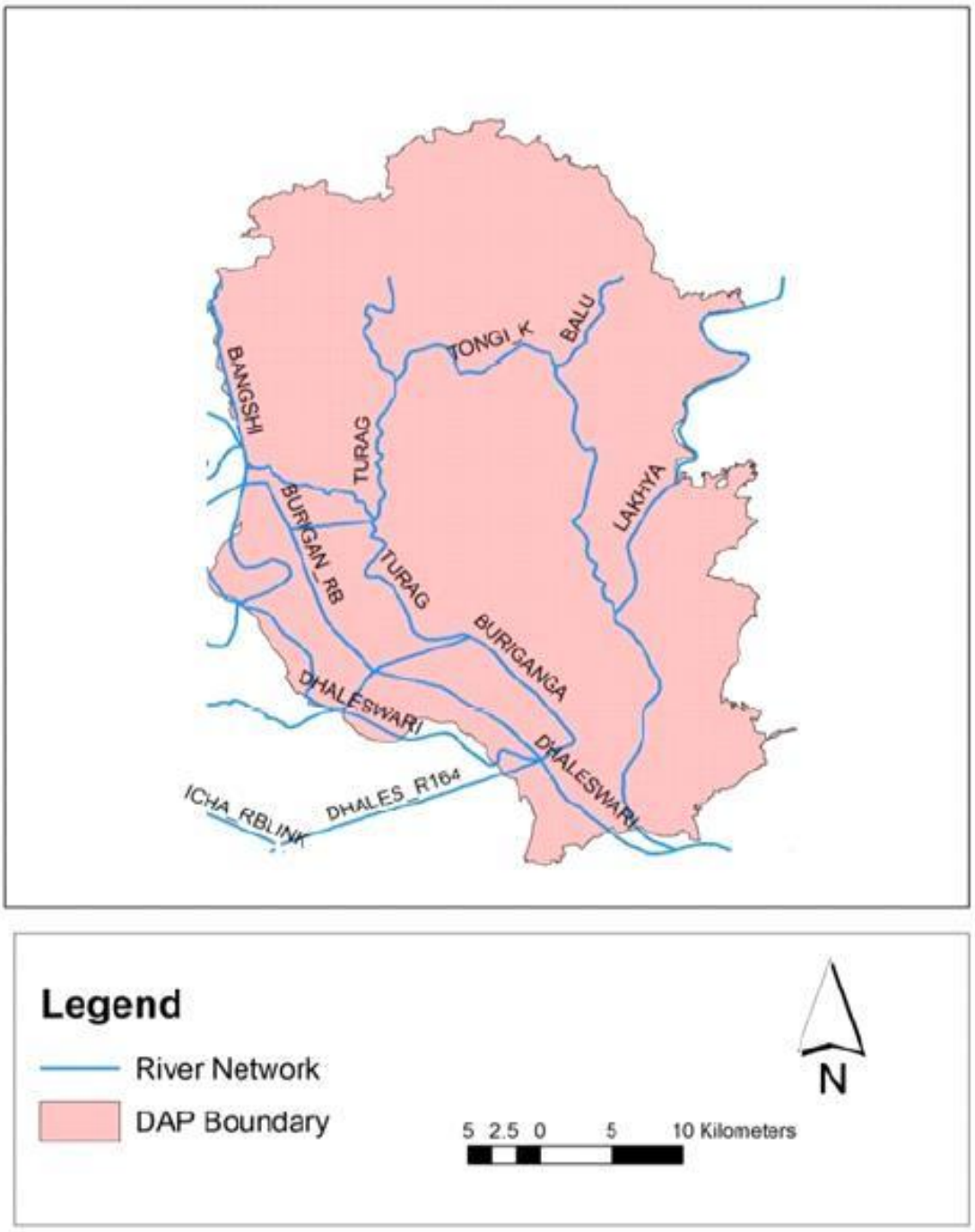


Figure 2.15 River system network of Dhaka
Source: Hossain and Chowdhury, 2019.

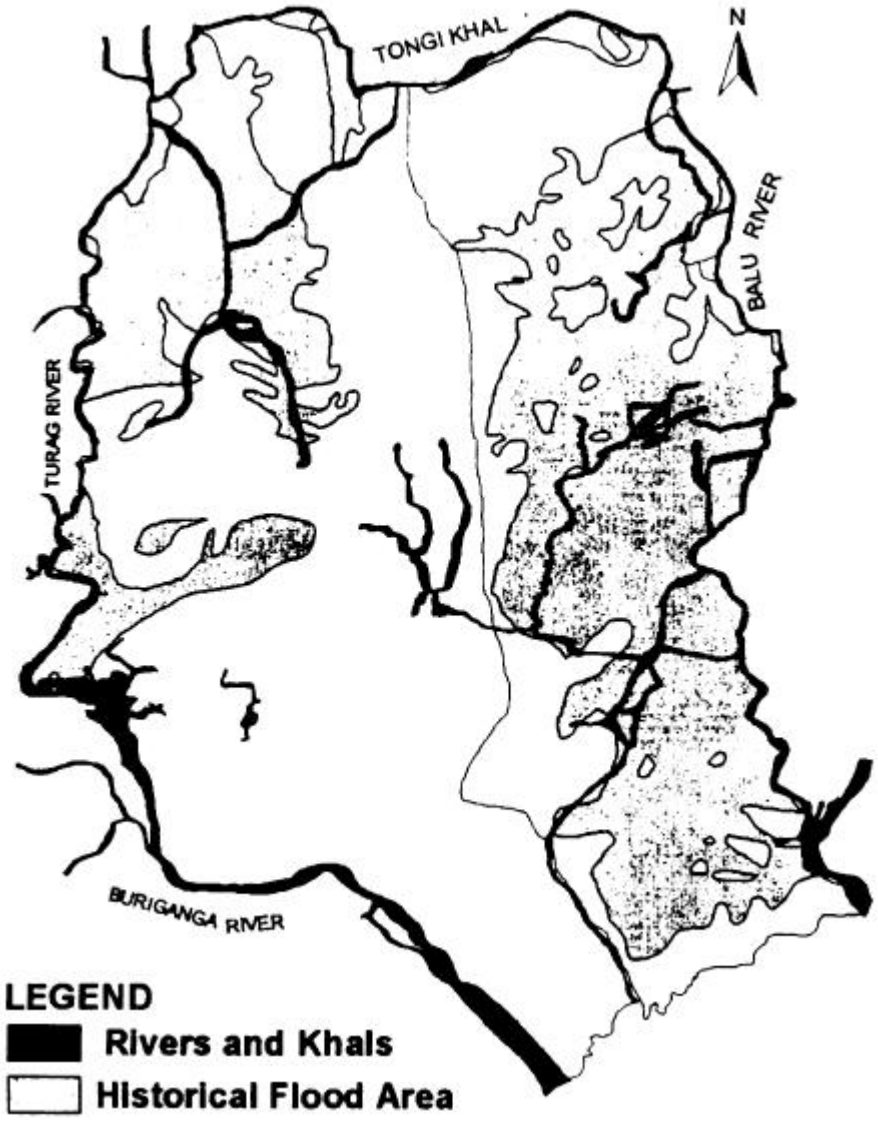


Figure 2.16 Historical flooding in Dhaka City before 1988
Source: Dewan et al., 2004.

2.4.2.2 Causes of Floods in Dhaka

Causes of floods in Dhaka City have been investigated by many researcher (Dewan et al., 2004; Alam and Rabbani, 2007; Barua et al., 2016; Khan, 2000). Major causes identified by these researchers are:

1) *Urban Development and Population Growth:* Dhaka city has been expanding rapidly since the independence of 1971. Population growth in Dhaka city is given in Table 1. Much of the city's rapid growth in population has been accommodated in informal settlements with little attempt being made to limit the risk of environmental impairments (Dewan and Yamaguchi, 2009b). Population increase results in urbanization which adversely affects retention and infiltration capacity of the land.

Traditionally, the temporary water bodies of Dhaka have acted efficiently as water retention areas, storing and draining the excess water caused by excessive rainfall and thus helped to reduce flood risk and sustain natural ecosystem (Haque et al., 2010; Mahmud et al., 2011). However, need for shelter, roads, parking spaces increased with the increase of population. The build environment is stretched towards low-lying areas, backswamps and depressions are filled and space is created for construction in Dhaka city (Barua et al., 2016). The process of land development through land filling buries large number of natural channels and wetlands disrupting natural storage characteristics of the land. Thus, as urbanization increases water draining and retaining areas such as low-lying land and wetlands decrease and impervious surfaces such as concrete and asphalt increase. This item is further explained in the following item.

Table 2.2 Population growth in Dhaka city (urban area).

Year	Population (million)	Growth Rate (%)
1955	0.4	4.02
1965	0.82	10.07
1975	2.22	10.09
1985	4.66	7.37
1995	8.33	4.71
2005	12.33	3.70
2015	17.59	3.62
2019	20.28	3.62

Source: World Population Review, 2019.

2) *Encroachment of Lowlands:* In recent times, rapid urbanization is mainly taken place in lowlands in the city which serve as retention pond during flooding season. Urban expansion of Dhaka metropolitan resulted in the considerable reduction of wetlands (Mahmud et al., 2011), cultivated land, vegetation and water bodies (Dewan and Yamaguchi, 2009b). Land cover maps of Dhaka metropolitan comparing 1960 and 2005 is given in Figure 2.17.

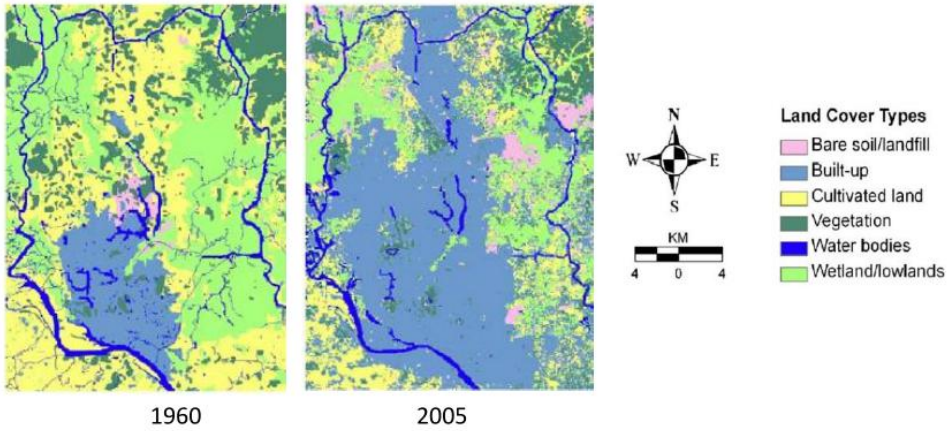


Figure 2.17 Land cover maps of Dhaka metropolitan in 1960 and 2005
Source: Dewan and Yamaguchi, 2009b.

As can be seen from Figure 2.17, between 1960 and 2005 built-up areas increased approximately 15,924 ha, while agricultural land decreased 7,614 ha, vegetation decreased 2,336 ha, wetland/lowland decreased 6,385 ha, and water bodies decreased about 864 ha (Dewan and Yamaguchi, 2009b). Comparison of vegetation, wetland and built-up area in 1989, 1999 and 2010 are given in Figure 4. Loss of rural and arable lands, water bodies and wetlands/lowlands due to urbanization aggravates negative impacts of natural disasters such as floods and hinders sustainable development. To maintain ecological balance, urban development should be limited on wetlands, vegetation, cultivated land and flood plains (Dewan and Yamaguchi, 2009b).

3) *Insufficient Drainage*: Dhaka does not have a proper and well-planned storm water drainage system, thus the city depends on a natural drainage system through wetlands, infiltration resulting in reduced runoff in addition to operation of the storm water drainage system including pumps and regulators, and water level on peripheral rivers for draining water (Khan, 2000). In the monsoon season, Dhaka city receives major rainfall that generates runoff that is beyond the capacity of its drainage system (Alam and Rabbani, 2007). Due to filling of natural channels and lowlands/wetlands, huge amount of runoff, produced by the heavy rainfall during monsoon period cannot be discharged through the existing storm water drainage system. Most parts of Dhaka metropolitan area, especially where natural drainage channels disturbed and demolished or blocked due to garbage disposal by the human interference are facing sever waterlogging and associated environmental problems during monsoon (Barua et al., 2016).

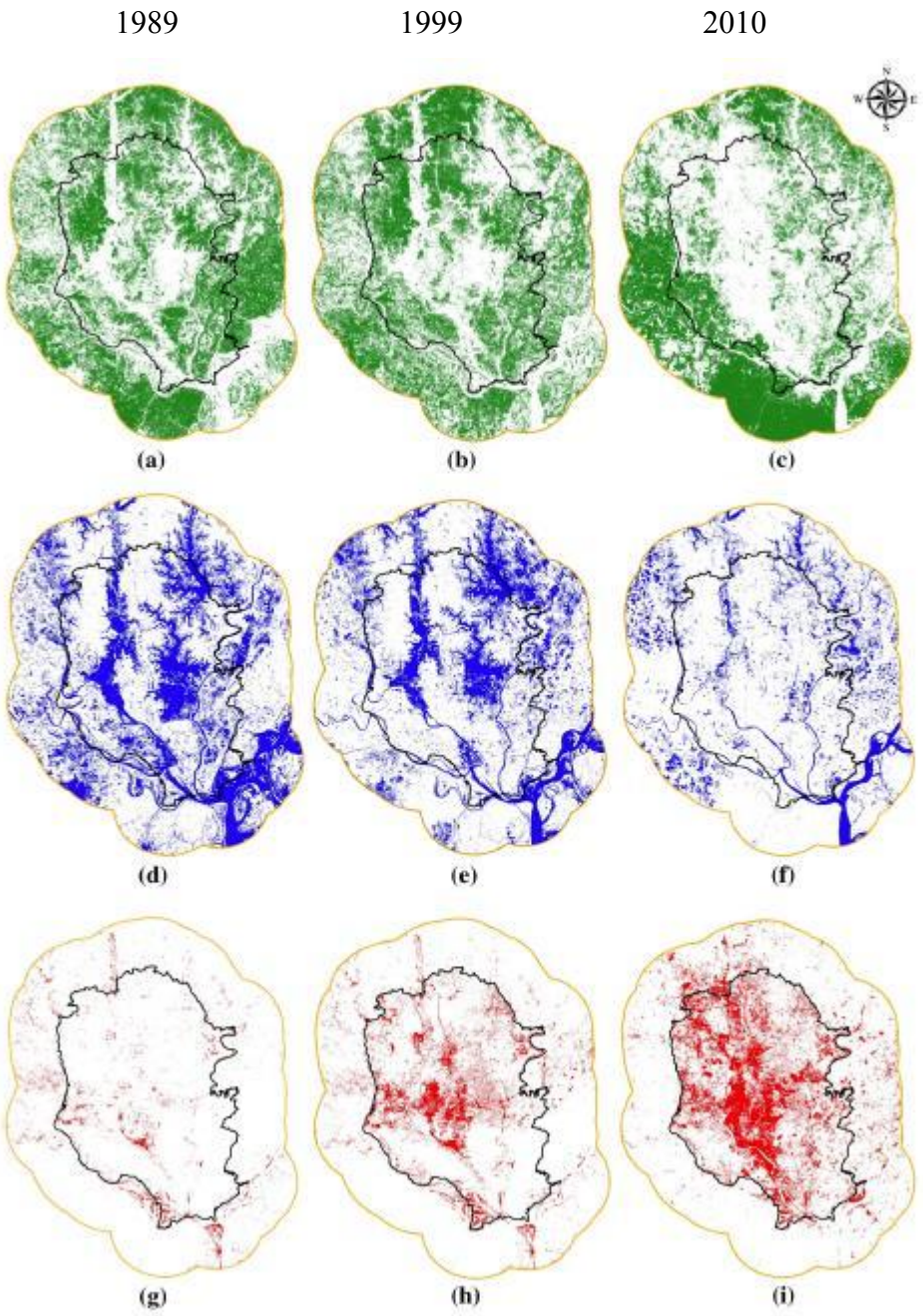


Figure 2.18 Comparison of vegetation, wetland and built-up area by time

Source: Shubho et al., 2015.

