City Resilience Strategy
Barisal City, Bangladesh

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ACCCRN Asian Cities Climate Change Resilience Network

The ROCKEFELLER FOUNDATION

ICLEI Local Governments for Sustainability

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ICLEI - Local Governments for Sustainability, South Asia
C-3 Lower Ground Floor, Green Park Extension
New Delhi 110 016; India
iclei-southasia@iclei.org
http://southasia.iclei.org/

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Executive Summary

Barisal city is the sixth largest city of Bangladesh with respect to population, but one of the smallest in terms of geographical area (58.05 sq. km.). It is located in the southern region of Bangladesh, on the western part of the river Kirtonkhola between 22°37'N and 22°45'N and 90°16'E and 90°32'E. According to the Bangladesh Bureau of Statistics (BBS) population census 2011, the population of Barisal City Corporation (BCC) was 328,278 with a population density of 5,396 persons/sq. km distributed among 30 wards. The city is a river port with several established trade and commerce centres and its economy is largely dependent on business. Moreover, the city is one of the most important rice producing centres of Bangladesh. Barisal city is one of the oldest municipalities in Bangladesh established in the year 1876 and became a City Corporation in 2002. BCC regulates most of the civic function and services in the city.

Barisal has a tropical wet and dry climate. The annual average temperature is a maximum of 35.1°C and a minimum of 12.1°C and average annual rainfall is 1,955 mm. Cyclones and floods are the main natural hazards in the city. Barisal's City Resilience Strategy (CRS) was formulated using the ICLEI ACCCRN Process (IAP) with the support of ICLEI South Asia. The IAP process was led by the Mayor, Chief Health Officer, Chief Planning Officer, with assistance from the municipal technical staff who guided the process through Shared Learning Dialogues (SLDs). Barisal city had already developed an urban vulnerability assessment (under the Urban Vulnerability Assessment (UVA) Project supported by GIZ that was conducted by ICLEI South Asia) and a lot of the information generated during this project was utilized and built upon in the IAP.

Regional and city level studies (when available) on past trends and climate projections were referred to in order to identify climate risks for the city. Outcomes of the national level study 'National Plan for Disaster Management' (2010-2015) published by the Government of Bangladesh, the 'Vulnerability, Risk Reduction and Adaptation to Climate Change, Climate Risk and Adaptation-Country profile' (2011), published by the World Bank, SLDs and Focus Group Discussions with the local community, the stakeholder committee and core climate team defines three potential climate risks- increased temperature, high intensity rainfall and increase in the frequency of cyclones for the city as seen below.

Changing Climate Conditions	Assessments	Climate Scenario Summary Statements
Precipitation change	National Assessment	Pre-monsoon rainfall will decrease while monsoon and post-monsoon rainfall will increase. From 2051 onwards annual average rainfall and monsoon rainfall will follow a higher increasing trend.
	National Assessment	There will be an increase in the amount of run-off, and rainfall intensity.
Temperature change	National Assessment	The monthly average maximum temperature will increase during the monsoon period and will decrease in other periods. The monthly average minimum temperature will increase in all periods and the Annual Maximum and Minimum temperature will follow an increasing trend.
	National Assessment	Mean temperatures across Bangladesh are projected to increase between 1.4°C and 2.4°C by 2050 and 2100, respectively.

Changing Climate Conditions	Assessments	Climate Scenario Summary Statements
Extreme events	National Assessment	The frequency of tropical cyclones in the Bay of Bengal may increase and, according to the Intergovernmental Panel on Climate Change's Third Assessment Report, there is *"evidence that the peak intensity may increase by 5% to 10% and precipitation rates may increase by 20% to 30%"* (IPCC 2001). Cyclone-induced storm surges are likely to be exacerbated by a potential rise in sea level of over 27cm by 2050.

The IAP identified the key fragile urban systems in the city which are already impacted by infrastructural, governance, economic, social and political issues and may be aggravated by climate change. These systems were water supply, sanitation, land use change, ecosystem, storm water drainage and health. A situation analysis of these urban systems was carried out to develop the fragility statements that were superimposed on the climate risks in order to formulate the climate fragility statements for each urban system. Highly vulnerable areas in the context of each urban system of the city with high and extreme risks, the actors who are vulnerable and who can play a critical role towards building urban resilience and the adaptive capacity of the fragile urban systems to absorb and respond to shocks that determines their resilience were identified as illustrated in the table below.

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive capacity of the system
			Vulnerable	Potential Supporting	
Sanitation	Increased temperatures lead to more growth of disease causing vectors in river/canal water polluted by septic tank sludge which impacts health of citizens. High intensity rainfall may cause overflow of septic tanks, leading to greater water pollution and more health impacts. Excessive rain and water logging caused by cyclones may cause septic tank overflow and water pollution, leading to health issues.	Ward 5, 8, 9, 10, 13, 15, 16, 17, 18, 23, and partly in wards 6, 7, 11, 12, 14, 19, 20.	• Citizens • Low income labourers • Fishery owners	• Health & conservancy department of BCC	• Economic- Medium • Technology/ Infrastructure- Low • Governance- Medium • Societal- High • Ecosystem Services- Medium

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive capacity of the system
			Vulnerable	Potential Supporting	
Water Supply	Increased temperatures will lead to greater use of tubewells to meet increased water demand, depleting the ground water table and exacerbating arsenic pollution. Increased intensity of rainfall will cause greater run off leading to lower percolation and lower recharge of ground water, putting stress on drinking water resources. Excessive rainfall and water logging caused by cyclones will cause contamination of water sources - both surface and ground water, leading to drinking water scarcity and health impacts.	Wards 3, 24, 25, 26, 27, 28, 29, 30, and partly in wards 4 & 5.	• Citizens • Residents of slum • Farmers	• Health & conservancy department of BCC	• Economic- Medium • Technology/ Infrastructure- Medium • Governance- Medium • Societal- Medium • Ecosystem Services- Low

Photo credit: Wikimedia

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive capacity of the system
			Vulnerable	Potential Supporting	
Land use Change	High intensity rainfall in case of unplanned development will result in water logging and urban flooding, with related impacts on the health and socio-economic structure of the city. Cyclones will cause damage to urban service infrastructure resulting in financial losses to BCC and disrupting urban services. Cyclones will cause greater damage to personal property, life and livelihood in case of unplanned development.	Wards 5, 9, 10, 11, slum areas of ward 6 and old areas of the city.	• Residents of slum area • Rickshaw pullers & auto rickshaw drivers • Citizens • Floating population	• BCC • District Commissioner (DC) Office • Bangladesh Police • Bangladesh Power Development Board (BPDB) • Department of Fire Service & Civil Defence	• Economic- Low • Technology/ Infrastructure- High • Governance- Medium • Societal- Low • Ecosystem Services- Medium
Ecosystem	Increased temperatures may cause changes in crop pattern. Increased intensity of rainfall can damage agriculture/ livestock/fishery impacting livelihood. Cyclones can affect agriculture/fishery/ livestock and therefore livelihood is impacted.	Extended areas of the city under ward 30, as well as wards 3, 5, 8, 10, 23, 24, 25, 26, 27, 28, 29 and partly in ward 4.	• Farmers • Fishery owners • Day labourers • Small shop owners • Women • Children	• BCC • Department of Agricultural Extension (DAE) • NGOs • Department of Environment	• Economic- Low • Technology/ Infrastructure- Low • Governance- Low • Societal- Low • Ecosystem Services- Low

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive capacity of the system
			Vulnerable	Potential Supporting	
Health System	Increased temperatures may cause heat stress and related health disorders, e.g. diarrhoea, thereby increasing demand of health infrastructure.	Wards 5, 6, 10, 11, 24, 26, 27, 30 mostly in riverside areas.	• Women Children • Citizens • Residents of slum area	• Health and conservancy department of BCC • NGOs	• Economic- Low • Technology/ Infrastructure- Low • Governance- Low • Societal-Low • Ecosystem Services- Low
Storm Water Drainage	High intensity rainfall or rain from cyclones can cause overflow of drains leading to urban flooding and impacting health.	Wards 1, 2, 4, 5, 6, 7, 8, 9, 13, 19, 20, 29.	• Women Children • Citizens • Residents of slum area	• Health and conservancy department of BCC	• Economic- Low • Technology/ Infrastructure- Low • Governance- Low • Societal- Low • Ecosystem Services- Low

In Barisal the area found to be the vulnerability hotspot is ward 5 which is vulnerable to all six fragile urban systems, while ward 6 and 10 are vulnerable to four fragile urban systems. It is important to note that all three wards are situated near Kirtonkhola River and have substantial slum population. Other wards 4, 8, 9, 11, and fringe areas belonging to wards 24, 26, 27, 28, 29 and 30 are impacted by multiple fragile urban systems.