4) *Insufficient Water Retention*: The depressions, abandoned channels and low-lying areas are acting as depression storage for Dhaka metropolitan area which is retaining excess storm runoff or over flow or rivers thus delaying and lowering the flood peak and also slowing down the average speed of the flood water (Khan, 2000). Thus, natural low-lying areas act like a flood mitigation dam delaying and lowering

the peak discharge. As a result of urbanization (i.e. construction of impervious structures such as buildings, roads, parking lots, etc.) at these low-lying areas naturally occurring flood mitigation processes are hindered. This increases risk of localized flooding in previously well drained and flood free areas. Adverse effects of landfilling in the surface water system is listed by Khan (2000) as follows:

a. It is reducing the storage area for the rainfall-generated runoff, which aggravated the internal flooding in terms of frequency, duration, and depth.

b. It is disrupting the hydraulic link between major and minor channels.

c. It is affecting the groundwater regime of the city.

d. It is destructing the ecological balance of the city and its surrounding area and reducing the natural fish breading ground.

5) *Surrounding Rivers*: Dhaka city is surrounded by rivers (see Figures 2.15 and 2.16) and is faced with a major threat of both river and rain flooding. Flooding by river waters is a frequently occurring natural hazard in Dhaka and surrounding areas during monsoon season (Dewan at al., 2007b). Thus, excessive and continuous heavy rainfall is the main cause of flood in Bangladesh (Mowrin et al., 2017). In recent times four severe river floods have occurred in 1987, 1988, 1998 and 2004 (Gain et al., 2015). Generation of flood hazard and flood risk maps are critical in developing flood risk management strategies and reducing flood damage. Recently flood risk assessment studies are carried out for Dhaka (Gain and Hoque, 2013; Gain et al., 2015; Masood and Takeuchi, 2012).

2.4.2.3 Flood Management Practices in Dhaka

Dhaka flood protection works are managed and operated by three agencies BWDB, WASA and RAJUK (Rahman and Chowdhury, 2002). Many conventional flood mitigation measures like flood control reservoirs, flood diversions or flood bypasses are not feasible inside Bangladesh because of its extreme flat topography and high population density in the floodplain (Rahman and Chowdhury, 2002). The principle structural flood management measures that has been adopted in Bangladesh is construction of embankments parallel to the river banks (Rahman and Chowdhury, 2002). One of the first flood protection embankments was the Buckland Bund constructed on the eastern bank of the Buriganga River in 1880s (Barua et al., 2016). Western embankments and flood walls at Dhaka were also constructed in accordance with the Flood Action Plan (FAC) of 1989 (Barua et al., 2016) and during 1998 flood,

most of the western part of Dhaka City was saved from inundation by the embankment (Rahman and Chowdhury, 2002). Various flood management practices suggested in different plans for Dhaka is summarized by Barua et al. (2016) as shown in Table 2.3 and an embankment is shown in Figure 2.19.

Table 2.3 Key issues on flood management in various plans for Dhaka

Year	Plans of Dhaka	Key Issues Regarding Flood Management	Implementation Status
1864	Construction of Buckland Bund	Protecting the city from flooding of the Buriganga and mitigating flood damage within the city	Construction was completed by 1880.
1917	Dacca Town Planning Report 1917	Emphasized the preservation of water bodies	The plan was never accepted by the government.
1959	Dacca Master Plan 1959	Acknowledged flooding as a major problem, but did not consider the role of water bodies, including rivers and canals, in flood management	The plan was accepted by the government and partially implemented.
		Envisioned that the wetlands and flood plains of the city will be developed as housing estates in the future	
1981	Dhaka Metropolitan Area Integrated Urban Development Project (DMAIUDP)	Long-term development strategy for the future of Dhaka city, with flood protection as the main focus	The plan was not accepted by the government.
1989	Flood Action Plan (FAP)	Construction of embankment and flood wall along the rivers surrounding Dhaka	Western embankments and flood walls were constructed.
		Improvement of canals within the cities	21 canals were rehabilitated.
		Construction of a pumping station along the embankments	Three permanent pump houses were constructed.
		Acquiring land for retention pond	The government failed to acquire the required amount of land for a retention pond.
1989	Water Drainage Improvement Plan	Preservation and improvement of the canal network	This was partially implemented as part of the development of a Storm Water Drainage System.
1995–2015	DMDP (1995–2015)	Identified Main Flood Flow and Subflood Flow Zones of the rivers surrounding Dhaka	In DAP, the "subflood flow zone" proposed in the Structure Plan was merged with the "Main Flood Flow Zone," as well as the "urban residential zone."
		Proposed protection and preservation of retention ponds on western embankment of the city	In the name of DAP review, the government is approving a project in the designated flood flow and subflood flow zone.

Source: Barua et al., 2016.

Figure 2.19 An embankment in the western part of Dhaka

2.5 Biodiversity

"Within a relatively small geographic boundary, Bangladesh enjoys a diverse array of ecosystems. Being a lowlying deltaic country, seasonal variation in water availability is the major factor, which generates different ecological scenarios of Bangladesh. Temperature, rainfall, physiographic variations in soil and different hydrological conditions play vital roles in the country's diverse ecosystems. 2 The ecosystems of Bangladesh could be categorized into two major groups, i.e. (i) land based and (ii) aquatic. The land-based ecosystems include forest and hill ecosystems, agro-ecosystems and homestead ecosystems; while seasonal and perennial wetlands, rivers, lakes, coastal mangroves, coastal mudflats and chars, and marine ecosystems fall into the aquatic category. Each of the ecosystems has many sub-units with distinct characteristics as well. IUCN Bangladesh in 2002 classified the country into twenty five bio-ecological zones (Figure 2.20), some of which are constituted of one or more than one type of ecosystems mentioned above" (Ministry of Environment and Forests DOE, 2010).

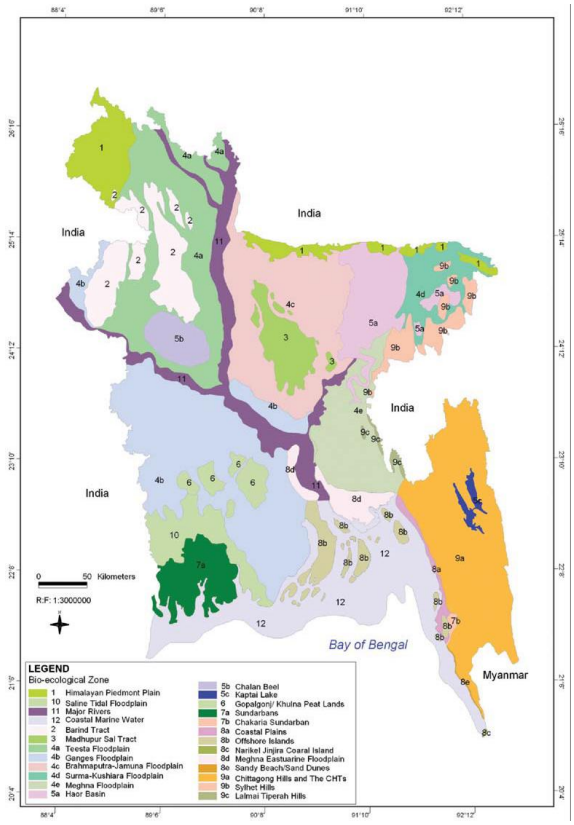


Figure 2.20 Bio-ecological zones of Bangladesh.
Source: Ministry of Environment and Forests DOE, 2010.

2.5.1 Wetlands of Bangladesh

"According to Ramsar Convention, wetlands are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters. Bangladesh is a land of water and wetlands (Figure 2.21). Wetlands constitute more than fifty percent territory of the total country and play significant role in social and economic livelihood of the population" (Ministry of Environment and Forests DOE, 2010).

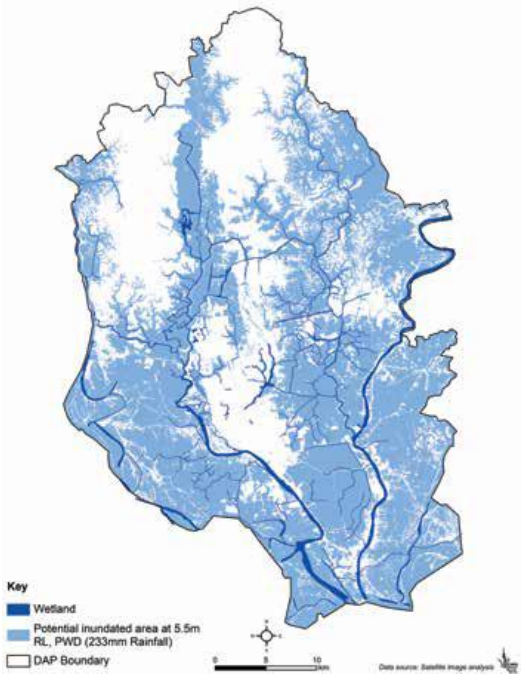


Figure 2.21 Potential inundated area under 233 mm rainfall.
Source: World Bank, 2018.

"Wetlands can be of different types based on their hydrological and ecological attributes (Table 2.4). The wetlands in Bangladesh encompass a wide variety of ecosystems including: the main rivers (Ganges, Brahmaputra and Meghna) and their 700-plus tributaries and distributaries; some 6,300 beels (permanent and seasonal shallow lakes in floodplain depressions); at least 47 major haors (deeply flooded depressions in the north-east), baors (oxbow lakes); vast areas of seasonally flooded land; the extensive mudflats and coastal chars of the estuaries of the rivers; mangrove forests; intertidal zones along the eastern coast; reservoirs; and fish ponds and tanks. They occupy about half the land area of the country in the monsoon season" (Ministry of Environment and Forests DOE, 2010).

Types of Wetlands	Area in Hectares
Open water wetlands	
Rivers	749,700
Estuarine and mangrove forest	610,200
Beels and haors	114,200
Inundable floodplains	548,6600
Kaptai lake	68,800
Closed water wetlands	
Ponds	146,900
Baors (oxbow lake)	5,500
Brackish water farms	108,000
Total	7.289,900

Table 2.4 Wetlands areas by types
Source: Ministry of Environment and Forests DOE, 2010

"There is no recent assessment of wetland area in Bangladesh. However, National Water Resources Database (NWRD) has estimated about 172,087 hectares of permanent wetlands (excluding rivers and estuary) in the country. The database also revealed that 21% of the country is deeply flooded (more than 90 cm) and 35% experiences shallow inundation during monsoon. National Water Management Plan (NWMP) has divided the country into eight hydrological zones based on their characteristics. Hydrological zone wise areas of permanent wetlands are provided in Table 2.5. In Figure 2.22, a map is presented to show the spatial distribution location of permanent wetlands of the country" (Ministry of Environment and Forests DOE, 2010).

Hydrological Regions	Area in 1997 (ha)
South -East	1,255
South-Central	2,604
South-West	18,400
North-West	27,016
North-Central	15,940
North -East	53,180
Eastern-Hills	53,692
Total	172,087

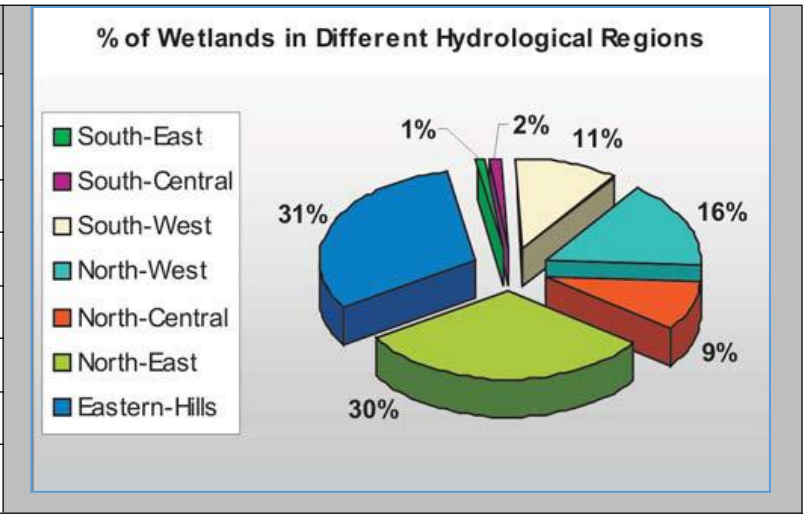


Table 2.5 Wetland areas in different hydrological regions
Source: Ministry of Environment and Forests DOE, 2010

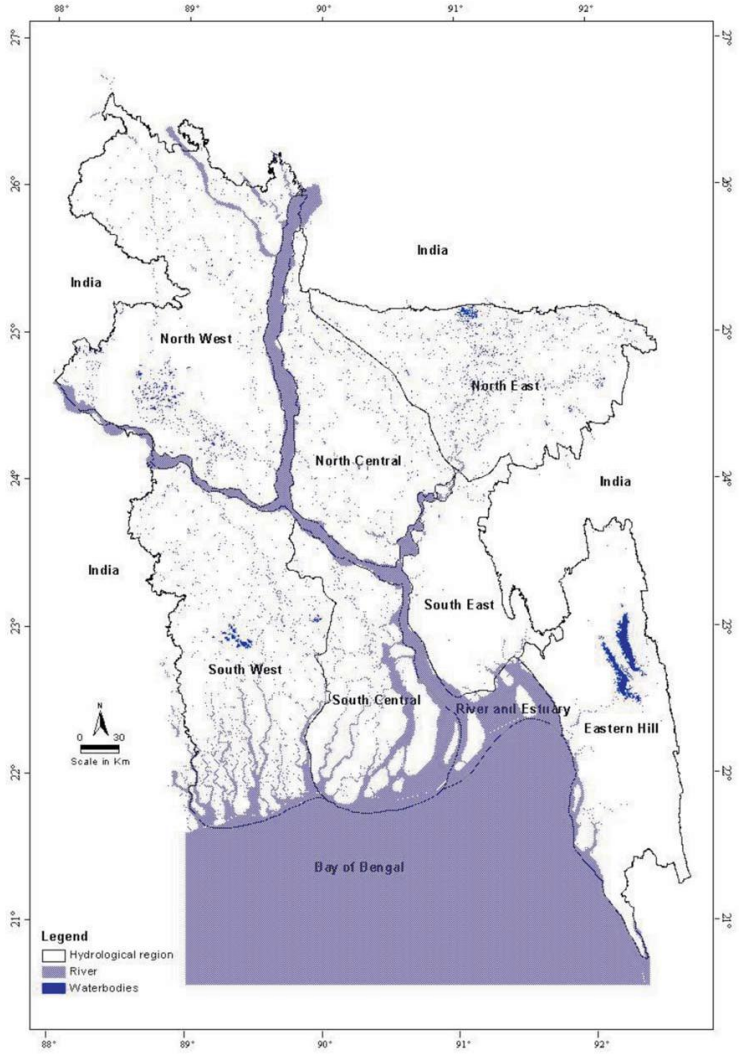


Figure 2.22 Spatial distribution and location of permanent wetlands of Bangladesh with hydrological boundaries overlaid.
Source: Ministry of Environment and Forests DOE, 2010

2.5.2 Biodiversity in Wetlands of Bangladesh

"Wetlands of Bangladesh are particularly rich in biodiversity, the number of aquatic macrophytes reaches more than 200 species. Moreover, approximately 150 species of birds are found to be fully or partially wetland dependent. For wetland dependent mammal, reptile and amphibian species, more than 80 species in 37 families are thought to have existed in the country. A total of 251 species of freshwater fishes and many more estuarine fish species also inhabit these wetland habitats. This ecosystem hosts the greatest diversity (41 species) of globally threatened species of any ecosystem, in the faunal groups considered. The Haor Basin of Sylhet and eastern Mymensingh has special biological significance. This area is recognized as wetland ecosystem of international importance, especially for waterfowl habitats. These wetlands provide habitat for about 125 species of resident and migratory water birds as well as a diversity of aquatic and terrestrial plants, aquatic invertebrates, fish, mammals, amphibians and reptiles. In the winter several of the haors support internationally important concentrations of waterbirds including 100,000-200,000 ducks, and provide refuge for many other species rarely found elsewhere in the country. Not only the haors but also the main river system provide vital habitat for a diverse fauna of freshwater turtles, the majority of which are now globally threatened" (Ministry of Environment and Forests DOE, 2010).

2.5.3 Flora and Fauna of Dhaka City

Dhaka City has been increasingly urbanized, and the forest areas in the city have been shrinking. Today, only northern part of the city (i.e., Gazipur district) still has natural forests where varieties of biodiversities are relatively protected. The Bhawal National Park is located 10 km to the north of the Gazipur urban district and is easily accessible throughout the year by road. It has been kept under International Union for Conservation of Nature (IUCN) management category as a protected landscape. This national park covers an area of 5,000ha. The forest area is actually honeycombed with habitations and rice fields. The dominant forest trees -Shaal, Shorea, Robusta- of the national park have been almost completely removed, but now protection programs have planted Shaal which covers 90% of the area. The wildlife at Bhawal National Park was well known for its peacocks, tiger, leopard (black panther also) elephant, clouded leopard, sambar deer, etc. However, the overall situation is that these wild

lives have disappeared and few mammals (squirrel, mongoose, jackal, civet, jungle cat, etc.), few reptiles (monitor lizard, snakes) and some indigenous birds remain (JICA, 2017; LGED, 2010).

2.5.3.1 Flora of Dhaka City

The vegetation of Dhaka City has a variety of indigenous and exotic species especially in parks and gardens. Approximately 310 hectares in Dhaka Metropolitan Area (DMA) accommodate parks and gardens. It is estimated that there are nearly 41-46 parks/gardens in Dhaka city such as Osmani Uddyan, Bahadur Shah Park, Botanical Garden, Zia Uddyan, Baldha Garden, Suhrawardi Uddyan, and Ramna Park. Of these, Baldha garden, Botanical Garden has a wide variety of plants and trees (World Bank, 2017). The Botanical Garden in Mirpur, on the other hand, covers an area of 85 ha and consists 255 plant species (total 28,200 plants), 310 shrub species (8,400 plants), and 385 herb species (10,400 plants). The total number of families of trees, herbs and shrubs is 114. Baldha garden covers 1.15 ha with 18,000 trees, herbs and shrubs from 820 species and 92 families.

Table 2.6 Area of vegetation coverage of DMA in square kilometers.

Thana Names	1989		1999		2009	
	Dense	Sparse	Dense	Sparse	Dense	Sparse
Uttara	2.40	4.50	1.24	2.90	0.96	1.16
Pallabi	2.10	3.65	0.40	0.59	0.20	0.60
Cantonment	5.26	4.70	3.01	4.45	1.00	1.82
Mirpur	2.16	2.86	0.64	0.93	0.35	0.51
Kafrul	3.30	4.32	1.10	1.30	0.78	0.82
Gulshan	1.90	2.42	0.20	0.49	0.004	0.03
Badda	1.06	2.6	0.98	1.57	0.6	1.03
Mohammadpur	1.00	0.84	0.02	0.05	0.001	0.004
Tejgaon	1.66	2.10	0.30	0.66	0.23	0.45
Khilgaon	0.60	0.90	0.40	0.80	0.31	0.69
Dhanmondi	0.78	1.13	0.12	0.37	0.09	0.15
Hazaribug	0.20	0.61	0.02	0.06	0.0012	0.0028
Ramna	2.15	0.90	1.10	0.46	0.84	0.18
Motijheel	0.80	0.78	0.08	0.09	0.02	0.03
Sabujbug	1.20	1.73	0.40	0.60	0.25	0.36
Lalbug	0.93	1.10	0.65	0.98	0.24	0.45
Kotwali	0.002	0.038	0.004	0.004	0.00001	0.0002
Sutrapur	0.3	0.56	0.002	0.001	0.0012	0.0008
Demra	3.60	7.34	2.40	3.50	1.00	1.03
Shyampur	3.40	2.28	1.10	0.72	0.67	0.33
Kamrangichar	0.67	1.41	0.0021	0.0279	0.00003	0.00007
Total	84.07		35.952		17.1894	

Source: Al Jabar, Ghosh, & Mahmud, 2014.

Yet, urban development and industrialization has some significant negative effects on the vegetation of the city. As a study conducted by Al Jaber, Ghosh, and Mahmud (2014) clearly indicates, only between 1989 and 2009, almost 70 sq km of vegetation has been lost in Dhaka Metropolitan Area, which is arguably a shocking change.

2.5.3.2 Fauna of Dhaka

- **Mammals:** In Dhaka, the Madhupur area had been a habitat for many animals particularly elephants, tigers, leopards, boars, deer and buffaloes till the beginning of the nineteenth century. Monkeys had also been found in abundance till the mid-nineteenth century. Foxes, jackals, squirrels and otters have almost disappeared. Bats and rats are still seen sometimes within the city area. Some monkeys and mongoose were seen in old Dhaka even in the early 1960s but their number has decreased considerably. They are almost out of sight nowadays (World Bank, 2017; JICA, 2011).
- **Birds:** A large number of bird species were common in Dhaka, particularly pigeons, doves, kingfishers, parrots, jungle fowl, common pea-fowl, kite, fishing eagle, vulture etc. But many of these are now extinct and the rest are rapidly disappearing. One good point is that a large number of migratory birds are found in Dhaka (especially in the lake of the National Zoo) in winter. Various species including ducks, seagull, falcons, harriers, plovers, curlews and sandpipers are seen there during winter (World Bank, 2017).
- **Reptiles:** The depletion of reptilian fauna in the country is noteworthy. Reptiles are environment friendly as they eat many agricultural pests, and help control their numbers. However, turtles, tortoises, snakes, lizards, and crocodiles are exploited economically because of a tradition of making useful commodities from their body parts, e.g., bones, skins, etc. Therefore, most of them are in high demand by traders in these items who usually over-exploit these animals (Rahman et al., 2002).
- **Amphibian:** In Bangladesh, 22 species of Amphibians have been recorded. Some of these are economically important and thus are being exploited commercially. Until the early eighties many traders in the country were exporting frog legs in large quantities. Most of the frogs were collected from the wild, and exported as a frozen

food item. This practice also causes insect and predator populations to be affected (Rahman et. al., 2002).

- **Fish:** The biodiversity of fish species has been reduced severely due to pollution of surface water. The land ecosystem is also threatened with rapid and unplanned urbanization. Fishes are still reasonably available in the area, especially in the two major rivers. The fish include catfish (magura and shing), major carps (katla, rui, and mrigal), minor carps (puti), other (Tengra, Boal, Mola, Shol). Also prawn, particularly the popular small prawns, locally known as Ichha are abundant. Small fishes are available, particularly during early monsoon and pre-winter season (World Bank, 2017).
- **Crustaceans:** Shrimp and prawn farming is an age-old practice in brackish, saltwater and fresh water of the coastal areas of Khulna, Satkhira, Bagherhat and Cox's Bazar Districts of Bangladesh. The main cultivated species are *Penaeus monodon* (Tiger shrimp) and *Macrobrachium rosenbergii* (Giant freshwater prawn). Other farmed shrimps are *Metapenaeus monoceros* (Brown shrimp), *P. indicus* (Indian white shrimp), *P. semisulcatus* (Green tiger shrimp) and *P. merguinensis* (Banana shrimp). Total aquaculture shrimp production increased from 14,773 tons in 1986 to 1,28,313 tons in 2014. Area under shrimp farming has increased from a mere 52,000 hain 1983 to a massive 276,495 ha in 2014. The country earned about $ 535 million in 2013-14 through the export of 47,635 ton frozen shrimp to the overseas. The earning was $ 568 million in 2014-15. The contribution of farmed shrimp to total shrimp production and export has been increasing over the last 15 years at a rate of about 20% per year. Bangladesh supports a wide range of crustaceans, including shrimps, prawns, crab, lobsters, zooplanktons, etc. For updating the crustacean red list, a total of 141 crustaceans were enlisted including prawn, shrimp, crab, lobster, king crab, zooplankton, barnacles, etc., (IUCN, 2015b).
- **Butterflies:** It is estimated that there are 305 species of butterflies belonging to 10 families in Bangladesh (IUCN, 2015c).

Bengal Tiger (*Panthera tigris ssp. tigris*)

The Sundarbans mangrove forest lies on the delta of the Ganges, Brahmaputra and Meghna rivers on the Bay of Bengal, and it is one of the largest of its kind in the world. This World Heritage-listed natural treasure is home to many endangered species including the famous Bengal tiger, which represents the largest remaining population of wild tigers (~67%) in the world despite also being listed as "Endangered" (EN) on the IUCN Red List (UNESCO, 2019; Chundawat, Khan, & Mallon, 2011). According to WWF (2019) data, there are approximately 2,500 Bengal tigers remain in their native habitat of India, Bangladesh, Nepal, Bhutan, China and Myanmar today. Yet, only a small proportion of these live in Bangladesh. The latest "Tiger Status Report" by Bangladesh Forest Department (2015) reveals that the remaining population of Bengal tigers in the Sundarbans is only between 83 and 130 (midpoint=106).

Figure 2.23 Bengal tiger.
Photo credit: Rakesh Narula

The long-term conservation of Bengal tigers in the Sundarbans has long been included in the agenda of various local and international institutions. In addition to the efforts by the Bangladesh government, international organizations such as WWF and IUCN have also been putting so much effort and allocating a lot of resources into protection of Bengal tigers and restoration of their habitats, for a long time (Khan, 2004: 32-36). In 2009, Bangladesh Forest Department (2009) published "Bangladesh Tiger Action Plan, 2009-2017", and set the goals of increasing or stabilizing the Sundarbans tiger population; maintaining sufficient prey base to support the Sundarbans tiger population; maintaining sufficient habitat to support the Sundarbans tiger and prey populations; and assessing the viability of tiger populations in the Chittagong Hill Tracts.

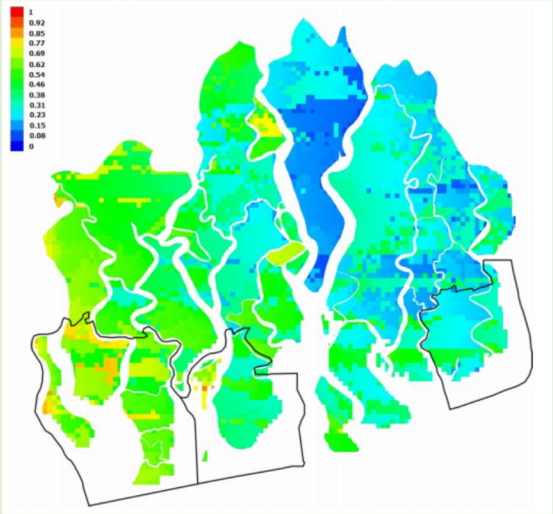


Figure 2.24 Projected current distribution of Bengal tiger in the Sundarbans (Colors closer to the red indicate a high probability of Bengal tiger presence in the area)
Source: Mukul et al., 2019.

However, a recent study by Mukul et al. (2019) shows that -despite all these protection efforts- there will probably be no suitable Bengal tiger habitat remaining in the Sundarbans by 2070 due to combined destructive effects of the constant sea-level rise and the climate change. Since both climate change and sea-level rise are unavoidable processes in many respects, the authors suggest the Bangladesh government that it "should prioritize tiger conservation by designating more areas for tiger conservation, creating corridors for trans-boundary tiger movements, continues with strict monitoring and law enforcement to control illegal human activity in the area, avoid unplanned development in the vicinity, and raise public awareness to control human-tiger conflicts in the area" (Mukul et al., 2019: 838).

Bengal Tiger Habitat Loss In Bangladesh Sundarbans					
Scenario		2050		2070	
		Percentage Area Loss (%)	Area Loss (Sq Km)	Percentage Area Loss (%)	Area Loss (Sq Km)
1 (RCP 6.0)	Only climate change	49.7	2,401.50	99.4	4,803.10
	Only Sea Level Rise	5.42	261.9	28.5	1,377.10
	Climate change and Sea Level Rise	54.2	2,618.90	100	4,832
2(RCP 8.5)	Only climate change	96.2	4,648.40	100	4,832
	Only Sea Level Rise	11	546	48.9	2,362.80
	Climate change and Sea Level Rise	97	4682	100	4,832

Table 2.7 Bengal tiger habitat loss in the Bangladesh Sundarbans under two different climate scenarios (RCP 6.0 and RCP 8.5)
Source: Sanghera, 2019.

In addition to negative impacts of environmental degradation and climate change, illegal tiger and prey poaching activities usually conducted by local forest users, professional poachers and jungle pirates also threaten the presence of Bengal tigers in the Sundarbans. In order to advance the struggle against poachers, the Bangladesh government implements community mobilization strategies (i.e. launching a hotline for receiving information on poaching) as well as innovative patrol monitoring techniques in recent years ("Wildlife poaching…", 2013; Uddin, 2019).

Box 2.2 Bengal Tiger

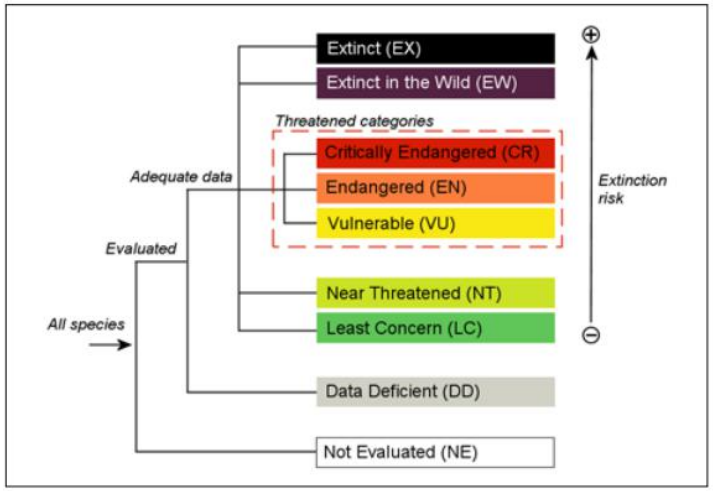


Figure 2.25 Structure of the IUCN categories.
Source: IUCN, 2012: 5.

Table 2.8 Critically Endangered (CE), Endangered (EN) and Vulnerable (VU) animal species (species belong to "Threatened Categories") in Dhaka City and surrounding areas according to IUCN Red List (2015, 2019-1).

RE-Regionally Extinct, **CR**-Critically Endangered, **EN**-Endangered, **VU**-Vulnerable, **LC**-Least Concern, **NT**-Near Threatened, **DD**-Data Deficient, **NE**-Not Evaluated								
No	**Order**	**Family**	**Scientific Name**	**English Name**	**Local Name**	**Status in Bangladesh**	**Global status**	**Species ID**
Mammals								
1	Primates	Cercopithecidae	*Macaca mulatta*	Rhesus Macaque	Banor, Bandor	VU	LC	MA0053
2	Primates	Cercopithecidae	*Macaca leonina*	Pig-tailed Macaque	Ultaleji banor, Chhotoleji banor, Kolu banor	EN	VU	MA0054
3	Primates	Cercopithecidae	*Trachypithecus pileatus*	Capped Langur, Capped Leaf	Mukhpora Hanuman, Lalchey Hanuman	EN	VU	MA0057

				Monkey, Capped Monkey				
4	Primates	Hylobatidae	*Hoolock hoolock*	Hoolock Gibbon, Western Hoolock Gibbon	Ulluk, Holou Bandar, Bonmanush, Hulu, Huru	CR	EN	MA0002
5	Primates	Lorisidae	*Nycticebus bengalensis*	Slow Loris, Bengal Slow Loris, Bengal Loris, Northern Slow Loris	Lojjaboti Banor, Lajuk Banor	EN	VU	MA0050
6	Lagomorpha	Leporidae	*Lepus nigricollis*	Indian Hare, Rufou-tailed Hare, Blacknapped Hare	Shashak, Khorgosh	EN	LC	MA0117
7	Pholidota	Manidae	*Manis crassicaudata*	Indian Pangolin, Scaly Anteater, Thick-tailed Pangolin	Banrui, Pipilikavuk, Piprabhuk, Keot-machh, Katpohu	CR	EN	MA0090
8	Carnivora	Mustelidae	*Aonyx cinerea*	Oriental Small-clawed Otter, Asian Small-clawed Otter, Small-clawed Otter	Dhaira Uud, Uud Biral, Bhodar	EN	VU	MA0071
9	Carnivora	Mustelidae	*Lutrogale perspicillata*	Smooth-coated Otter, Indian Smooth-coated Otter	Ud, Ud Biral, Bhodar	CR	VU	MA0074
10	Carnivora	Ursidae	*Helarctos malayanus*	Sun Bear, Malayan Sun Bear	Choto Bhalluk, Shurjo Bhalluk	CR (2015) Reclassified as extinct (EX) in Dhaka and surroundings by 2016	VU	MA0076