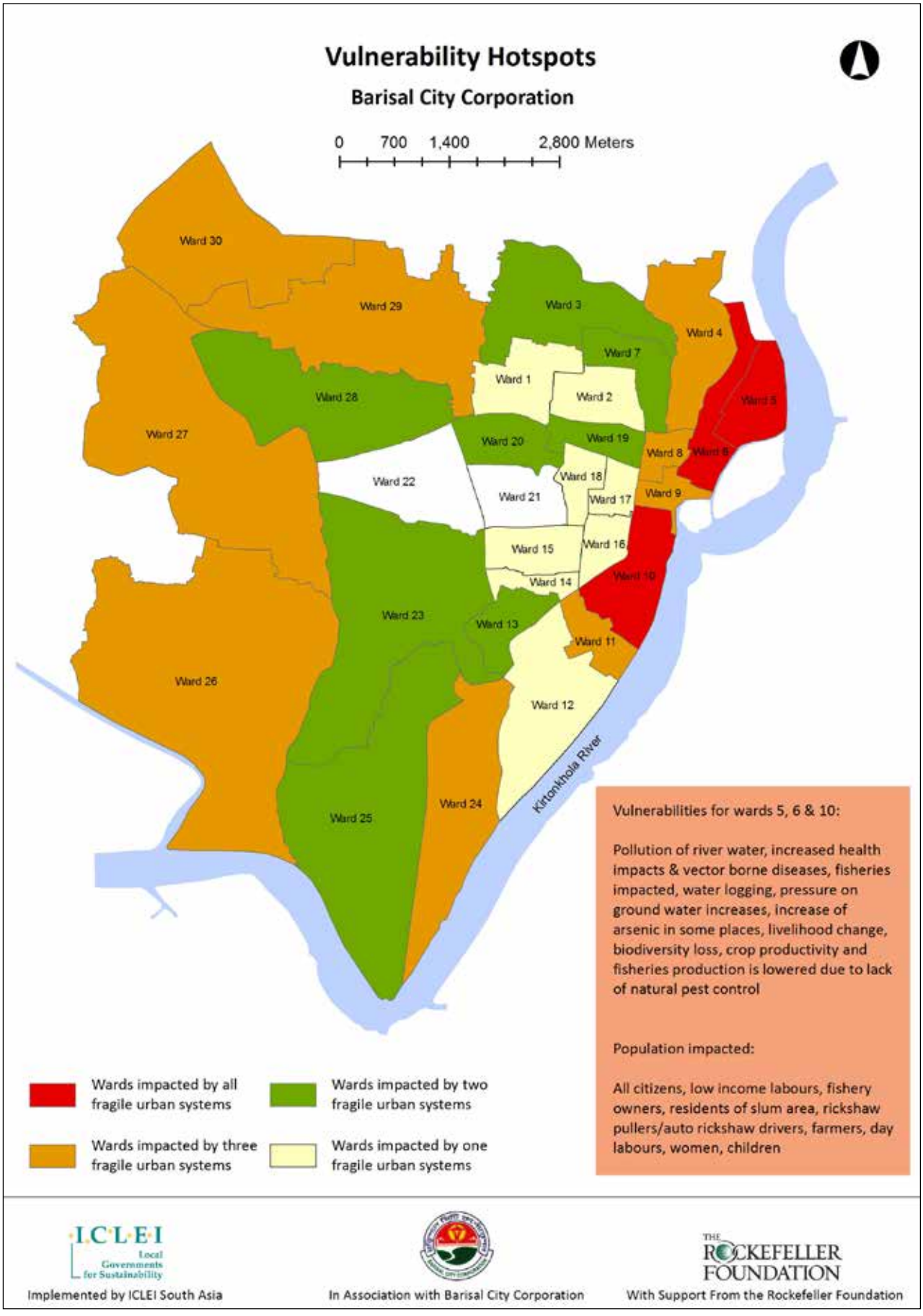
Interventions that would address the vulnerabilities identified through the IAP were developed for all six fragile urban systems. The 26 interventions have been divided into two categories – infrastructural measures and policy & institutional measures. Some of the major areas that should be looked into for Barisal city are:

1. **Land Use Change** – The land use pattern is changing in Barisal and government regulations need to be strictly implemented so as to manage and regulate indiscriminate construction. This will also lead to better drainage, health and ecosystem services in the city.

2. **Water supply, sanitation and drainage** – Planned construction with timely Operation and Maintenance (O&M) of these systems will help to reduce their vulnerability. Service delivery also needs to be improved in the city.

3. **Ecosystem Management** – A large population, especially poor and marginalised sector, depend on the ecosystem for their livelihood through agriculture, livestock, fishery, etc. In order to protect their livelihood, it is essential to take action to protect the ecosystems in and around the city, the forests, gardens, water bodies, farmlands, etc.

BCC and other implementing agencies can pick projects according to their priority and need for implementation. Integration of all prioritised interventions into other plans of the city is also important in order to avoid duplicity of efforts and enhance coordination.


Vulnerability Hotspots
Barisal City Corporation
0 700 1,400 2,800 Meters
Ward 30
Ward 29
Ward 3
Ward 4
Ward 7
Ward 1
Ward 2
Ward 28
Ward 5
Ward 27
Ward 20
Ward 19
Ward 8
Ward 6
Ward 22
Ward 18
Ward 21
Ward 17
Ward 9
Ward 15
Ward 16
Ward 14
Ward 10
Ward 23
Ward 13
Ward 11
Ward 26
Ward 12
Kirtonkhola River
Ward 24
Ward 25
Vulnerabilities for wards 5, 6 & 10:
Pollution of river water, increased health impacts & vector borne diseases, fisheries impacted, water logging, pressure on ground water increases, increase of arsenic in some places, livelihood change, biodiversity loss, crop productivity and fisheries production is lowered due to lack of natural pest control
Population impacted:
All citizens, low income labours, fishery owners, residents of slum area, rickshaw pullers/auto rickshaw drivers, farmers, day labours, women, children
Wards impacted by all fragile urban systems
Wards impacted by two fragile urban systems
Wards impacted by three fragile urban systems
Wards impacted by one fragile urban systems
ICLEI Local Governments for Sustainability
Implemented by ICLEI South Asia
In Association with Barisal City Corporation
THE ROCKEFELLER FOUNDATION
With Support From the Rockefeller Foundation

Abbreviations and Acronyms

ACCCRN:	Asian Cities Climate Change Resilience Network
BBS:	Bangladesh Bureau of Statistics
BCC:	Barisal City Corporation
BPDB:	Bangladesh Power Development Board
BMD:	Bangladesh Meteorological Department
CEO:	Chief Executive Officer
CRS:	City Resilience Strategy
DAE:	Department of Agricultural Extension
DC:	District Commissioner
DPHE:	Department of Public Health Engineering
FAR:	Floor Area Ratio
IAP:	ICLEI ACCCRN Process
INCCA:	Indian Network for Climate Change Assessment
IPCC:	Intergovernmental Panel on Climate Change
LGED:	Local Government Engineering Department
MoU:	Memorandum of Understanding
NGO:	Non Government Organisation
PWD:	Public Work Department
SLD:	Shared Learning Dialogue
sq. m:	Square Meter
sq. km:	Square Kilometre
UCCR:	Urban Climate Change Resilience

UDD:	Urban Development Directorate
ULB:	Urban Local Body
USD:	United States Dollar
WTP:	Water Treatment Plant

Photo credit: ICLEI South Asia

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1. Background

1.1. Introduction

It is projected that over 60% of the world's population will be based in cities by the year 2030[1]. Bangladesh is gradually making the shift from 'rural' to 'urban'. Though the level of urbanization is still rather low, only 28.4 percent, it however already had a very large population 42.7 million in 2011, living in nearly 570 urban centres in the country. Projections, keeping in mind the growth rates of population observed during 2001-2011 and based on the UN population projection model, indicate that Bangladesh would achieve 'the tipping point' of 50 per cent urban by 2047. Thus, Bangladesh is expected to be majority 'urban' within the next 35 years[2]. Due to high concentrations of people, infrastructure and resources, the most adverse impacts of climate change will likely be in these areas according to the World Bank[3]. In this context, it is of the utmost urgency that a city is able to increase climate resilience to avoid these impacts.