11	Cetartiodactyla	Cervidae	*Rusa unicolor*	Sambar, Sambar Deer	Sambar, Sambar Horin	CR	VU	MA0085
Birds								
12	Galliformes	Phasianidae	*Francolinus francolinus*	Black Francolin	Kala Titir	EN	LC	BI0001
13	Anseriformes	Anatidae	*Aythya baeri*	Baer's Pochard	Bearer Bhutihansh	CR	CR	BI0028
14	Ciconiformes	Ciconidae	*Leptoptilos javanicus*	Lesser Adjutant	Cchoto Madantaak	VU	VU	BI0293
15	Pelecaniformes	Threskiornithidae	*Platalea leucorodia*	Eurasian Spoonbill	Eurasio Chamochthuti	CR	LC	BI0286
16	Pelecaniformes	Threskiornithidae	*Threskiornis melanocephalus*	Black-headed Ibis	Kalamatha Kasteychora	VU	NT	BI0285
17	Accipitriformes	Accipitridae	*Clanga (Aquila) hastata*	Indian Spotted Eagle	Deshi Guti-eegol	EN	VU	BI0248
18	Accipitriformes	Accipitridae	*Clanga (Aquila) clanga*	Greater Spotted Eagle	Boro Guti-eegol	VU	VU	BI0247
19	Accipitriformes	Accipitridae	*Aquila heliaca*	Eastern Imperial Eagle	Eshio Shahi-eegol	VU	VU	BI0249
20	Accipitriformes	Accipitridae	*Haliaeetus leucoryphus*	Pallas's Fish-eagle	Palasi Kura-eegol	EN	VU	BI0227
21	Coraciformes	Alcedinidae	*Ceyx erithaca*	Oriental Dwarf Kingfisher	Udoyee Bamonranga	EN	LC	BI0067
22	Passeriformes	Sylvidae	*Chaetornis striata*	Bristled Grassbird	Shatadagi Ghashpakhi	EN	VU	BI0454
Reptiles								
23	Testudines	Geoemydidae	*Batagur baska*	Batagur, Common Batagur, Four-toed Terrapin, River Terrapin, Mangrove	Baro Kaitta	CR	CR	RE0002

				Terrapin, Asian River Terrapin				
24	Testudines	Cheloniidae	*Chelonia mydas*	Green Sea Turtle, Green Turtle, Black (sea) Turtle, Pacific Green Turtle	Sabuj Shamudrik Kachhim, Samudrik Kasim, Baro Kassop or Kasim	CR	EN	RE0009
25	Testudines	Cheloniidae	*Eretmochelys imbricata*	Hawksbill Turtle, Hawksbill Sea Turtle	Samudrik Kachhim, Bajthuti Samudrik Kachhim	CR	CR	RE0023
26	Testudines	Cheloniidae	*Lepidochelys olivacea*	Olive Ridley Sea Turtle, Pacific Ridley Sea Turtle	Jolpaironga Samudrik Kasim, Samudrik Kachchap, Dojjey Dur	VU	VU	RE0024
27	Testudines	Dermochelyidae	*Dermochelys coriacea*	Leatherback Sea Turtle	Samudrik Kachhim, Baro Kachhim, Chamra Kachhim	CR	VU	RE0025
28	Squamata	Varanidae	*Varanus salvator*	Ring Lizard, Water Monitor, Common Water Monitor, Asian Water Monitor, Twobanded Monitor, Rice Lizard, Plain Lizard, No-Mark Lizard	Kalogui, Ramgodi	VU	LC	RE0067
29	Squamata	Pythonidae	*Python bivittatus*	Burmese Python, Rock Python, Indian Rock Python	Ajogor, Burmese Ajogor	VU	VU	RE0173
30	Squamata	Colubridae	*Oligodon cinereus*	Black-barred Kukri Snake	Kalo-ber Kukri Shap, Kalo-daghi Udoy Kal	EN	LC	RE0085
31	Crocodylia	Crocodylidae	*Crocodylus porosus*	Salt-water Crocodile,	Lona-panir Kumir Crocodylia	EN	LC	RE0169

				Estuarine Crocodile				
Amphibians								
32	Anura	Microhylidae	*Kaloula taprobanica*	Sri Lankan Painted Frog, Sri Lankan Bullfrog	Chittrito Venpu Bang, Balun Bang, Rangin Venpu Bang	VU	LC	AM0038
33	Anura	Microhylidae	*Uperodon globulosus*	Baloon Frog, Indian Globular Frog, Indian Balloon Frog, Grey Balloon Frog, Greater Balloon Frog	Baloon Bang, Photka Bang, Phola Bang	VU	LC	AM0036
Freshwater Fishes								
34	Anguilliformes	Anguillidae	*Anguilla bengalensis*	Indian Mottled Eel, Giant Molted Eel, Mottled Eel	Bamosh, Banehara, Bao Baim, Boa Baim, Telkoma	VU	NT	FI0046
35	Cypriniformes	Cyprinidae	*Megarasbora elanga*	Bengala Barb	Elong, Sephatia, Elanga	EN	LC	FI0069
36	Cypriniformes	Cyprinidae	*Labeo ariza*	Ariza Labeo	Lasso, Raik, Bata	VU	LC	FI0084
37	Cypriniformes	Cyprinidae	*Oreichthys cosuatis*	Cosuatis Barb	Kosuati punti, Kosua punti, Titkinda, Tit punti	EN	NE	FI0096
38	Cypriniformes	Cobitidae	*Lepidocephalichthys irrorata*	Loktak Loach	Puiya	VU	LC	FI0134
39	Osteoglossiformes	Notopteridae	*Notopterus notopterus*	Grey Featherback, Freshwater Knife Fish	Foli, Haila, Kanla	VU	LC	FI0045
40	Perciformes	Channidae	*Channa marulius*	Giant Snakehead, Great Snakehead	Gajar, Gajal, Gajori	EN	LC	FI0005
41	Siluriformes	Bagridae	*Sperata aor*	Long-whiskered Catfish	Air, Ayre, Bhangat, Talla Ayre	VU	LC	FI0149

42	Siluriformes	Siluridae	*Ompok bimaculatus*	Butter Catfish, Two Spot Glass Catfish	Kani Pabda, Boali Pabda	EN	NT	FI0151
43	Siluriformes	Siluridae	*Ompok pabo*	Pabo Catfish	Pabda, Kala Pabda	CR	NT	FI0153
44	Siluriformes	Siluridae	*Wallago attu*	Freshwater shark	Boal, Boali,, Patari, Boyari, Boayair, Keyali	VU	NT	FI0154
45	Synbranchiformes	Synbranchidae	*Ophisternon bengalense*	Bengal eel; Pygmy eel	Bamosh	VU	LC	FI0197
46	Syngnathiformes	Syngnathidae	*Microphis deocata*	Deocata Pipefish	Kumirer Khil	VU	NT	FI0195
Crustaceans								
47	Decapoda	Palinuridae	*Panulirus versicolor*	Painted Spiny Lobster	Nil Kanta Lobster, Chhua Icha	EN	LC	CR0075

Source: Adopted and compiled from IUCN, 2015a, & IUCN, 2019. Each species classified as Critically Endangered (CE), Endangered (EN) or Vulnerable (VU) in Bangladesh by IUCN in 2015 has been compared with the relevant habitat map on IUCN Portal (last update: 2019-1) to determine if the species is still present in the area of interest (i.e., Dhaka City and surrounding areas). Only the species present in and around Dhaka by 2019 according to IUCN are included in this list. Species without distribution maps available from the IUCN database ('unmapped species') have simply been neglected in this study.
A more detailed list will be provided in interim and final reports.

Table 2.9 List of the known plant species in Dhaka.

RE-Regionally Extinct, **CR**-Critically Endangered, **EN**-Endangered, **VU**-Vulnerable, **LC**-Least Concern, **NT**-Near Threatened, **DD**-Data Deficient, **NE**-Not Evaluated

No	Herbarium Code	Family	Scientific Name	IUCN Global Status (as of 2019-1)
1	DACB	Cannaceae	*Canna indica*	Unknown

2	DACB	Pontederiaceae	*Eichhornia crassipes*	Unknown
3	DACB	Pontederiaceae	*Monochoria hastata*	LC
4	DACB	Pontederiaceae	*Monochoria vaginalis*	LC
5	DACB	Magnoliaceae	*Michelia champaca*	LC
6	DACB	Annonaceae	*Artabotrys odoratissimus*	Unknown
7	DACB	Annonaceae	*Artabotrys uncinatus*	Unknown
8	DACB	Annonaceae	*Chnanga odorata*	Unknown
9	DACB	Annonaceae	*Annona muricata*	LC
10	DACB	Annonaceae	*Anona reticulata*	Unknown
11	DACB	Annonaceae	*Milusa tomentoza*	Unknown
12	DACB	Annonaceae	*Miliusa velutina*	Unknown
13	DACB	Annonaceae	*Polyalthia longifolia*	Unknown
14	DACB	Annonaceae	*Polyalthia simiarum*	Unknown
15	DACB	Annonaceae	*Polyalthia suberosa*	Unknown
16	DACB	Lauraceae	*Cinnamomum camphora*	Unknown
17	DACB	Lauraceae	*Cinnamomum tamal*	Unknown
18	DACB	Lauraceae	*Cinnamomum verum*	Unknown

19	DACB	Lauraceae	*Cinnamoum zeylanicum*	Unknown
20	DACB	Lauraceae	*Dehaasia kurzii*	Unknown
21	DACB	Lauraceae	*Litsea angustifolia*	Unknown
22	DACB	Lauraceae	*Litsaea chinensis*	Unknown
23	DACB	Lauraceae	*Litsea salicifolia*	Unknown
24	DACB	Lauraceae	*Litsea sabifera*	Unknown
25	DACB	Piperaceae	*Piper longum*	Unknown
26	DACB	Piperaceae	*Peperomia pellucida*	Unknown
27	DACB	Lauraceae	*Litsea sp.*	LC
28	DACB	Aristolochiaceae	*Aristolochia elegans*	Unknown
29	DACB	Aristolochiaceae	*Aristolochia indica*	Unknown
30	DACB	Nymphaeaceae	*Nelumbo nucifera*	DD
31	DACB	Nymphaeaceae	*Euryale ferox*	LC
32	DACB	Nymphaeaceae	*Nuphar luteum*	Unknown
33	DACB	Nymphaeaceae	*Nymphaea amazonum*	Unknown
34	DACB	Nymphaeaceae	*Nymphaea capensis*	LC
35	DACB	Nymphaeaceae	*Nymphaea nduchali*	Unknown
36	DACB	Nymphaeaceae	*Nymphaea nouchali*	LC

37	DACB	Nymphaeaceae	*Victoria amazonica*	Unknown
38	DACB	Nymphaeaceae	*Nymphaea stellata*	EN
39	DACB	Ceratophyllaceae	*Ceratophyllum demersum*	LC
40	DACB	Cabombaceae	*Cabomba sp.*	Unknown
41	DACB	Ranunculaceae	*Delphinum ajacis*	Unknown
42	DACB	Ranunculaceae	*Delphinium consolida*	Unknown
43	DACB	Ranunculaceae	*Delphinium sp.*	Unknown
44	DACB	Ranunculaceae	*Nigella sativaL.*	Unknown
45	DACB	Ranunculaceae	*Ranunculus scleratus*	Unknown
46	DACB	Menispermaceae	*Cissampelos pareira*	Unknown
47	DACB	Menispermaceae	*Cocculus villosus*	Unknown
48	DACB	Menispermaceae	*Cocculus hirsutus*	Unknown
49	DACB	Menispermaceae	*Stephania hernandifolia*	Unknown
50	DACB	Menispermaceae	*Stephania japonica*	Unknown

Source: Adopted and compiled from BNH, 2018, & IUCN, 2019. Each plant species located in Dhaka according to BNH (2018) has been compared with the relevant entry on IUCN database (2019-1)
A more detailed list will be provided in interim and final reports.

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III REVIEW AND ASSESSMENT OF 2007 SEA REPORT

3.1 Population Growth

There is a brief summary about population growth in 2007 SEA Report. Yet, the topic is not discussed in relation to estimated population growth in the future, population density, squatting trend in Dhaka, health and nutrition related problems of the slum residents, population trends in Dhaka compared to the other South Asian cities, and so on in details.

We think that this brief explanation is by no means sufficient. Today, population growth and high population density in the city are the source of many other problems, such as the poverty, water pollution, infant mortality, increase in crime rate, epidemics, slum-oriented socio-economic problems and environmental degradation, as well. Therefore, in 2019 Report, a special emphasis will be given to these topics, which have been mainly neglected in the previous SEA report.

3.2 Child Health and Nutrition Related Problems of the Slum Residents

In 2007 SEA report briefly touches upon various diseases prevalent among Dhaka's slum residents. In 2019 Report, importance of health and nutrition related problems that the slum residents face as well as the causes of these problems will be thoroughly explained. Although 2007 Report does not mention extremely high fertility rate, which is arguably one of the most important problems of Dhaka today, 2019 Report will also provide a comparative analysis in this sense.

3.3 Land Use

2007 SEA Report successively explains inadequacy of the planning efforts to manage urban land use and its consequences in Dhaka City. This topic will also be explained more broadly in 2019 Report. Disaster risk management strategies implemented by the Government of Bangladesh, evolution of urban planning and development in Dhaka, categories of land use in the city, and land use composition in different districts of Dhaka and its surroundings will all be touched upon.

3.4 Air Management

2007 SEA Report broadly discusses the high levels of $PM_{2.5}$ and PM_{10} in Dhaka. 2019 Report will follow the footsteps of the previous report in this sense. In 2007

Report, traffic congestion, transportation methods (usage of diesel vehicle, 3-wheelers, CNG taxis etc.), industrialization, poor solid waste management and brick kiln factories operating in the city are identified as the main sources of air pollution in the city. Our preliminary research shows that, in this respect, not so many things have changed in Dhaka during the previous decade. Thus, all these factors will be further elaborated to demonstrate the current situation of air pollution in Dhaka in our study.

2019 SEA Report will also provide some basic explanations about the main components, advantages and disadvantages of the Air Quality Management Project (AQMP) by following a more reader-friendly approach.

3.5 Water Resources and Quality

The topic of water resources and quality seems to be well explained in 2007 SEA Report. The issues analyzed in 2007 Report such as the problems related to water supply, growing demand for potable water, depletion of water resources, poor sewage treatment, and ground and surface water pollution in the city still persist (and became even more severe in recent years). Therefore, our research team will mainly try to update this section in the light of the most recent data.

3.6 Solid Waste Management

2007 SEA Report provides sufficient information about waste generation practices in Dhaka, landfill sites in the city, responsibilities of the city corporation in terms of waste management etc. It also emphasizes some important problems (poor bio-medical and industrial waste management, inefficiency in waste collection...) that the city faces in this sense. In terms of waste management, 2019 SEA Report aims at providing an even more detailed analysis.

3.7 Impacts of Climate Change on Dhaka

In 2007 SEA Report, impacts of climate change on Dhaka and the main reasons of climate change are explained in details. Given the fact that threats stemming from the climate change and sea-level rise have become much more sophisticated and persistent in recent years, 2019 Report will focus more on this topic.

3.8 Flooding and Drainage

2007 SEA Report successfully explains the reasons behind severe floods that

frequently take place in Dhaka City. 2019 Report will provide a more up-to-date analysis on the basis of a fieldwork research in this sense.

Table 3.1 A comparison between 2007 and 2009 SEA Reports.

2007 SEA REPORT	2019 SEA REPORT
Slums and Population in Dhaka	
-Increasing squatting trend in Dhaka (1998-2005) -Where the slums concentrate -Public health in slums -Poverty and monthly income level in shanty towns -Health facilities, drinking water, sewage pipelines -Disease profile in slums of Dhaka	-Population growth between 1981-2019 - Estimated population growth by 2035 and 2050 -Global population density ranking -Future of squatting trend in Dhaka -Policies made and implemented to solve the problem -Health and malnutrition related problems that children often face in shanty towns
Flood and Drainage	
-Severe river floods in Dhaka -Causes of severe floods in between 1954 and 1998 -Disadvantages of earth filling in some districts	-Location of Dhaka City and amount of annual rainfall -Topography of the land -Historical flooding in Dhaka City -Details about two recent catastrophic floods -Conditions of built-up areas and agricultural land -Disadvantages of unplanned urbanization
Air Pollution	
-Short summary on the location of brick kilns and their relation to air pollution	-Location of brick kilns in Dhaka -Brick production in the economy of Bangladesh -Concentration and composition of emissions from brick kilns in Dhaka City -The most efficient and environment-friendly options for brick production -Health effects of brick kilns on humans
Roads & Transportation	
-High number of diesel vehicles in Dhaka -Poor transport infrastructure planning	-Different models for transportation -Traffic problems in Dhaka -The number of registered vehicles in Bangladesh and Dhaka in 2018
Solid Waste	
-A brief summary about landfill sites in Dhaka	-Daily solid waste production in Dhaka -Growth rate of population and waste between 2005-2025 -Problems in waste management -Different sectors and amount of their generated wastes in Dhaka -Waste generation in Dhaka

	-The problems related to dumping - Allocated budget for waste management in Dhaka
Industry	
-The most polluting industries	-Interrelationship between economic growth, industrialization and pollution
Water Source and Water Pollution	
-Source of water supply of the city -Daily demand for potable water	-Present and future of water supply and demand -Rivers around the city -DWASA and activities -Protection of water bodies in Dhaka -Reasons of water pollution in Dhaka -Effects of water pollution
Disaster Management	
	-Tectonic structure of Bangladesh -History of the seismic activities in Bangladesh and Dhaka -The purpose of Earthquake and Emergency Preparedness (DEEP) project -Effective ways in flood management in Dhaka -History of floods in Dhaka
Climate change in Dhaka	
-Location of Dhaka in a dynamic and deltaic system -Vulnerability of Dhaka to climate change a -Adverse effects of climate change	-Location of Dhaka city -Climate change effects in near future in the region: loss of land and livelihood/ increase in flooding potential/ backflow from the larger rivers - unplanned filling up of drainage channels, wetlands, low lying areas and climate change
Biodiversity	
	-IUCN Red List of Threatened Species -Ecosystem diversity in Bangladesh -Types of wetlands in Dhaka - Biodiversity of wetlands in Bangladesh -Wetland ecosystem of Bangladesh -Wetland degradation and causes
Cumulative Impact Assessment	
-Cumulative Impact Assessment has not been undertaken.	-Cumulative impact assessment will be examined in details in interim and final reports.

IV STAKEHOLDER ANALYSIS

A stakeholder is a party that has an interest in or is affected by (i.e, has a 'stake' in) a project. Stakeholder Analysis (SA), on the other hand, is the methodology utilized to identify and classify possible stakeholders in a project in order to increase practicability and effectiveness of the intended policy recommendations by incorporating the needs and interests of all relevant parties.

After conducting an extensive stakeholder analysis, our team of researchers has identified the following parties as the potential stakeholders to cooperate or consult with during the preparation of our project.

4.1 Public Institutions and Government Bodies

Ever since the 16th century, development of administrative structure in Bangladesh has been heavily influenced by the legacy of the former dominators of the country, namely, the Mughals, colonial British, and Pakistani. Although many administrative reform attempts have taken place since military rule was overthrown and Bangladesh switched back to parliamentary democracy in 1991, some scholars and experts continue to argue that especially the colonial British imprint is still visible in the political and administrative arrangement of the country (Panday, 2019).

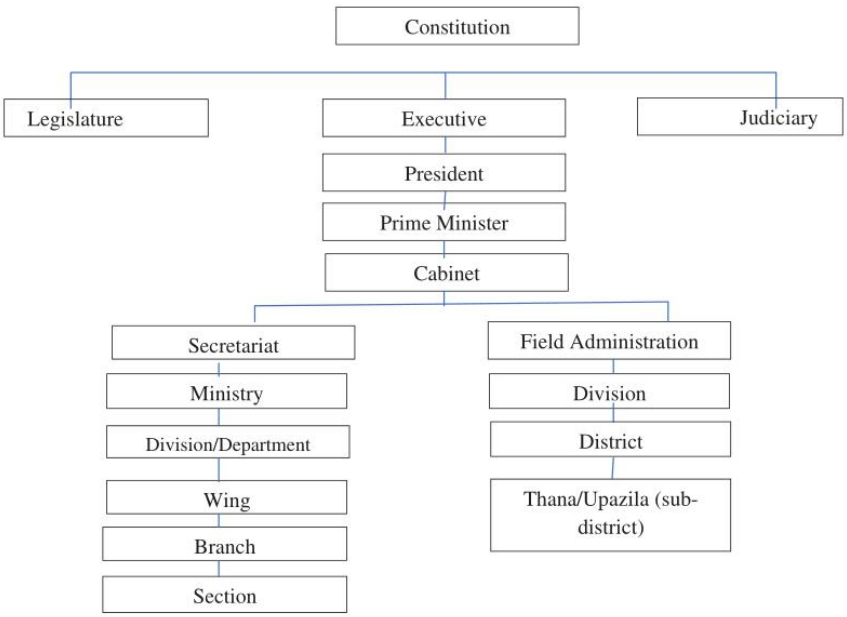

Figure 4.1 General administrative structure in Bangladesh
Source: Panday, 2019: 218.

As clearly stated in the Constitution of the People's Republic of Bangladesh (1972), all executive actions of the government of Bangladesh are taken by the cabinet having the Prime Minister at its head, and in the name of the President. The cabinet exercises all its executive powers through an extensive administrative mechanism. Today, the government of Bangladesh has a two-tier administrative system. The central secretariat at the national level consisting of the ministries and divisions to provide policies and to perform clearinghouse functions constitutes the "upper tier." 'Line' departments/directorates attached to the ministries and divisions that are mainly responsible for general administration, service delivery to citizens and implementation, on the other hand, constitute the "lower tier." Each ministry is hierarchically organized: While the minister is the political head of a ministry, secretary (or an additional secretary in the absence of a secretary) functions as the administrative/executive head who is in charge of conducting and looking after the duties of a division, which includes routine operation, supervision of its staffing and organizational processes (Jahan, 2006: 3-4; Panday, 2019: 216-217).

There are a number of public authorities responsible for implementation and monitoring of environmental protection measures in Bangladesh. In order to fulfill the objectives set for the SEA study of Dhaka URP-Component B, a close cooperation and information exchange between the research team and these authorities are required. Therefore, the following public institutions and government bodies have been identified as public stakeholders by our research team. The position of each stakeholder in the administrative hierarchy has also been shown in the relevant figure.

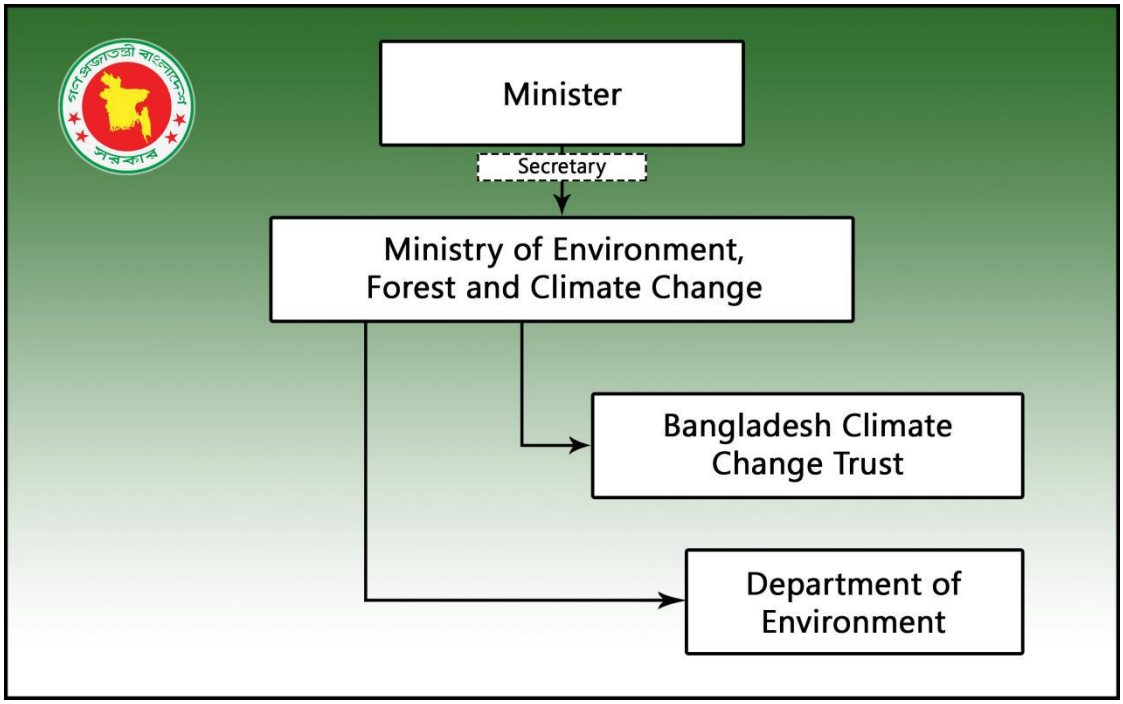

Figure 4.2 Possible stakeholders operating under the MoEF of Bangladesh
Source: Adopted and compiled from Bangladesh National Portal, 2019.

- **Ministry of Environment, Forests and Climate Change (MoEF):** A ministry of the government of the People's Republic of Bangladesh whose role is ensuring sustainable environment and forest through conservation of ecosystem and biodiversity, controlling environmental pollution, addressing climate change, protecting/developing forest resources and conducting relevant researches to ensure sustainable environment and optimum forest coverage (MoEF, 2019).
- **Bangladesh Climate Change Trust (BCCT):** A government trust operating under the MOEF designed to enhance the national capacity to cope with the risks induced by climate change in Bangladesh (BCCT, 2014).
- **Department of Environment (DoE):** A government department operating under the MOEF founded in 1977 under the name of Environment Pollution Control Board as a follow up action to Stockholm Conference on Human Environment in 1972, and renamed to Department of Environment after being restructured in 1989. The department is responsible for the protection of environment from deforestation, deteriorating water quality, natural disasters, land degradation, salinity, unplanned urbanization, discharge of untreated sewage and industrial wastes, and so on in Bangladesh (DoE, 2019).

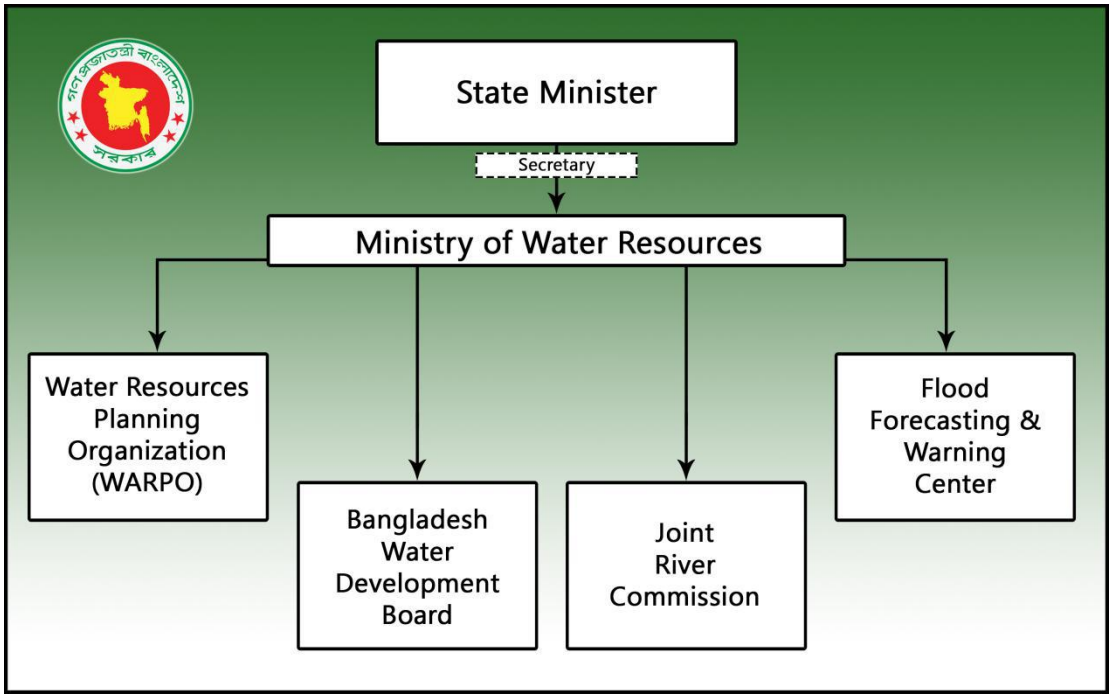

Figure 4.3 Possible stakeholders operating under the MoWR of Bangladesh
Source: Adopted and compiled from Bangladesh National Portal, 2019.

- **Ministry of Water Resources (MoWR):** A ministry of the government of the People's Republic of Bangladesh which is responsible for development and management of the whole water resources of the country. It formulates policies, plans, strategies, guidelines, instructions and acts, rules, regulations, etc. relating to the development and management of water resources, and regulation and control of the institutions reporting to it. It prepares and implements development projects relating to flood control and drainage; flood control, drainage and irrigation; riverbank erosion control; delta development and land reclamation; etc. and provides irrigation, drainage, flood protection, bank erosion protection, land reclamation facilities by constructing barrages, regulators, sluices, canals, cross-dams, embankments and sea-dykes along the banks of the rivers and the coast, etc. (MoWR, 2019).
- **Water Resources Planning Organization (WARPO):** A nationwide organization operating to achieve sustainable water resources development in Bangladesh by pursuing Integrated Water Resources Management (IWRM). WARPO functions as the central coordinating body for all relevant activities in the water sector in Bangladesh (WARPO, 2019).
- **Bangladesh Water Development Board (BWDB)**: An agency of the government of the People's Republic of Bangladesh, which is responsible for

developing and managing water resources projects; managing and mitigating river bank erosion; and developing a state of knowledge and capability that will enable the country to design future water resources management plans by itself with economic efficiency, gender equity, social justice and environmental awareness to facilitate achievement of water management objectives through broad public participation (BWDB, 2019).

- **Joint River Commission (JRC):** A bilateral working group established by Bangladeshi and Indian authorities in 1972, which is in charge of equitable sharing and joint management of trans-boundary water resources for sustainable water security (JRC, 2019).
- **Flood Forecasting and Warning Center (FFWC)**: A government agency in Bangladesh, which generates and provides flood forecast and warning information to enhance the disaster management capacity of national agencies and communities using the best scientific principles, real time data, weather forecast information and mathematical models (FFWC, 2019).

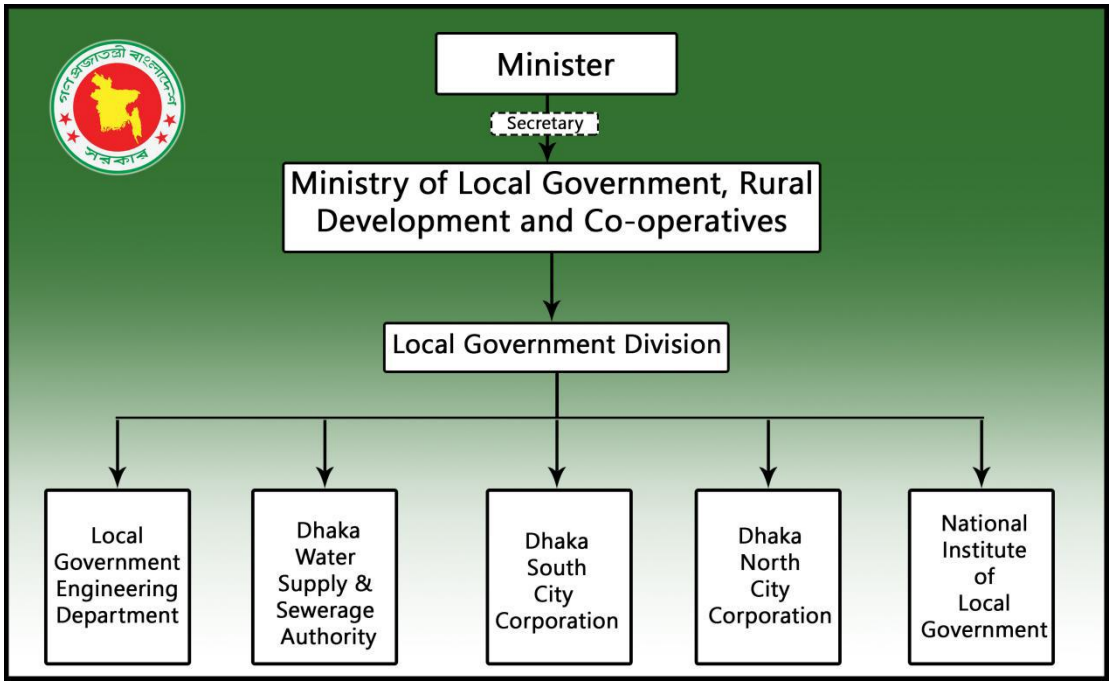

Figure 4.4 Possible stakeholders operating under the MoLGRDC of Bangladesh
Source: Adopted and compiled from Bangladesh National Portal, 2019.