Climate resilience is defined as the capacity for a socio-ecological system to: (1) absorb stresses and maintain function in the face of external stresses imposed upon it by climate change and (2) adapt, reorganize, and evolve into more desirable configurations that improve sustainability of the system, leaving it better prepared for future climate change impacts[4]. Urban Climate Change Resilience (UCCR) is defined by Rockefeller Foundation as the capacity of cities (individuals, communities, institutions, businesses and systems) to survive, adapt, thrive in the face of stress and shocks, and even transform when conditions require it[5].

There are a host of benefits for cities associated with building resilience as outlined in Table 1. Investing in resilience reduces losses and damages in the event of a disaster. However, even if the anticipated disaster does not occur for a long time, increased resilience will mean reduction in background risk and unlocking of economic development potential[6].

Table 1: Potential Benefits of Resilience Building

Economic Benefits	Environmental Benefits	Social Benefits
Avoidance of runaway costs of climate change Livelihood creation Higher savings by population, businesses and government Reduced risks associated with current climate variability	Biodiversity conservation Preservation of vital ecosystems and species Conservation of water resources Improved practices for disaster risk reduction	Improved public health Decreased mortality Increased benefits to low-income households Reduced damage and loss due to natural disaster Enhanced well-being of all social groups

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5. The Rockefeller Foundation. 2015. Insights from the Asian Cities Climate Change Resilience Network: Urban Climate Change Resilience in Action: Lessons from Projects in 10 ACCCRN Cities.
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1.2. Methodology

Barisal's CRS was formulated using the IAP. The process helped to identify fragile urban systems, major climate risks to urban systems and vulnerable areas and populations in the city, which were used to formulate resilience interventions.

Pioneered by the Rockefeller Foundation, the Asian Cities Climate Change Resilience Network (ACCCRN) supports practitioners to build inclusive urban climate change resilience in over 50 rapidly urbanising cities. To facilitate this initiative, the IAP toolkit was developed which targets city governments and helps them develop their city resilience strategies with little or no external assistance.

1.2.1. Overview of ICLEI ACCCRN Process (IAP)

The IAP toolkit consists of a set of 16 tools which enables local governments to assess the climate risks of various systems in the city in context of urbanization and vulnerability, and plan resilience interventions corresponding to the fragilities identified. The IAP is designed in a step-by-step format, divided into following six phases as shown in Figure 1.

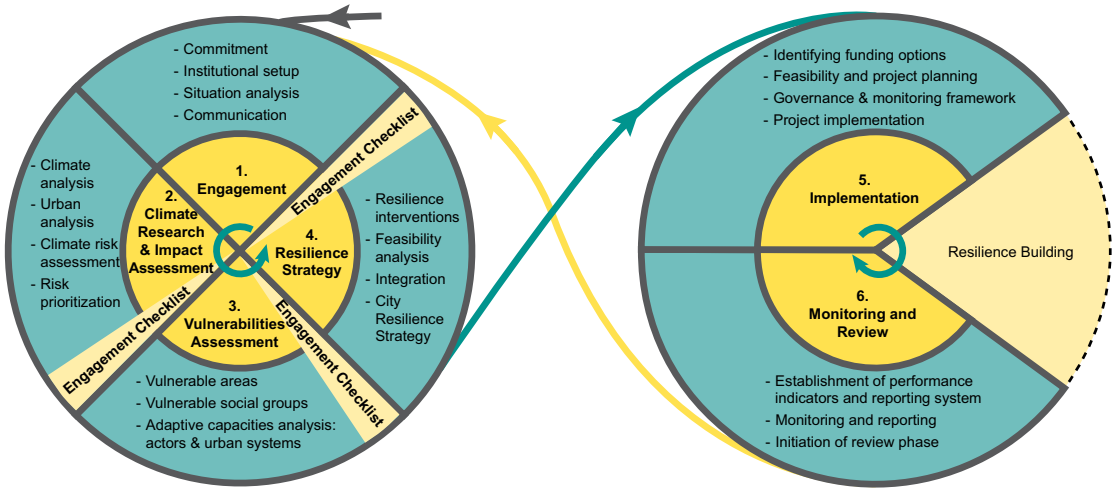

Figure 1: ICLEI ACCCRN Process

Phase 1 - Engagement: This phase begins with gaining political support in the city by formulating a Climate Core Team and a Stakeholder Committee. The Climate Core Team is responsible for the execution of project activities in the city and comprises of key officials from the city government. The Stakeholder Committee is formed with citizen representatives from various relevant institutions and organisations of the city. The Climate Core Team forms a communication plan for the city highlighting key messages to be conveyed to the public and the ways for doing so. This is followed by a scoping exercise which helps in gaining insight about the various city services and the problems faced by the city.

Phase 2 - Climate Research and Impact Assessment: This phase identifies the main impacts of climate change faced by city through SLDs with the Climate Core Team and Stakeholder Committee. An assessment of the past climate trends and future climate projections are conducted through secondary research. These are validated through analysis of city level data as well as local perceptions from city stakeholders. A risk assessment is conducted for fragile urban systems based on the likelihood and consequence of the climate risk statements for those systems.

Phase 3 - Vulnerabilities Assessment: This phase helps in identifying the key vulnerable areas with the fragile urban system and the vulnerable population for each system. This information is gathered in consultation with the stakeholder committee through SLDs. The adaptive capacity of the urban systems is also assessed in this phase.

Phase 4 - Resilience Strategy: In this phase, the city government uses the information and analysis from the previous phases to identify the relevant resilience interventions. These interventions are prioritised on the basis of their feasibility and applicability to the city. The resilience strategy is then developed and ratified through political support.

Phase 5&6 - Implementation and Monitoring & Review: After identifying the resilience interventions for the city, concrete project implementation plans can be prepared. Opportunities for financing and implementing these projects need to be explored. In all cases, monitoring and review remains a mandate of the city government, with active involvement of the Climate Core Team.

1.2.2. IAP in Barisal City

The Mayor spearheaded the IAP with support from the Chief Health Officer, Chief Planning Officer, Engineers of BCC and ICLEI South Asia. Figure 2 illustrates the process and timeline followed in Barisal.

To initiate the IAP, planners, engineers, councillors and other representatives from BCC, were oriented on the fundamentals of urban development and climate resilience. Barisal city had already developed an urban vulnerability assessment (under the UVA Project supported by GIZ that was conducted by ICLEI SA) using IAP processes in 2013. A lot of the information that was generated during this project was utilized and built upon in the IAP. Members for the Climate Core Team (Annexure 3) and the Stakeholder Committee were identified in consultation with the Mayor, Chief Health Officer, Chief Planning Officer and Engineers of the BCC by building upon the teams who were part of the group during the UVA Project.

Under the IAP, an SLD was conducted in Barisal to identify two potential climate risks. These were validated by the Climate Core Team and Stakeholder Committee in an SLD. Through this SLD and other consultations/ discussions, a comprehensive urban systems analysis was carried out that involved the identification of six urban systems e.g. (i) Sanitation (ii) Water Supply (iii) Land use Change (iv) Ecosystem (v) Health System and (vi) Storm Water Drainage as fragile. The six fragile urban systems identified were critically analyzed considering the direct and indirect impacts of identified climate risks.

A vulnerability assessment was carried out to critically evaluate the sensitivity, exposure and adaptive capacity of the six fragile urban systems, identify vulnerable areas for each climate risk and their associated vulnerable actors. Finally, the vulnerability hotspots, reflecting the fragility of a ward, were arrived at by overlaying all the vulnerable wards identified under each fragile urban system.

A list of resilience interventions targeting improved urban resilience and reduced climate risk for all fragile urban systems was developed. These were assessed for their technical, social and financial feasibility and their applicability to Barisal. Interlinkages of these resilience interventions with on-going and planned projects were established and further integration into existing city-level plans was explored.

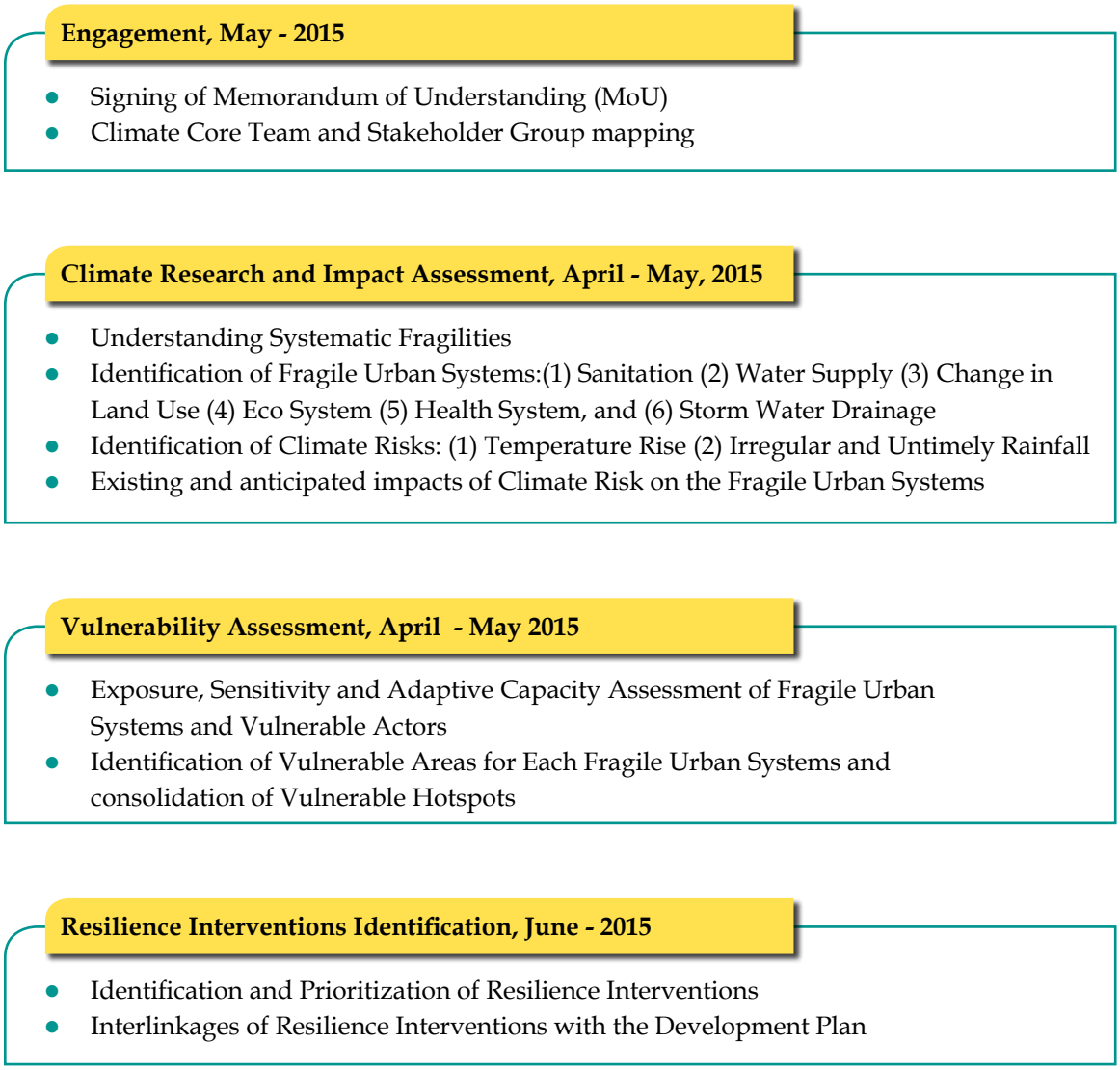

Figure 2: Methodology of IAP in Barisal

Using this CRS, the BCC can develop a more resilient city.

2. City Profile

Barisal city is one of the oldest municipalities in Bangladesh which was established in the year of 1876. It became a City Corporation on 25 July 2002 and includes a total area of 58.05 sq. km. The Corporation consists of four *thanas* (sub-district), 30 wards and 225 *mahallas* (neighbourhoods). The city is a major river port, meeting point of several roads connecting the various important areas of the region, but without any rail communication. Barisal city is the sixth largest city of Bangladesh in respect of population, but is one of the smallest in terms of geographical area.

2.1. Location

Barisal city is located in the southern region of Bangladesh, on the western part of the river Kirtonkhola between 22°37′N and 22°45′ N and 90°16′E and 90°32′ E. It is bounded by Kaunia and Airport *thanas* on the north, Nalchity and Bakerganj *thanas* on the south, Kaunia and Bandar *thanas* on the east, Airport and Kotwali Model *thanas* and Nalchity *thana* on the west (Figure 3).

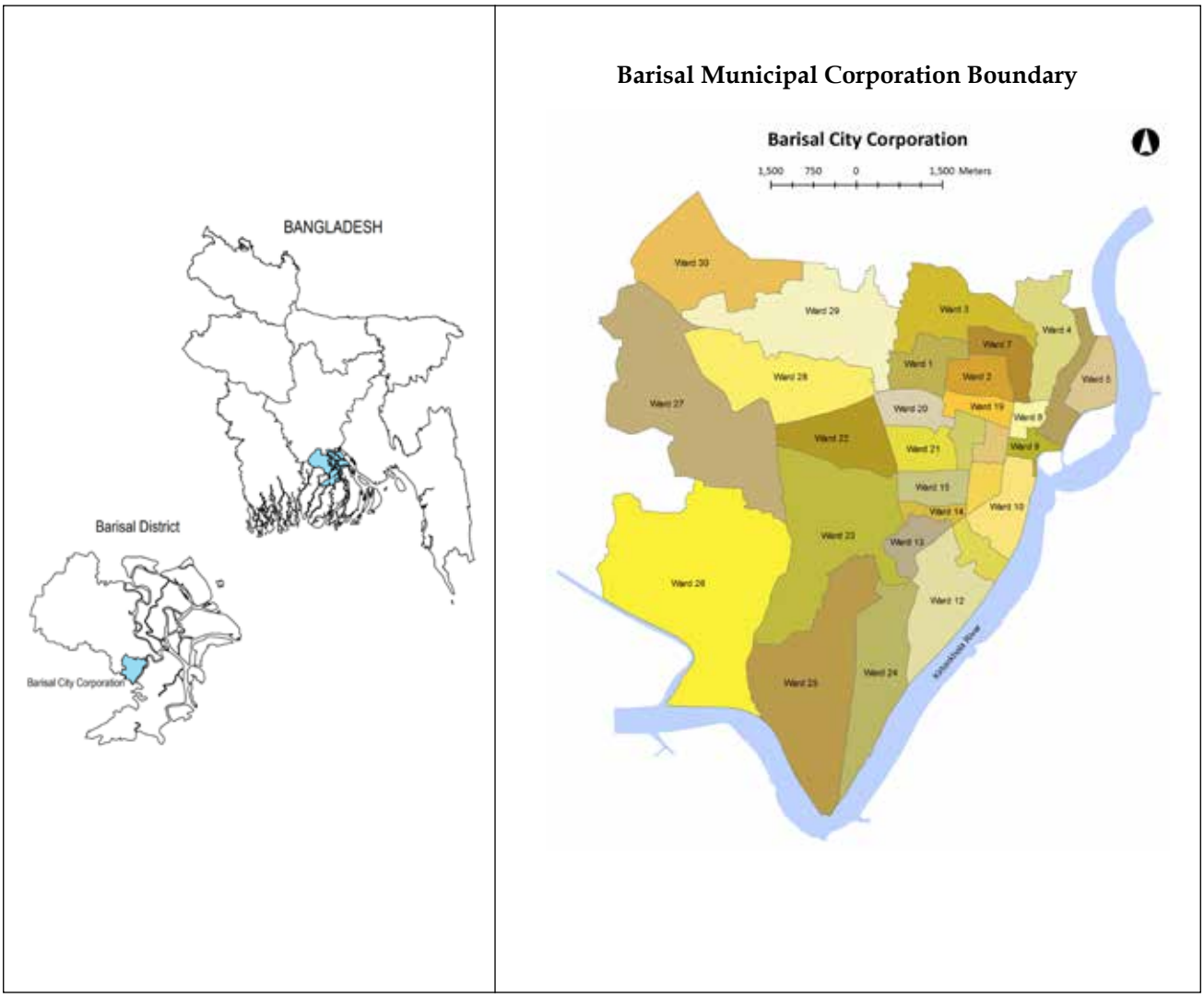

Figure 3: Location Map of Barisal

According to the BBS population census 2011, the population of BCC was 328,278 comprised of 169,475 males and 158,803 females and comprises of 72,709 households. The population density was 5,396 persons/sq. km. distributed among 30 wards spread over 58.05 sq. km. city corporation area, where, wards 5 and 27 are the most and least congested ward respectively. The following table represents the ward wise population of BCC and their population density. The literacy rate of the city corporation is 75.30%.