- **Ministry of Local Government, Rural Development and Co-operatives (MoLGRDC):** A ministry of the government of the People's Republic of Bangladesh which is responsible for managing all matters relating to local government and local

government institutions in order to improve the living standards of the people (MoLGRDC, 2019).

- **Local Government Engineering Department (LGED):** An agency of the government, which is responsible for planning and implementation of rural, urban and small-scale infrastructure development programs, as well as providing technical assistance to the local government institutions in Bangladesh (LGED, 2019).
- **Dhaka Water Supply and Sewerage Authority (DWASA):** Originally founded in 1963, DWASA is the main unit administering water supply, drainage and sanitation system in Dhaka (DWASA, 2019).
- **National Institute of Local Government (NILG):** A government training and research institute in Bangladesh responsible mainly for training of elected and appointed local government functionaries and government officials linked with local government bodies (NILG, 2015).

Figure 4.5 Areas under authority of DNCC and DSCC.
Source: Iqbal, & Asikunnaby, 2015.

- **Dhaka North and South City Corporations (DNCC & DSCC):** Two municipal corporations having responsibility of running the municipal affairs of Dhaka City created after Dhaka City Corporation (DCC) was divided into two in 2011 (see, Figure 4.5) (Iqbal, & Asikunnaby, 2015).

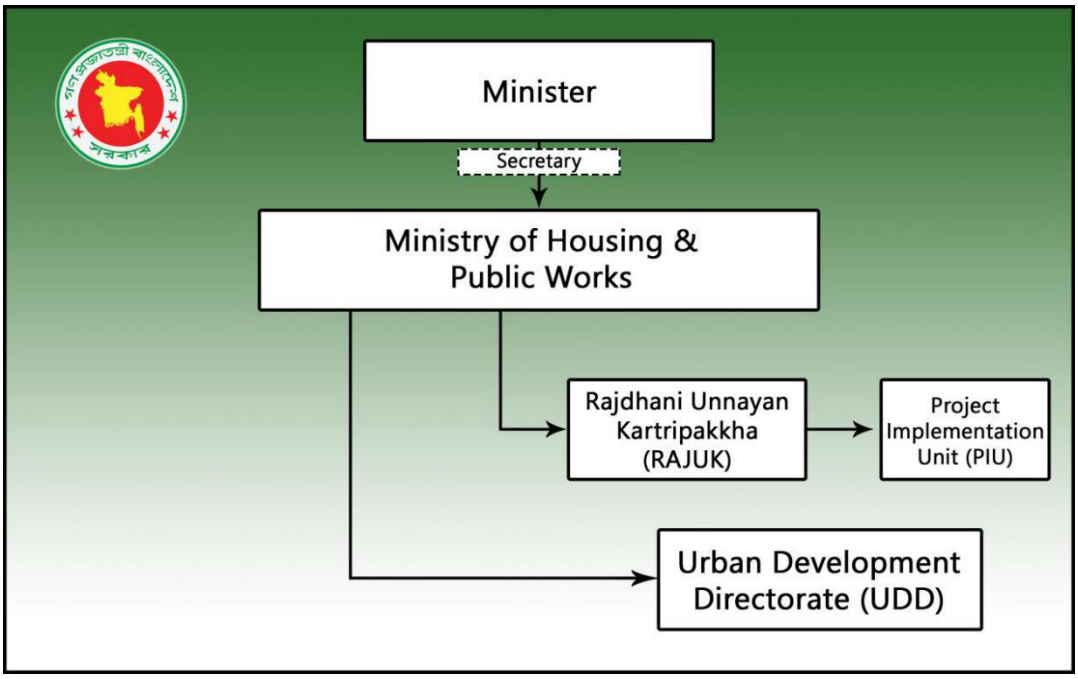

Figure 4.6 Possible stakeholders operating under the MoHPB of Bangladesh
Source: Adopted and compiled from Bangladesh National Portal, 2019.

- **Ministry of Housing and Public Works (MoHPB):** A ministry of the government of the People's Republic of Bangladesh whose role is planning and undertaking of activities to solve housing problem of the country (MoF, 2018: 357).
- **Urban Development Directorate (UDD):** A directorate working under the MoHPB created to contribute in developing Master Plan/Land Use Plan for small, medium and large town and cities of Bangladesh. (GeoDASH, 2019).
- **Rajdhani Unnayan Kartripakkha (RAJUK):** The Capital Development Authority of Bangladesh, which is responsible for developing, improving, extending and managing Dhaka City and the peripheral areas through a process of proper development planning and development control. RAJUK is trying to make Dhaka a planned, liveable and environment friendly city through solving housing and transportation problems, and creation of large-scale water based public spaces (RAJUK, 2019).

4.2 Universities and Higher Education Institutions

Universities of a nation are the hubs for not only training and education, but also research and innovation. In this sense, the research team thinks that the relevant departments and research centers of the higher education institutions located in Dhaka are the 'natural partners' of our project. Therefore, the following institutions have been chosen as the potential stakeholders.

- **National University, Bangladesh:** Founded in 1992, National University, Bangladesh is a non-profit public higher education institution located in the urban setting of the medium-sized city of Gazipur, Dhaka. Officially accredited by the University Grants Commission of Bangladesh, National University, Bangladesh (NU) is a very large coeducational higher education institution. (See, http://www.nu.ac.bd/)

University	Faculty	Department
National University	Faculty of Life and Earth Science	Geography and Environmental Studies

- **Bangladesh University of Engineering and Technology:** Established in 1962, Bangladesh University of Engineering and Technology is a non-profit public higher education institution located in the urban setting of the metropolis of Dhaka. (See, http://wre.buet.ac.bd/)

University	Faculty	Departments
Bangladesh University of Engineering and Technology (BUET)	Faculty of Civil Engineering	Department of Water Resources Engineering
	Faculty of Architecture and Planning	Department of Urban and Regional Planning (URP)
	Institutes	Institute of Water and Flood Management (IWFM)

- **University of Dhaka:** Established in 1921, the main purpose of the University of Dhaka is to create new areas of knowledge and disseminate this knowledge to the society through its students. At present the university consists of 13 faculties, 83 departments, 12 institutes, 20 residential halls, 3 hostels and more than

56 research centers. (See, https://www.du.ac.bd/)

University	Faculty	Department
University of Dhaka	Faculty of Earth and Environmental Sciences	Department of Geology and Environment

- **BRAC University:** Since its inception in 2001, Brac University has become one of the most reputed educational institutions in Bangladesh. They have focused on generating new knowledge and promoting critical thinking among the students.

Brac University has conducted a series of cross-sectoral research on climate change and disaster management in direct collaboration with BRAC so far. To coordinate and manage these different activities, the Syndicate and the Board of Trustees of BRAC University have accorded for establishment of a research center titled "Centre for Climate Change and Environmental Research (C3ER)". The Center establishes a synergy between BracU and BRAC in the field of climate change and other environmental issues. (See, https://www.bracu.ac.bd)

University	Centre
BRAC University	Centre for Climate Change and Environmental Research (C3ER)

- **Daffodil International University:** Established in 2002, Daffodil International University is a non-profit private higher education institution located in the urban setting of the metropolis of Dhaka. (See, https://daffodilvarsity.edu.bd/)

University	Faculty	Department
Daffodil International University	Faculty of Science and Information Technology	Department of Environmental Science and Disaster Management

- **North South University:** Founded in 1992, North South University is a non-profit private higher education institution located in the urban setting of the metropolis of Dhaka. (See, http://www.northsouth.edu/)

University	Faculty	Departments
North South University	School of Engineering and Physical Sciences	Civil and Environmental Engineering
	School of Health and Life Sciences	Environmental Science and Management

- **Jahangirnagar University:** Founded in 1970, Jahangirnagar University is a non-profit public higher education institution located in the suburban setting of the small city of Savar, Dhaka. (See, http://www.juniv.edu/)

University	Faculty	Departments
Jahangirnagar University	Faculty of Mathematical & Physical Sciences	Department of Environmental Sciences
	Faculty of Social Sciences	Department of Urban & Regional Planning

- **Independent University, Bangladesh:** Founded in 1993, Independent University, Bangladesh is one of the oldest private universities in Bangladesh. The School of Environmental Science and Management (SESM) at Independent University, Bangladesh (IUB) has achieved a reputation as one of the best institutions providing environmental education in the country. The school -interdisciplinary and holistic in nature- integrates science, management, law, economics, public health and governance with an aim to create professionals for environmental problem solving. (See, http://www.sesm.iub.edu.bd/)

University	Faculty	Departments
Independent University	School of Environmental Science and Management (SESM)	Department of Environmental Sciences
		Department of Environment Management
		Department of Population Environment

- **Islamic University of Technology:** Islamic University of Technology (IUT) is an educational and research institution in Bangladesh run and funded by the Organization of Islamic Cooperation (OIC). The main objective of IUT is to contribute in developing the human resources of the member states of the OIC, particularly in the fields of engineering, technology and technical education. (See, http://www.iutoic-dhaka.edu/)

University	Faculty	Department
Islamic University of Technology (IUT)	Faculty of Engineering	Department of Civil and Environmental Engineering (CEE)

- **Jatiya Kabi Kazi Nazrul Islam University:** Jatiya Kabi Kazi Nazrul Islam University was established by the Government of Bangladesh in 2005, though the initiative for its establishment was taken some years before, firstly by a non-official group of socio-cultural local elites, namely Greater Mymensingh Cultural Forum. JKKNIU is a general university with a special focus on liberal-cum-performing arts education and research. (See, https://jkkniu.edu.bd/)

University	Faculty	Department
Jatiya Kabi Kazi Nazrul Islam University	Faculty Of Science And Engineering	Environmental Science and Engineering

- **Dhaka University of Engineering and Technology, Gazipur:** The University started its operation in 1980 as College of Engineering at its temporary campus at Tejgaon, under the University of Dhaka. It offers degree programs to meet the growing need for advanced engineering education in Bangladesh. (See, http://www.duet.ac.bd/)

University	Institute
Dhaka University of Engineering and Technology, Gazipur	Institute of Water & Environment Sciences

- **Bangladesh University of Textiles:** Founded in 2010, BUTEX is the only public university in Bangladesh specializing in the field of textile engineering. Being aware of the fact that the production of textile materials is associated with tramendous environmental pollution, BUTEX offers an academic program in "Textile Engineering (Environmental Science)". (See, http://www.butex.edu.bd/)

University	Faculty	Department
Bangladesh University of Textiles (BUTEX)	Faculty of Textile Chemical Engineering	Environmental Science and Engineering

- **BGMEA University of Fashion and Technology:** BGMEA University of Fashion & Technology (BUFT) was set up in March 2012 under the Private Universities Act of 2010 and is dedicated to the development of human resources for the ready-made garment, textile and allied sectors of Bangladesh. (See, http://buft.edu.bd/)

University	Faculty	Department
BGMEA University of Fashion and Technology	Faculty of Architecture & Planning (FAP)	Environmental Science

- **State University of Bangladesh:** State University of Bangladesh (SUB) is a private university in Dhanmondi, Dhaka. It was established in 2002 under the Private University Act 1992. (See, http://www.sub.edu.bd/)

University	Department
State University of Bangladesh	Environmental Science

4.3 Non-Governmental Organizations (NGOs)

In the studies conducted with the motto of "the people who are residents are the only ones who can beautify their living quarters", it is vital to incorporate non-governmental organizations (NGOs) that are active in the study area into research

and policy formulation processes in order to ensure the progress and practicability of the study.

Formulating applicable environmental regulations is key to provide a cleaner and more liveable Dhaka to the coming generations. Apparently, NGOs can play a significant role in helping relevant authorities with policy formulation and implementation efforts by correctly identifying the needs and interests of the social group that they represent; seeking efficient and eco-friendly solutions to the problems that this social group faces; providing their members with a clear understanding of their roles and responsibilities for eliminating or minimizing environmental impacts; and conveying the demands of their members to the relevant institutions objectively. We, as the research team, firmly believe that all NGOs working in the field of environmental protection in Bangladesh should feel themselves responsible in this sense.

In order to identify the relevant NGOs that we can develop stakeholder relationships with, our team has conducted a preliminary research, and the following list has been prepared. The listed NGOs have been informed about the content and the purpose of our SEA project through email and social-media interactions. We have also prepared a short online survey to gather their ideas and suggestions directly (see, "Dhaka Urban Resiliency Project Online Survey for NGOs" at https://www.smartsurvey.co.uk/s/AS7YU/). In the next step, we plan to hold an NGO representatives workshop in Dhaka to further strengthen our stakeholder relationship and cooperation with these organizations.

Table 4.1 List of the NGOs working in a field relevant to the content and purpose of our SEA project in Bangladesh.

No	Non-Governmental Organization		About
1	SEHD Society for Environment and Human Development	**Society for Environment and Human Development (SEHD)**	SEHD works for human rights and environmental justice in Bangladesh through research, capacity building and advocacy. Working closely with communities where the environment and human rights have eroded, SEHD gives the affected communities a voice through its publications, investigative reporting, training, and grassroots empowerment programs. (See, https://www.sehd.org/)

2		**Syed Nuruddin Ahmed Development Foundation (SNAD Foundation)**	The goal of SNAD Foundation is to alleviate the poverty and empower the poor as to improve their livelihood status through undertaking various need based sustainable (development programs) income generating activities. (See, http://www.snadfoundation.org/)
3		**Water Sanitation for Urban Poor, Bangladesh (WSUP Bangladesh)**	WSUP is an international NGO seeks to develop sustainable water and sanitation services for the poorest consumers in the cities of Asia and Africa. They also have a branch in Bangladesh. (See, https://www.wsup.com/)
4		**Water and Life (Eau et Vie) Bangladesh (e&v Bangladesh)**	Water and Life is an international NGO responsible for developing training on hygiene and the environment, fire prevention and community strengthening, and ensuring the implementation of improved waste collection and sanitation services. It is registered in the Bangladeshi office of international NGOs. (See, http://eauetvie.fr/en/pays/bangladesh)
5		**Work for a Better Bangladesh Trust (WWB Trust)**	The mission of WWB Trust is to support policymakers to draft, pass, and enforce policies that will help in achieving a healthy population and environment. (See, http://www.wbbtrust.org/)
6		**Nagorik Uddyog Citizen's Initiative**	Nagorik Uddyog Citizen's Initiative is an NGO that mainly promotes people's participation and access to democracy, rights, justice & development. (See, https://nuhr.org/)
7		**Habitat for Humanity Bangladesh**	Bangladeshi branch of Habitat for Humanity International currently operates in six project locations across the country, aiming to break the cycle of poverty related to poorly-constructed homes and inadequate shelter. (See, https://www.habitatbangladesh.org/)
8		**Institute for Environment and Development (IED)**	IED is a non-profit organization committed for developing and promoting active citizenship among civil society members including community people with special emphasis to the poor, women, youths and minorities (ethnic and religious). (See, http://iedbd.org/)
9		**Association for Land Reform and Development (ALRD)**	ALRD was established in January 1991 as a single focused rights-based independent national policy advocacy and networking organization committed to the promotion and strengthening of land rights and agrarian reform. (See, https://www.alrd.org/)
10		**Association for Social Development of Bangladesh (ASDB)**	ASDB is a non-profit organization committed for developing and promoting active citizenship among community people with special emphasis to the poor, women, youths and minorities including civil society members. (See, https://bdplatform4sdgs.net/profile/association-for-social-development-of-bangladesh/)