Table 2: Ward-wise Area and Population of Barisal City Corporation, 2011

Ward No.	Area of Ward (sq. km.)	Total Population	No. of Households	Population Density (Persons/sq. km.)
1	0.90	14,768	3,441	16,409
2	2.10	13,888	3,425	6,613
3	1.80	11,634	2,899	6,463
4	1,00	12,695	2,903	12,695
5	0.90	18,740	4,193	20,822
6	0.75	13,818	3,153	18,424
7	0.60	10,284	2,324	17,140
8	0.50	7,297	1,274	14,594
9	0.75	6,790	1,199	9,053
10	1.00	8,328	1,870	8,328
11	0.90	14,611	3,002	16,234
12	1.35	5,791	1,146	4,290
13	0.75	9,700	2,115	12,933
14	0.50	8,321	1,872	16,642
15	0.60	11,196	2,549	18,660
16	0.50	6,360	1,325	12,720
17	0.40	6,171	1,397	15,428
18	0.60	8,119	1,730	13,532
19	0.70	13,695	3,051	19,564
20	0.85	8,802	1,736	10,355
21	0.80	9,007	2,093	11,259
22	2.00	9,409	2,193	4,705
23	4.95	14,765	3,236	2,983
24	3.70	19,904	4,498	5,379
25	5.04	14,523	3,126	2,882
26	6.65	10,132	2,195	1,524
27	4.90	7,440	1,598	1,518
28	3.81	8,947	1,969	2,348
29	4.70	15,140	3,493	3,221
30	4.05	8,003	1,704	1,976
Total	**58.05**	**328,278**	**72,709**	**308,694**

2.2. Economy and Employment

Barisal is a river port city with several established trade and commerce centres. The economy of the city is largely dependent on business. Moreover, the city is one of the most important rice producing centres of Bangladesh. A socio-economic survey under preparation of Barisal city master plan (2010-30) revealed that the percentage of major occupational engagements is in government and autonomous organizations (approximately 25%).

2.3. City Administration

BCC regulates most of the civic function and services in the city. At present, the City Corporation consists of elected members including a Mayor, 30 Councillors, including nine female Councillors for the reserved seats. The Mayor and Councillors are responsible for all policy decisions. There is a position for Chief Executive Officer (CEO) who is the head of city corporation administration and is responsible for the functioning of the Corporation including tax collection, estates maintenance, projects, among other things. This is an administrative cadre service post and appointed by the central government. The BCC provides and maintains services which include water purification and supply, sewage treatment and disposal, garbage disposal and street cleanliness, solid waste management, building and maintenance of roads and streets, street lighting, maintenance of parks and open spaces, cemeteries and crematoriums, registering of births and deaths, conservation of heritage sites, disease control including immunization, and public municipal schools.

Other than the City Corporation, development and planning schemes are implemented by some other government organizations which are as follows:

a) Urban Development Directorate –Responsible for preparing the city master plan, and other development policies.

b) Local Government Engineering Department – Responsible for construction of local roads, bridges, culverts etc.

c) Department of Public Health Engineering – Responsible for conducting surveys to determine the water contamination level like arsenic and its pollution in the area.

d) Public Works Department –Responsible for implementation of government construction projects. It also undertakes projects for autonomous bodies as deposit works.

e) Department of Agricultural Extension – Promotes subsidy for betterment of farmers, distributes fertilizer to the poor farmers, and often arranges trainings for farmers on modern techniques of cultivation.

f) Forest Department – Responsible for forest extension, biodiversity and wildlife conservation etc.

g) Roads and Highways Department – Responsible for the construction and maintenance of major roads and bridge networks.

h) Bangladesh Water Development Board – Responsible for flood control, drainage and irrigation activities as well as to enhance water resource management.

i) Bangladesh Power Development Board – Provides electricity to the residents, commerce and industrial establishment on priority and their capacity basis.

j) Bangladesh Rural Development Board – Responsible for socio-economic development through implementation of policies and projects for rural development.

3. Past Hazards and Climatic Events

Cyclones and floods are the main natural hazards in the city. In Barisal, flooding occurs due to excessive precipitation during monsoon or during cyclonic events. Flooding clearly enhances the vulnerability of Barisal city. Barisal has always been located in a cyclone prone area and the general perception is that there has been no significant change in frequency or intensity of these events. However, it has been noticed that in a period of five years i.e. 2007 to 2012 there have been three high intensity cyclones, whereas before 2007, in the past 20 years, i.e. 1998 to 2006 only one high intensity cyclone has been reported (in 1991). This seems to indicate an increase in the frequency of high intensity cyclone events. Some of the important disasters have been categorized below (Table 3).

Table 3: List of climatic disasters affecting Barisal and adjacent areas since the 1950s[7]

Event	Year	Impact	Affected Area
Cyclonic Storm	1958	870 persons killed, 14,500 cattle lost and standing crops destroyed.	East and west Meghna estuary, east of Barisal, Noakhali.
Cyclonic Storm	1965	16,456 people were killed.	Barisal and Bakerganj.
Cyclonic Storm	1983	300 fishermen with 50 boats missing and 2,000 houses destroyed.	Chittagong, Cox's Bazar coast near Kutubdia and the low lying areas of St Martin's Island, Teknaf, Ukhia, Moipong, Sonadia, Barisal, Patuakhali and Noakhali.
Cyclonic Storm	1986	14 persons killed, damage to 97,200 ha of paddy fields, schools, mosques, warehouses, hospitals, houses and buildings at Amtali *upazila* in Barguna.	Offshore island and chars of Chittagong, Barisal, Patuakhali and Noakhali.
Cyclonic storm followed by Flood	1988	Killed 5,708 persons and a lot of wild animals –15,000 deer, 9 Royal Bengal Tiger, 65,000 cattle - and crops worth about Tk 9.41 billion damaged.	Jessore, Kushtia, Faridpur, offshore islands and chars of Barisal and Khulna; severe cyclonic storm with core wind speed 162 km/hr, storm surge of 4.5m at Mongla point.
Cyclonic Storm	1991	People killed, cattle head perished, boats lost and standing crops destroyed.	Offshore islands and chars of Patuakhali, Barisal, Noakhali and Chittagong.
Flood	2004	Affected over 6.5 lakh people and marooned at least two lakh in about 716 sq. km. areas. According to a preliminary estimate made by the district administration, the flood damage was worth at least Tk 32 crore in different sectors. These included Tk 21.86 crore crops damaged on 20,840 hectares of land, Tk 51.41 lakh fishes in 3,661 farms and Tk 1.5 crore shrimps in over 150 farms.	71 unions in Barisal district.

7. http://en.banglapedia.org/index.php?title=Cyclone

Event	Year	Impact	Affected Area
Cyclone (Sidr)	2007	Hundreds perished as buildings collapsed in the 240 km per hour winds. Thousands of others drowned in tidal surges that were over 15 feet high in many villages. The cyclone –resulted in 3,363 deaths, 55,282 injured people, 1.5 million damaged or destroyed homes, and 2.5 million acres of damaged cropland[8].	On the evening of 15 November 2007, Cyclone Sidr – a category four cyclonic storm – hit the low-lying and densely-populated coast of Bangladesh. The cyclone ravaged 30 southern districts in both Barisal and Khulna divisions.
Cyclone (Aila)	2009	An estimated 243,000 houses have been fully destroyed and over 373,000 partially damaged. As per information from the Food and Disaster Management Ministry (FDMM), it left up to 190 dead and thousands marooned in the coastal areas[9].	Cyclone Aila hit the south-western coast of Bangladesh on 25 May 2009. The eight affected districts included Barisal, Bhola, Pirojpur, Sathkira, Khulna, Bagerhat, Barguna and Patuakhali.
Flash flood	2010	At least 50 villages and shoals of five *upazilas* of the district went under water[10].	50 villages in Barisal district while tidal water flooded five villages in Patuakhali in the last two days.

Photo credit: ICLEI South Asia

8. https://www.unicef.org/bangladesh/4926_4990.htm
9. http://www.ifrc.org/docs/appeals/09/MDRBD004_OU2.pdf
10. http://reliefweb.int/sites/reliefweb.int/files/resources/2E1CD584FE933BB9C1257744002CF1E4-Full_Report.pdf

4. Climate Scenario in the City

Barisal has a tropical wet and dry climate. There is much less rainfall in winter than in summer. The annual average temperature is a maximum of 35.1°C and a minimum of 12.1°C and average annual rainfall is 1,955 mm.

The past climate trends of Barisal city using climate data collected from the Bangladesh Meteorological Department (BMD) are depicted in the following sections.

4.1. Past Climate Trends

According to the IPCCC (2007) in its fourth Assessment report, in Bangladesh, the average temperature has registered an increasing trend of about 1°C in May and 0.5°C in November during the 14 year period from 1985 to 1998. The annual mean rainfall exhibits increasing trends in Bangladesh. Decadal rain anomalies are above long-term averages since 1960s.

Using data collected by the BMD the past trends of the rainfall and temperature for Barisal city over a period of 64 years (from 1949 to 2013) were analysed. There is a distinct decrease in the average annual rainfall over the last 60 years. The pattern has also changed with the summer rain increasing slightly, but the rainfall during other seasons decreasing as shown in the following graphs. The sharpest decline can be seen in the monsoonal rainfall graph.

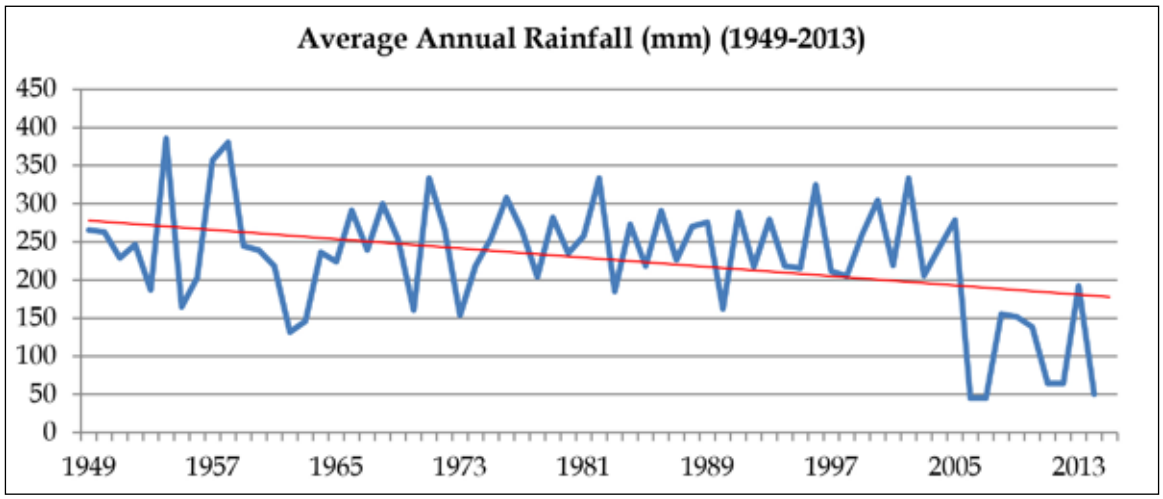

Figure 4: Average Annual Rainfall for Barisal City

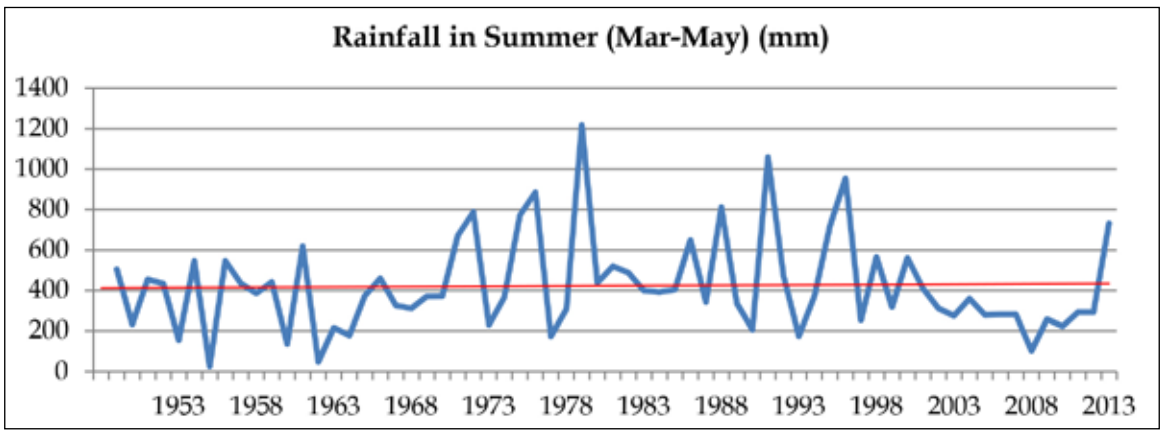

Figure 5: Rainfall in Summer for Barisal City

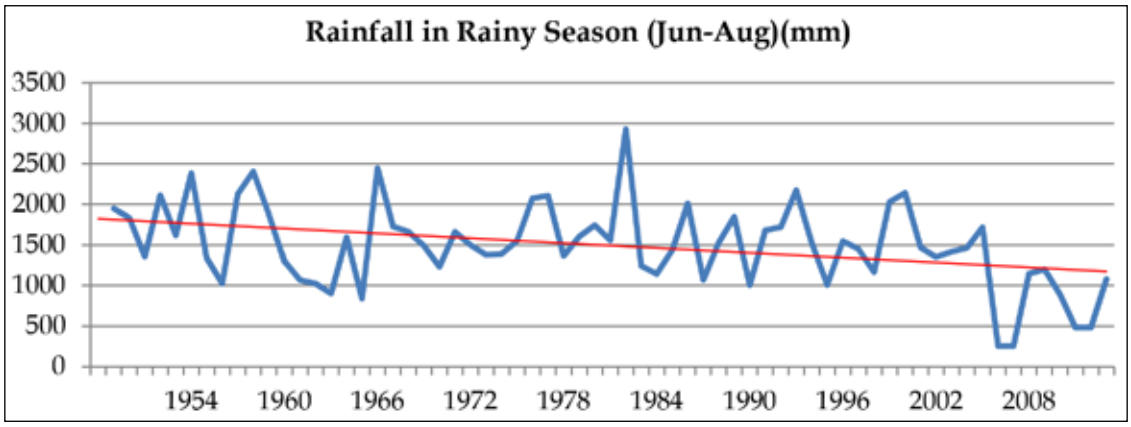

Figure 6: Rainfall in Rainy Season for Barisal City

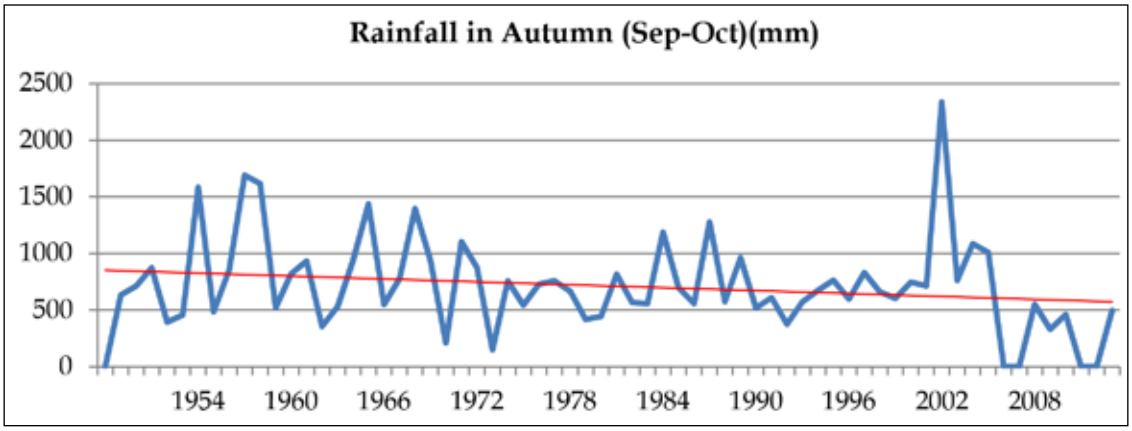

Figure 7: Rainfall in Autumn Season for Barisal City

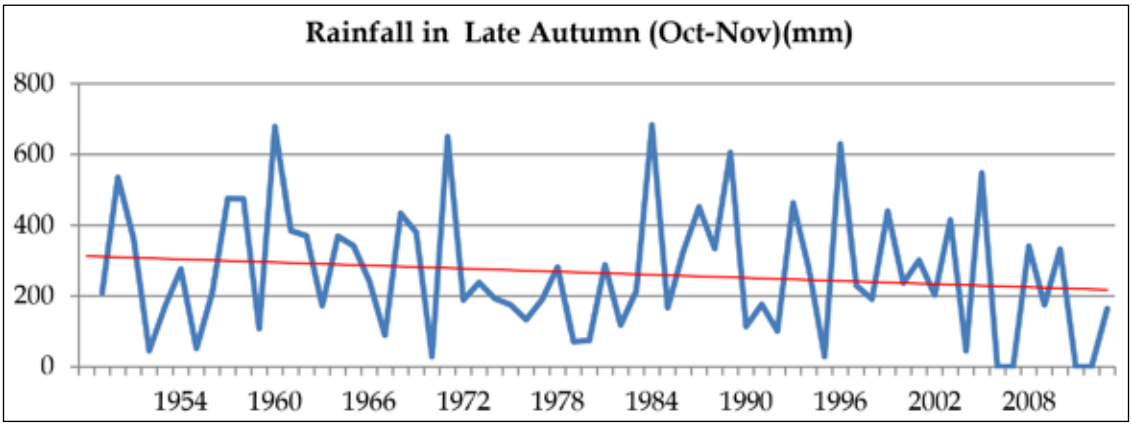

Figure 8: Rainfall in Late Autumn for Barisal City

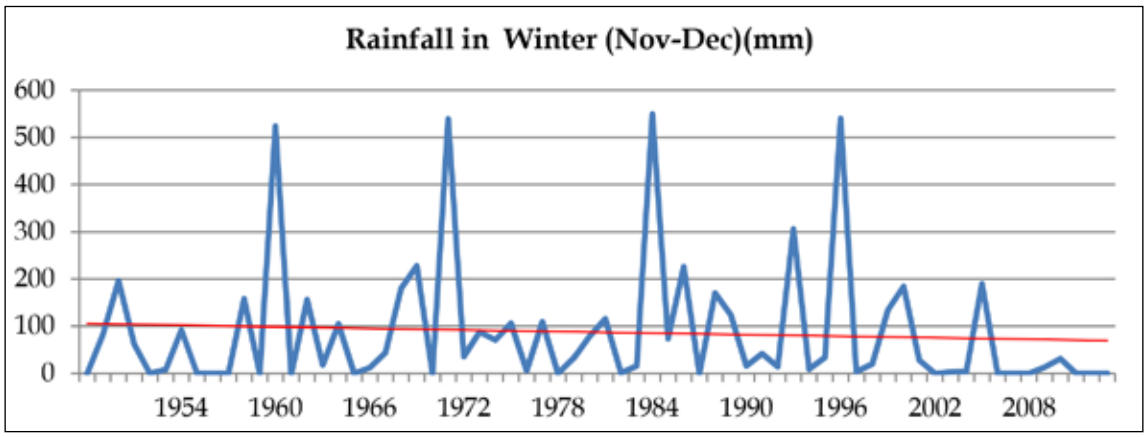

Figure 9: Rainfall in Winterfor Barisal City

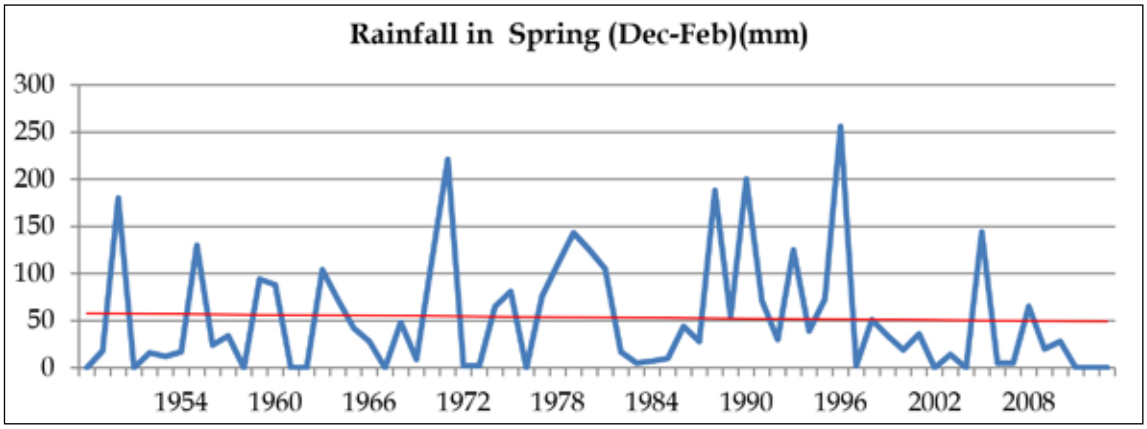

Figure 10: Rainfall in Spring for Barisal City