11	BASA	**Bangladesh Association for Social Advancement (BASA)**	BASA is a non-governmental, non-political, non-profit development organization established in 1991 with the objective of empowering the distressed, underprivileged; especially the deprived and vulnerable people and the improve their quality of life. (See, https://basango.org/)
12	brac	**Bangladesh Rural Advancement Committee (BRAC)**	BRAC, an international development organization based in Bangladesh, is present in all 64 districts of Bangladesh as well as 13 other countries in Asia, Africa, and the Americas. It works in a number of fields including ultra-poor graduation, integrated development, microfinance, skills development, migration, climate change, agriculture and food security, gender justice and diversity, community empowerment, human rights and legal aid services, urban development, water, sanitation and hygiene, education, road safety etc. (See, http://www.brac.net)
13	BELA Bangladesh Environ Lawyers Association	**Bangladesh Environmental Lawyers Association (BELA)**	BELA is an advocacy group founded by a group of young lawyers in 1992 with the broad objective of promoting environmental justice and contributing to the sound environmental jurisprudence. (See, https://www.belabangla.org/)
14	CENTRE FOR POLICY DIALOGUE	**Centre for Policy Dialogue**	CPD is a think tank established in 1993 committed to contributing towards participatory policy-making in Bangladesh. It undertakes research and analyses, organizes dialogues and brings out publications. (See, https://cpd.org.bd/)
15	DISA Since 1993	**Development Initiative For Social Advancement (DISA)**	DISA has been working for the rural people, especially women and children of the poor households of Bangladesh with the objectives of poverty alleviation, awareness building, social violence reduction and empowerment of women to uplift their socio-economic status. (See, https://www.disabd.org/)
16	ECO SOCIETY	**ECO Society Bangladesh**	ECO Society Bangladesh is a non-governmental, non-profit, non-political and voluntary organization established to provide basic services and vocational training to poor, vulnerable women and children regardless of cost, creed or religion. (See, http://www.ecosocietybd.com/)
17	ESDO	**Environment and Social Development Organization (ESDO)**	ESDO is a Bangladeshi NGO working to spread the message about the need for environmental conservation in order to ensure the protection of biological diversity and ecological balance. (See, https://esdo.org/)
18	BANGLADESH Y ENVIRONMENTA	**Bangladesh Youth Environmental Initiative (BYEI)**	Established as a youth non-profit organization, BYEI works to raise environmental awareness, build youth capacity, and nurture the next generation of leaders for socially inclusive and environmentally sustainable development of Bangladesh. (See, https://www.byei.org/)

19		**Bangladesh Environment and Development Society (BEDS)**	BEDS is a non-profit, non-political organization committed to sustainable socio-economic development, conservation of natural resources, use of clean energy and protection of the environment through research and implementation of specific activities. (See, https://www.bedsbd.org/)
20		**Centre for Coastal Environmental Conservation (CCEC)**	CCEC is a non-profit grassroots environmental NGO in Bangladesh for the protection and sustainable development of coastal ecosystem through local initiatives and participation. (See, https://www.ccec-bd.org/)
21		**Bangladesh Poribesh Andolon (BAPA)**	BAPA was founded in 2000 to create a sound voice to preserve the country's environment. Since its inception, the organization has been solemnly working for the welfare of Bangladesh's environment. (See, http://bapa.org.bd/)

4.4 Stakeholder Matrix

Table 4.2 Stakeholder Matrix for Public Institutions and Government Bodies

Public Institution	Department	Impact	Influence
		How much does the project impact them? (Low, Medium, High)	*How much influence do they have over the project? (Low, Medium, High)*
Ministry of Environment, Forests and Climate Change (MoEF)	Department of Environment	High	Low
	Bangladesh Climate Change Trust	High	Low
Ministry of Water Resources (MoWR)	Water Resources Planning Organization (WARPO)	High	Low
	Bangladesh Water Development Board (BWDB)	High	Low
	Joint River Commission (JRC)	High	Low
	Flood Forecasting and Warning Center (FFWC)	High	Low
Ministry of Local Government, Rural Development and Co-operatives (MoLGRDC)	Local Government Engineering Department (LGED)	High	Low
	Dhaka Water Supply and Sewerage Authority (DWASA)	High	Low
	National Institute of Local Government (NILG)	High	Low
Ministry of Housing and Public Works (MoHPB)	Urban Development Directorate (UDD)	High	Low
	Rajdhani Unnayan Kartripakkha (RAJUK)	High	Low
Dhaka North City Corporations (DNCC)		High	Low
Dhaka South City Corporations (DSCC)		High	Low

Table 4.3 Stakeholder Matrix for NGOs

NGO	Impact	Influence
	How much does the project impact them? (Low, Medium, High)	*How much influence do they have over the project? (Low, Medium, High)*
Society for Environment and Human Development	High	Low
Syed Nuruddin Ahmed Development Foundation	High	Low
Water Sanitation for Urban Poor (Bangladesh)	High	Low
Water and Life (Eau et Vie) Bangladesh	High	Low
Work for a Better Bangladesh (WWB) Trust	High	Low
Nagorik Uddyog Citizen's Initiative	High	Low
Habitat for Humanity Bangladesh	High	Low
Institute for Environment and Development (IED)	High	Low
Association for Land Reform and Development	High	Low
Association for Social Development of Bangladesh (ASDB)	High	Low
Bangladesh Association for Social Advancement	High	Low
Bangladesh Rural Advancement Committee (BRAC)	High	Low
Bangladesh Environmental Lawyers Association (BELA)	High	Low
Centre for Policy Dialogue	High	Low
Development Initiative For Social Advancement (DISA)	High	Low
ECO Society Bangladesh	High	Low
Environment and Social Development Organization (ESDO)	High	Low
Bangladesh Youth Environmental Initiative	High	Low
Bangladesh Environment and Development Society (BEDS)	High	Low
Centre for Coastal Environmental Conservation	High	Low
Bangladesh Poribesh Andolon (BAPA)	High	Low

Table 4.4 Stakeholder Matrix for Universities and Research Centers

University	Faculty	Department	Impact	Influence
			How much does the project impact them? (Low, Medium, High)	*How much influence do they have over the project? (Low, Medium, High)*
National University	Faculty of Life& Earth Science	Geography and Environmental Studies	High	Low
Bangladesh University of Engineering and Technology (BUET)	Faculty of Civil Engineering	Department of Water Resources Engineering	High	Low
	Faculty of Architecture and Planning	Department of Urban and Regional Planning (URP)	High	Low
	Institutes	Institute of Water and Flood Management (IWFM)	High	Low
University of Dhaka	Faculty of Earth and Environmental Sciences	Department of Geology and Environment	High	Low
BRAC University	Centre for Climate Change and Environmental Research (C3ER)		High	Medium
Daffodil International University	Faculty of Science and Information Technology	Department Of Environmental Science And Disaster Management	High	Low
North South University	School of Engineering and Physical Sciences	Civil and Environmental Engineering	High	Low
	School of Health and Life Sciences	Environmental Science and Management	High	Low

Jahangirnagar University	Faculty of Mathematical & Physical Sciences	Department of Environmental Sciences	High	Medium
	Faculty of Social Sciences	Department of Urban & Regional Planning	High	Low
Independent University	School of Environmental Science and Management (SESM)	Department of Environmental Sciences	High	Low
		Department of Environment Management	High	Low
		Department of Population Environment	High	Low
Islamic University Of Technology (IUT)	Faculty of Engineering	Department of Civil and Environmental Engineering (CEE)	High	Low
Jatiya Kabi Kazi Nazrul Islam University	Faculty of Science and Engineering	Environmental Science and Engineering	High	Low
Dhaka University of Engineering and Technology, Gazipur	Institute of Water & Environment Sciences		High	Low
Bangladesh University of Textiles (BUTEX)	Faculty of Textile Chemical Engineering	Environmental Science and Engineering	High	Low
BGMEA University of Fashion and Technology	Faculty of Architecture & Planning (FAP)	Environmental Science	High	Low
State University of Bangladesh	Department of Environmental Science		High	Low

V SWOT ANALYSIS

SWOT Analysis (or SWOT Matrix) is a strategic planning method that helps researchers, policy advisers and policy makers to set attainable objectives and to achieve their strategic goals by allowing them to focus on their strengths, minimize weaknesses and threats, and take the greatest possible advantage of opportunities (Quincy, Lu, & Huang, 2012). Therefore, to provide an effective analysis of the advantages and disadvantages that affect the Bangladesh government in its struggle to protect and preserve the environment especially in Dhaka, this method of analysis has been used in this study.

Outcomes of the SWOT Analysis conducted by our team of experts are as follows:

a) **Strengths**: Firstly, Bangladesh government seems firmly committed to 'UN Sustainable Development Goals' at the very highest level as its active participation in and support for the Paris Climate Agreement of 2016 clearly prove. This strong commitment has also resulted in the preparation of some policy documents aiming at mobilizing resources for a more environment-friendly development, and establishment of some new institutions (including Climate Change Trust) with the budgets under the direct responsibility of the Prime Minister, in recent years.

Secondly, since she gained her independence in 1971, Bangladesh has shown a miraculous economic development performance. The nation has achieved growth rates of around 6.5 percent ever since, and surpassed even India in this sense. Government has taken serious steps to reduce the poverty, and already got some favorable results so far. Apparently, Bangladeshi authorities have a serious endeavour to attain sustainable development.

Thirdly, as also observed during the stakeholder meetings, Bangladeshi public officials are remarkably talented and possess a very high intellectual capacity. Their close cooperation with the World Bank and Asian Development Bank (ADB) staff has also played, and is playing, a pivotal role in terms of increasing this capacity in recent years.

Fourthly, the World Bank's support for Bangladeshi efforts to combat environmental degradation is yet another strength. Given the fact that it works with top-quality experts with advanced skills, The World Bank Group is not only an

important source of economic assistance, but also a source of technical support and advice for developing nations.

Lastly, Bangladesh is the country where the micro-credit system has been invented as an important instrument in poverty alleviation (Yunus, 2017). Her very rich experience in this field, which can be traced back to the foundation of Grameen Bank by Prof. Mohammed Yunus in mid-1970s, may help Bangladesh to transform this method of financing also into an instrument in her current struggle against ecological breakdown. (See, Box 5.1)

GRAMEEN
Banking for the poor

"**Grameen Bank (GB)** has reversed conventional banking practice by removing the need for collateral and created a banking system based on mutual trust, accountability, participation and creativity. **GB** provides credit to the poorest of the poor in rural Bangladesh, without any collateral. At **GB**, credit is a cost effective weapon to fight poverty and it serves as a catalyst in the over all development of socio-economic conditions of the poor who have been kept outside the banking orbit on the ground that they are poor and hence not bankable. Professor Muhammad Yunus, the founder of "**Grameen Bank**" reasoned that if financial resources can be made available to the poor people on terms and conditions that are appropriate and reasonable, "these millions of small people with their millions of small pursuits can add up to create the biggest development wonder."

As of December, 2018, it has 9.08 million members, 97 percent of whom are women. With 2,568 branches, GB provides services in 81,677 villages, covering more than 93 percent of the total villages in Bangladesh.

Grameen Bank's positive impact on its poor and formerly poor borrowers has been documented in many independent studies carried out by external agencies including the World Bank, the International Food Research Policy Institute (IFPRI) and the Bangladesh Institute of Development Studies (BIDS)."

Source: http://www.grameen.com/introduction/

Box 5.1 The Gramen Bank model.

b) **Weaknesses**: Firstly, as many public officials also admitted during our fieldwork research and stakeholder meetings, there is no strong cooperation and interaction between different government bodies and public institutions in Bangladesh.

Secondly, as being addressed by many participants at "SEA Stakeholders Consultation Workshop" held in RAJUK Commercial Complex on May 8th, 2019, public awareness for environmental issues is miserably low in Bangladesh in general,

and in Dhaka in particular. Even street-level bureaucrats lack required knowledge about existing rules and regulations regarding environmental protection and preservation, let alone the ordinary citizens. Moreover, the average wages for public sector employees working for the relevant monitoring and law enforcement agencies are also ridiculously low. Their poor living conditions and low wages, not surprisingly, make these personnel more prone to corruption and bribery. All these drawbacks eventually lead to inefficiency in law enforcement efforts to protect the environment, and deal a death blow to the struggle against environmental degradation in Dhaka.

Thirdly, despite her relatively better economic performance, Bangladesh is still a very poor country. This may hamper her efforts to implement the required mitigation measures for Dhaka and achieve her sustainable development goals if some new sources of financing cannot be mobilized. This point is particularly important, since we roughly calculate that a fund of around (or at least) US $10 billion will be needed to put Dhaka Urban Resilience Project into practice in the coming 10 years.

c) **Opportunities**: Firstly, there lies an opportunity in the increasing environmental awareness worldwide. As knowledge about the risks of environmental degradation increases, the funds dedicated to environmental protection and preservation programs as well as sustainable development become larger and larger. As Winston (2014) points out, according to an HSBC Bank study, clean energy markets will be worth US $2.2 trillion by 2020.

Bangladesh government can also take this opportunity to raise funds and attract investments to subsidize Dhaka Urban Resilience Project. In addition to the subsidies from international institutions such as the World Bank, Asian Development Bank and the UNDP, the following financial resources shall also be used:

i. Carbon Funds.

ii. Clean energy investments made all over the world by global IT giants like Microsoft, Apple, Google Inc. and Facebook.

iii. Funds allocated by developed countries to compensate their carbon dioxide emissions.

iv. Low-interest-rate loans by the private financial institutions for environmentally friendly development projects.

We, the consultants, strongly suggest that Bangladesh government should try to mobilize at least US $1 billion/yr to deal with the most devastating effects of the environmental degradation in Dhaka. As being one of the countries that are affected

by climate change the most, Bangladesh may adopt the motto of "If humanity fails to counter the climate change in Bangladesh, it will also fail elsewhere!" while campaigning to attract the attention of world public, international organizations and multinational corporations.

In order to make use of this great opportunity, Bangladesh government should take initiative in establishing global stakeholder networks that will function as a huge international collective mind all together, convince globally recognized opinion leaders and public intellectuals to take part in the activities of these networks, develop cooperation with NGOs as local and international partners to promote its efforts, and adopt an innovative approach in project development, policy making and policy implementation.

d) **Threats**: Firstly, destructive impacts of climate change (sea level rise, floods, mass influxes, increasing rainfall intensity, melting of Himalayan Glaciers, and so on), of course, constitute an important threat.

Secondly, deterioration in Dhaka's ground-water quality and quantity is yet another serious problem. Ground-water is still the main source of water supply for approximately 20 million citizens living in the city. Although technical and financial assistance of Asian Development Bank allowed Bangladesh to establish one of the best water supply systems in the world, which even allows many urban poor residing in slums to access water, excessive usage and mobilization of arsenic into ground-water due to rising sea levels forces the authorities to shift to surface water supply schemes in the future. Yet, the available surface water in Dhaka is also very polluted due to poor water management in the city, hazardous chemicals discharged into water bodies without adequate treatment by the textile and leather industries, and intensely water polluting practices being held in neighbouring settlements and countries, especially India who has many industrial facilities.

Thirdly, air pollution in the city is at an alarming level and adversely affects the health of the residents. Dhaka exceeds WHO's air quality guideline level for $PM_{2.5}$ by almost 10 times, making it the 17^{th} most polluted city in the world. Air pollution in Dhaka is mainly caused by the traffic congestion, poor waste management, and brick production and kiln facilities operating in the city.

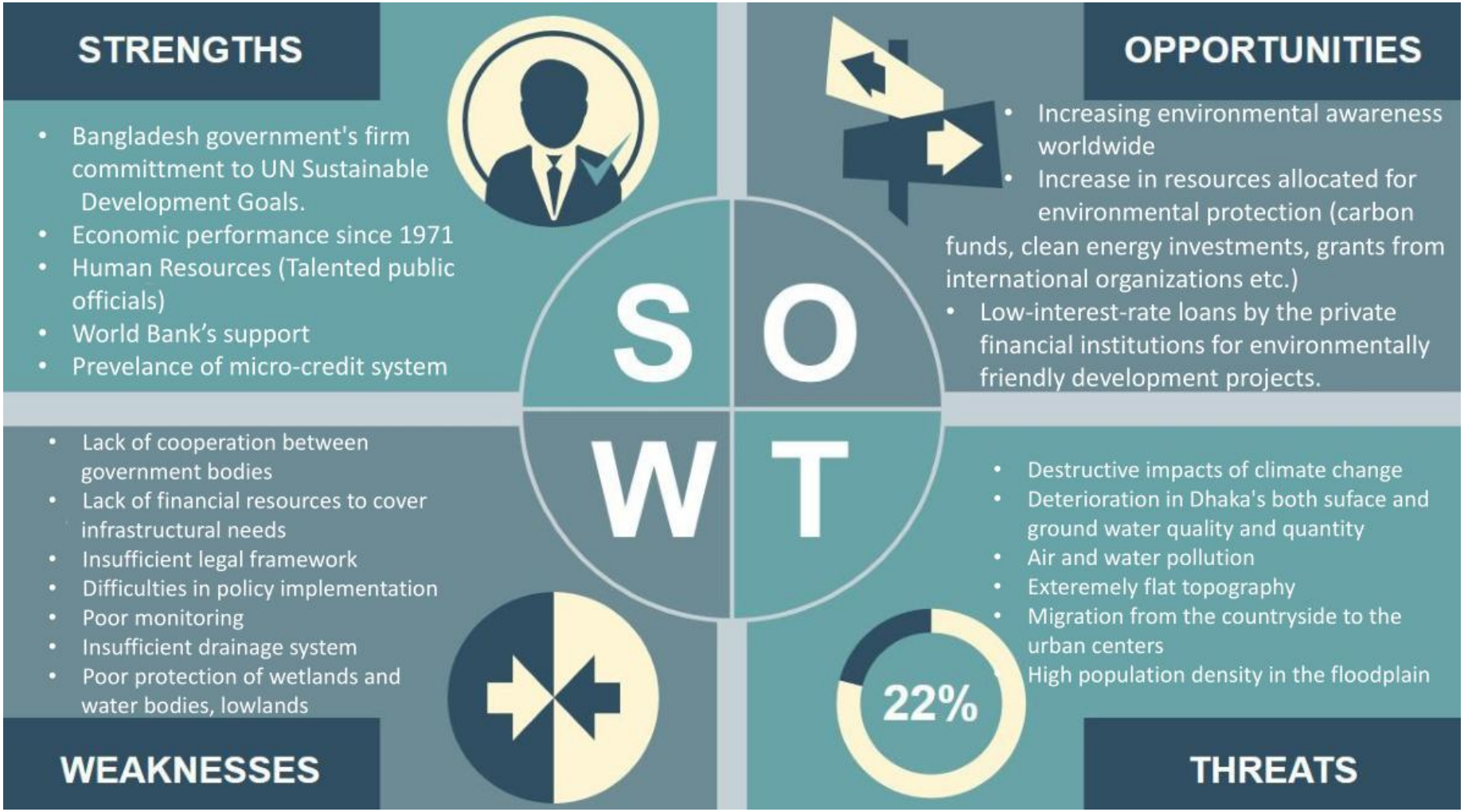

Figure 5.1 Matrix of the SWOT analysis.