Looking at the temperature trends of the 60 year period it appears that the average annual temperature has increased slightly over the last 60 years. The annual maximum temperature has increased slightly, but the annual minimum temperature has remained more or less the same.

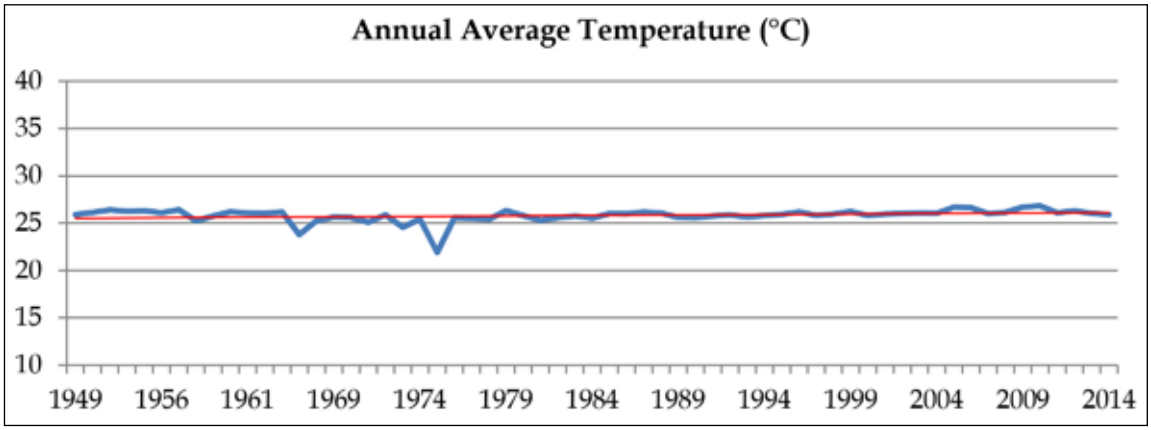

Figure 11: Average Annual Temperature for Barisal City

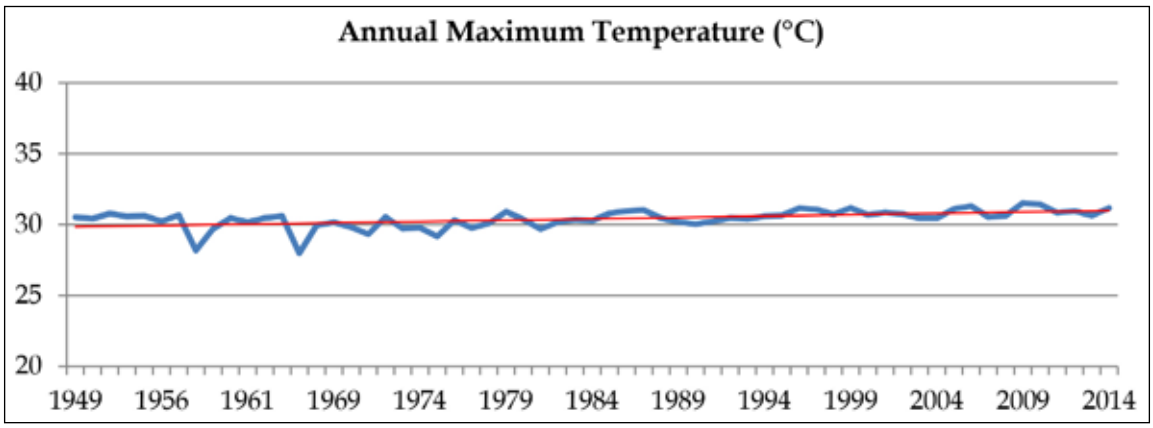

Figure 12: Average Annual Maximum Temperature for Barisal City

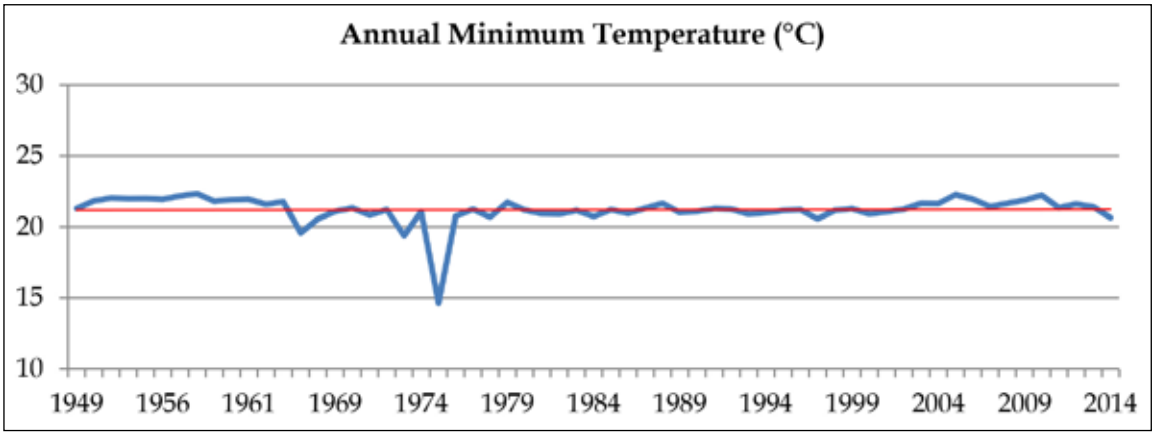

Figure 13: Average Annual Minimum Temperature for Barisal City

4.2. Climate Change Projections and Climate Scenario Statements

Although there is no dedicated literature available detailing climatic projections for various regions in Bangladesh, the National Plan for Disaster Management (2010-2015) published by the Government of Bangladesh[11] and the Vulnerability, Risk Reduction and Adaptation to Climate Change, Climate Risk and Adaptation Country profile, (2011) published by the World Bank is referred to[12]. The National Plan for Disaster Management used a regional climate model PRECIS for Bangladesh.