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APPENDICES

APPENDIX I

SEA Specialist Team

No	Name	Team Role/Profession
1	Prof. Elçin KENTEL	Water Management and Flood Specialist/ Civil and Environmental Engineer
2	Prof. Timur KOÇ	Waste Management Specialist/ Chemical Engineer and Investment Consultant
3	Prof. Sheikh Tawhidul ISLAM	Disaster Management and Climate Change Specialist/ Environment and Natural Resource Manager
4	Assoc. Prof. Ferhat CELEP	Wetland Specialist/ Biologist
5	Dr. Ayşegül İLİKER	Flora and Fauna Specialist/ Ecologist, Mammalogist
6	Dr. Mahmut Yıldırım ORAL	Urban Transportation and Traffic Planning Specialist/ Urban Planner
7	Selami HORZUM	SEA and Greenhouse Gas Specialist/ Agricultural Engineer
8	Murat YEĞİN	Flood Specialist/ Civil Engineer
9	Khaza Nawaz MAHMOUD	Network and GIS Specialist; Local Expert/ Computer Engineer
10	Feray ACAY	Environment and Waste Management Planning Specialist/ Chemist and Chemical Engineer
11	Uğur ŞAHİN	SEA Specialist/ Environmental Engineer
12	Hüseyin Bülent KADIOĞLU	SEA Specialist/ Environmental Engineer
13	Dr. Elham AGHLARA	Climate Change Specialist/ Environmental and Mathematics Engineer

APPENDIX II
Minutes of the Meetings with Some Key Stakeholder

POPULATION		
	Solutions	**Challenges**
RAJUK		Every year the population increases by 500 thousand people
		Currently the population is 20 million and by 2035 it is expected to reach 28 Million
		Only 7% of housing is formal where 4 million people are very poor and live in slums
BRAC		Shortly after independence was gained, the population was only 500.000 in 1972. Whereas it is approximately 20 million now, which makes Dhaka one of the most populated cities of the world with 48.000 people/sq km. population density.
TRANSPORTATION		
	Solutions	**Challenges**
RAJUK	*Improving public transportation system* especially through standardizing the buses will solve 40% of the transportation problem	Canals filled up with waste due to very poor management in the past 40 years. Better Waste Management Practices should be initiated.
	Rehabilitating the canals may result in providing **Water Way Transport** for the city and an alternative means to ease the problem.	There are roads that have been constructed on canals. These should to be pulled down and canals should be re-opened.
	Such a restructuring of canals will also help better ***drainage management*** towards less damage of the floods.	
SURFACE WATER QUALITY		
	Solutions	**Challenges**
RAJUK		Lack of coordination and firm cooperation between responsible agencies.
RAJUK &		20 millions residents directly discharge domestic wastewater into

DoE&BRAC&BUET		the water bodies.
		Textile and leather industries directly discharge their wastewater without any treatment,
		Some residents also discharge solid waste into water bodies
DoE		**Climate Change** also exacerbates the problem of flooding and drainage, where annual rainwater for Dhaka is 2.5 m.
		Lack of ***Water Retention Areas*** prevents a better Flood Control which has also taken place in the ***Political Manifesto of the Prime Ministry***
		A new and much better Flood Control Infrastructure and Management is a must
BRAC		Surface Water within the city borders carried by two rivers and canals are extremely polluted
		Due to cheaper labour cost most of the textile industry also from China have moved to Bangladesh during the last 10 years.However impact of this development on Water Pollution is huge
BUET	Five drainage – catchment – areas with five treatment plants needs to be implemented to be the only solution,	Currently 20% percent of the city has sewerage network but they are mostly clogged and don't function,
	Both for public health considerations and prevention of water pollution there is urgent need for improving the current poor Waste Management,	Flat topography of Dhaka makes too much pumping necessary
WATER SUPPLY		
	Solutions	**Challenges**
DoE	Dhaka must start using Surface Water as the main water supply resource in four to five years and it is a Government Policy	Surface water is also very polluted
WASTEWATER DRAINAGE		
	Solutions	**Challenges**

DoE&DWASA	**DWASA** has had a **Sewarage Master Plan** prepared where all domestic wastewater will be collected and treated through five drainage zones	Currently all domestic and industrial wastewater is directly discharged to the surface water bodies which results in the world's most polluted rivers and canals.
DWASA		DWASA is looking for financial assistance from **ADB and the WB**
FLOOD		
	Solutions	**Challenges**
BRAC		60 % of the city (potentially) suffers from the flood during storms and heavy rains in the monsoon season
		Embankments of one of the Rivers' has been risen which has helped up to some extent. But embankment rehabilitation is also needed for the other river
		Accumulated waste reduces drainage capacity of the Rivers and Canals.
		There are almost no open end green space at the embankments of these water bodies to store flood to minimize the impacts.
WASTE MANAGEMENT		
	Solutions	**Challenges**
DoE	Ministry is advocating for a Circular Production possibly with zero-waste end result	5000 tons of waste is produced everyday. Where % 35 of it is reduced, the rest is swept to the Surface Waters
		Lack of cooperation between different authorities
BRAC		Waste is collected very poorly and then discharged directly to the dump sites which are swept to the rivers and canals by the rain and wind
		This practice also results in severe health problems,
		However there is also an informal waste reduction practice; plastic materials are collected by the children, pressed for volume reduction and then exported to China
BUET	Only improvement solution seems to be the	There are limitations for conventional waste management practices

	zero-waste one with well applied practices of reuse and recycling	due to lack of vacant land and flat topography. It is almost impossible to design and construct sanitary landfill
CLIMATE CHANGE		
	Solutions	**Challenges**
CLIMATE CHANGE TRUST	Determining *Thematic Areas* and developing pilot implementation projects	
	Mobilizing Local and Foreign Funds to realize those functions	
BRAC		Bangladesh is the most vulnerable country to Climate Change in the World.
		Increase in the sea level is expected to be between 0.18 and 0.79 meters by 2035(or maybe even higher due to melting of Antarctic)
		Due to temperature rise, thunder storms and intensity of rain during monsoon season has increased a lot -~30% more-. This results in much more severe floods. With 300 mm rainfall 60% of Dhaka City will be underwater.
DoE		Climate Change also exacerbates the problem of flooding, where annual rainwater for Dhaka is already very high (2.5 m).
BUET		Thunder storms and increase in the intensity of the rainfalls
BRAC & BUET		With Sea Level Rise, 40 million people will migrate from the shoreline settlements, and almost 20 Million of them will possibly move to Dhaka.
AIR POLLUTION		
	Solutions	**Challenges**
BRAC		Dhaka is one of the most polluted 10 cities on the world
		Number of brick production facilities in the peripheries of the city has been continuously increasing due to rapid rise in construction markets as a result of the economic growth
		Pollution as a result of traffic congestion

APPENDIX III

Comments Made by the Participants of SEA Stakeholders Consultation Workshop

ENVIRONMENTAL FACTORS		COMMENTS BY THE PARTICIPANTS
Air Pollution	Industrial Pollution	• There must be skilled manpower for monitoring • There should be very intense monitoring on industries that contribute to air pollution in the region • Brick kilns industry creates lots of problems to environment such as water pollution and air pollution • How the factory works and the applied technologies must be inspected regularly • Penalties should be imposed if the factory violates the rules and regulations. • All the monitoring procedures must be recorded digitally
	Transport Pollution	• Newer technologies should be adopted in public transportation • Motor vehicles should be monitored regularly
Habitat Loss		• Increasing the consciousness of the residents about environmental degradation • Increasing the monitoring capacity • Informing the private sector about the responsibilities that it should take to protect environment • Weak law enforcement • Government should work for implementation of animal protection laws • Separating urban and forest areas
Public Awareness		• Government sector need more manpower for monitoring • Policy framework is not effective enough • Monitoring and policy implementation capacities are weak • Increasing public information through media campaigns • Community monitoring • Lack of consciousness • More specialists should be employed.

		• Traffic police should assume a more active role. • More CCTV cameras should be installed to identify the violators • Monthly/weekly surveys should be conducted to increase the popular awareness about environmental protection in different districts • Police shouldn't just punish the violators; law enforcement bodies should also educate people • Monitoring authorities are not dedicated • The wages of the officers who are in charge of monitoring are extremely low, which makes them often slack.
Water Pollution	River Pollution	• Need to update water policy • Lack of proper policy measures and monitoring. • STP and ETP are ignored • River pollution levels should be measured periodically. • Digging new water canals to increase water flow increase • Discharging industrial and house waste into water bodies should be banned. • Awareness of people should be increased through media, social media, and school campaigns • Implementing a ban on the dumping of oil and other hazardous materials from the ships into rivers • Regulations and laws are incredibly ineffective • Nobody knows about Water Body Conservation • Recycling capacity should be increased
	Flood	• Training people about the protection of water bodies
	Groundwater Pollution	• Large number of people do not know about ground water pollution • Implementation of Water Body Act, 2000 • Increasing awareness about groundwater protection • People dig wells with no control • Even maintaining the current level of groundwater in the city is not enough

	Industrial Waste Water Management	• Very intense monitoring on industries that contribute to pollution in the region • Brick kilns industry should be monitored • Weak law enforcement capacity • SEA Report should contribute to the revision of existing protection policy • Zero discharge of industrial waste water into the rivers and water bodies • The number ETP are very few in the industry • Factory owners and entrepreneurs should obey the legislation
	Domestic Waste Water Management	• Increasing waste removing capacity • Government monitoring on ETP management among the different industries. • Developing alternative ways to re-use domestic waste water (for example, for flushing) • Properly enclosed drainage system • Waste collection should be done under the supervision of government bodies
Waste Disposal		• Government control is weak • There is no proper waste collection system in Dhaka City • No separation of different types of wastes. • Waste dump sites are close to city center. • Inadequate legal framework • Building a modern waste collection system and adopting proper tools • Proper planing to find new land fill areas. • There is no enough space for dumping waste in the City. • Using BR (Bioreactor) technique for dump waste since it requires smaller space • Public-private partnership should be formed. • Solid wastes should be separated at home

Biodiversity		● -Strengthening the monitoring process ● Increasing awareness of people ● Making and implementing policies for biodiversity protection ● Improving employee efficiency ● Making feasible and sustainable plans for preserving the biodiversity ● Industrial wastes discharged into water bodies poison fish. ● More trees should be planted. ● Excessive touristic activities should not be permitted in the forests and parks. ● Adequate measures to preserve wetlands in the forests and the city ● Very few people are aware of wetland protection and preservation environment ● Deforestation should be stopped at any cost. ● A proper environmental development plan is needed ● Rigid and strict laws to protect environment

APPENDIX IV

Participants of Stakeholder Meetings

No	Name	Organization	Role
1	Aldul Latif HELALY	RAJUK	Project Director
2	Md. Mahboob HASSAN	RAJUK	Procurement Specialist
3	B. M. Nural ABSAR	RAJUK	Assistant Engineer
4	Deen Mohammed HELALY	RAJUK	Assistant Research Engineer
5	Prof. Ainun NISHAT	Center for Climate Change and Environmental Research (C3ER), BRAC University	Adviser
6	Md. Hasibul KABIR	RAJUK	Deputy Town Planner
7	Deepak Kanti PAUL	Bangladesh Climate Change Trust	Additional Secretary
8	Md. Mokhtar AHMED	Bangladesh Climate Change Trust	Director
9	A. K. M. Shadid UDDIN	DWASA	Technical Director
10	Dr. Sultan AHMED	DoE	General Director
11	Prof. Ashraf ALI	Department of Civil and Environmental Engineering, BUET	Division Director
12	Dr. Tariq BIN YOUSUF	DNCC	Project Director
13	Abu Syed Mohammad HASHIM	DDM	General Director
14	Md. Shafiqul Islam AKAND	LGED	Additional Chief Engineer

APPENDIX V

Photos From the Stakeholder Meetings

Meeting at RAJUK

Meeting at DoE

Meeting at DWASA

Meeting with Prof. Ainun Nishat from BRAC University.

APPENDIX VI

SEA Stakeholders Consultation Workshop Participant List[2]

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Rajdhani Unnayan Kartripakkha (RAJUK)

Attendance Sheet

Subject: Strategic Environmental Assessment (SEA) Stakeholders Consultation Workshop for Package:URP/RAJUK/S-05

Date: May 08, 2019

Time: 02:00 PM

Venue: Project Office, Urban Resilience Project: RAJUK Part, RAJUK Commercial Complex Cum Car Parking Building (9th Floor), Gulshan- 1, Dhaka-1212

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03	Dr. Rahat Siddiqui RTI/S6		
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05	B.S. Pushpendra Biswas Assistant Engr (Civil Geotechnical) S-09, URP-RAJUK		
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[2] For confidentiality reasons, personal information of the participants has been blurred.

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17	MD. TAIMUR TANVIR ASST ENGR URP: RAJUK		
18	Bilash Kumar Ghosh. Assl. Engr. URP: RAJUK		
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21	Md. Shahadat Hossain Sub-Assistant Engineer (Mechanical & Lab) URP-RAJUK part		
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23	Md. Mostafizur Rahman Rha Sr. Structral Engineer Emky Enterprise Ltd.		
24	Iftekhar Alam project Manager (civil) Emky Enterprise. Ltd.		
25	Abul Khair AE, URP/RAJUK Part		
26	Hamidul Ahasan Samrat, SDE		
27	Tapas Kumar, Asst Engr. URP; RAJUK Part		
28	MD. HASIBUZZAMAN SDE		
29	B. M. NURAL ABSAR AE(CRC) Focal at S-05 URP: RAJ		
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34	Engr. Md. Khayrul Hasan Director, URP:PCMU		
35	Engr. Khaza Nemat Muhammad JV (SEA) Project Coordinator		
36	Nigar Sultana Jr. Urban planner		
37	Ismat Jahan Sharna		
38	MUSFERA JAHAN		
39	Syed Shakib Al Muiz Structural Engineer-S-4-JV		
40	FERAY ACAY SEA SPECIALIST, JV		
41			
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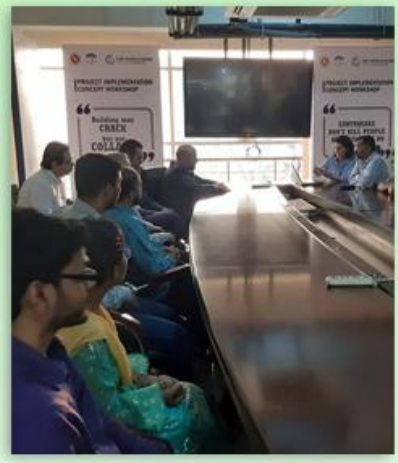
APPENDIX VII

Collage of photos from SEA Stakeholders Consultation Workshop





APPENDIX VII

Collage of photos from the fieldwork research

Photo credit: Feray ACAY

Dhaka City Urban Resilience Project

Strategic Environmental Assessment (SEA)

Revised Inception Report