11. Government of Bangladesh. 2010. National Plan for Disaster Management, 2010 – 2015, Disaster Management Bureau Disaster Management & Relief Division, Government of Bangladesh, Dhaka.
12. World Bank Group. 2011. Vulnerability, Risk Reduction and Adaptation to Climate Change, Climate Risk and Adaptation Country profile, World Bank, Global Facility for Disaster Reduction and Recovery, Climate Investment Funds.

Table 4: Climate Scenario Statements

Changing Climate Conditions	Assessments	Climate Scenario Summary Statements
Precipitation change	National Assessment[11]	Pre-monsoon rainfall will decrease while monsoon and post-monsoon rainfall will increase. From 2051 onwards annual average rainfall and monsoon rainfall will follow a higher increasing trend.
	National Assessment[12]	There will be an increase in the amount of run-off, and rainfall intensity.
Temperature change	National Assessment[11]	The monthly average maximum temperature will increase during the monsoon period and will decrease in other periods. The monthly average minimum temperature will increase in all periods and the Annual Maximum and Minimum temperature will follow an increasing trend.
	National Assessment[12]	Mean temperatures across Bangladesh are projected to increase between 1.4°C and 2.4°C by 2050 and 2100, respectively.
Extreme events	National Assessment[11]	The frequency of tropical cyclones in the bay of Bengal may increase and, according to the Intergovernmental Panel on Climate Change's Third Assessment Report, there is *"evidence that the peak intensity may increase by 5% to 10% and precipitation rates may increase by 20% to 30%"* (IPCC 2001). Cyclone-induced storm surges are likely to be exacerbated by a potential rise in sea level of over 27cm by 2050.

The perceived changes correspond to the national assessments observed through different studies. In Barisal, it has been observed that there are higher temperatures in summer with a decrease in the number of cold days. There is observed to be a trend of decreasing precipitation with short duration and high intensity rainfall increasing in the city. The frequency of cyclones is also believed to have increased lately with higher intensity as well.

The three climate risks are therefore

Climate risk 1: Increased temperature,

Climate risk 2: High intensity rainfall and

Climate risk 3: Increase in frequency of cyclones.

5. Climate Impact Assessment

Climate impact assessment of urban systems helps to assess their fragilities with respect to the climate impacts identified earlier. These urban systems could include 'core systems' such as water, sewerage, transport which are essential for running the city and 'secondary systems' such as health, education, sanitation which rely on the core systems. The urban system analysis in Barisal identified six fragile urban systems through rigorous discussions in the SLDs:

(i) Sanitation

(ii) Water Supply

(iii) Land use Change

(iv) Ecosystem

(v) Health System

(vi) Storm Water Drainage

5.1. Urban Systems Analysis

5.1.1. Sanitation

Situation Analysis

There is no sewerage system in Barisal at present. Toilets are connected to septic tanks, but these often lack soak pits or are poorly designed. The septic tanks lead to the drains sometimes clogging them. The drains open into nearby rivers, polluting the water, causing vector borne diseases and impacting fisheries. It indirectly affects human health and productivity.

Fragility Statement and Climate Fragility Statement

There is no existing sewerage system in Barisal. Households have septic tanks, but toilets often bypass the tanks and empty into rivers or drains causing water pollution and adverse impacts on health.

The climate fragility statements for Sanitation are:

Climate Risk 1: Increased temperature may lead to an increase in the spread of disease causing vectors in river/canal water polluted by septic tank sludge which will impact the health of citizens.

Climate Risk 2: High intensity rainfall may cause overflow of septic tanks, leading to greater water pollution and more health impacts.

Climate Risk 3: Excessive rain and water logging caused by cyclones may cause septic tank overflow and water pollution, leading to health issues.

5.1.2. Water Supply

Situation Analysis

The municipal water supply system is unreliable and most people depend on tubewells for drinking water. In case there is shortage, tankers are used to supply water from the corporation. Cyclonic events which are a regular feature in the city damage tubewells and contaminate them. Indiscriminate use of tubewells also contributes to the lowering of the ground water table.

There are a number of ponds in the city which are being encroached upon and built upon, but there is a possibility of renovating and conserving them for use as water sources.

Fragility Statement and Climate Fragility Statement
Water supply system is fragile because of poor maintenance, which does not ensure supply of good quality water, thereby leading to excessive use of tubewells, causing ground water depletion and arsenic pollution, impacting health.

The climate fragility statements for this system are:

Climate Risk 1: Increased temperature will lead to greater use of tubewells to meet increased water demand, depleting the ground water table and exacerbating arsenic pollution.

Climate Risk 2: Increased intensity of rainfall will cause greater run off leading to lower percolation and lower recharge of ground water, putting stress on drinking water resources.

Climate Risk 3: Excessive rainfall and water logging caused by cyclones will cause contamination of water sources - both surface and ground water, leading to drinking water scarcity and health impacts.

5.1.3. Land use Change

Situation Analysis
In Barisal, there is no master plan that is followed during purchase of land. As a result, industrial and commercial areas are being built up within residential areas. Public spaces are reducing because of unplanned construction. There is no regulation of land use by the City Corporation.

Since Barisal is a port city, and is a major commercial centre in the region, in-migration is a major issue causing stress on land resources and other natural resources. The existing problems include:

1. Unplanned development
2. River/canal bank encroachment
3. Filling up of ponds
4. Livelihood change
5. Water logging of certain areas

Fragility Statement and Climate Fragility Statement
There is a lack of information among public regarding the existing land use policy in master plan. Not considering the policy while purchasing land for specific purposes, encroachment and filling up of water bodies cause unplanned development and environmental damage.

The climate fragility statements for this system are:

Climate Risk 1: High intensity rainfall in case of unplanned development will result in water logging and urban flooding, with related impacts on the health and socio-economic structure of the city.

Climate Risk 2: Cyclones will cause damage to urban service infrastructure resulting in financial losses to BCC and disrupting urban services.

Cyclones will cause greater damage to personal property, life and livelihood in case of unplanned development.

5.1.4. Ecosystem

Situation Analysis

Barisal city is next to the Kirtonkhola River and is heavily dependent on the river for its economy. However, ever-increasing siltation in the canals, river pollution, and deforestation are causing destruction of ecosystems. The major impacts on ecosystems and their services include:

- Biodiversity loss
- Air pollution
- Disturbance of Microclimate regulation
- Lower Crop productivity, and Fisheries production due to lack of natural pest control
- Reduction in ecosystem services affecting livelihood

Fragility Statement and Climate Fragility Statement

Since local livelihood is strongly based on ecosystem services, damage to ecosystems impacts productivity and economic well-being of citizens and natural resources (air, water, forests).

The climate fragility statements for this system are:

Climate Risk 1: Increased temperatures may cause changes in crop pattern.

Climate Risk 2: Increased intensity of rainfall can damage agriculture/livestock/fishery impacting livelihood.

Climate Risk 3: Cyclones can affect agriculture/fishery/livestock and therefore livelihoods will be impacted. Cyclones may result in deforestation, leading to damage to soil and water resources.

5.1.5. Health System

Situation Analysis

The primary health care is a service that is provided by NGOs rather than the Municipal Corporation for whom healthcare is not a mandate. Currently there is no monitoring of the health service and no integration of different governments and NGOs for health services. Rapid urbanisation in the city and increasing population, especially rapid increase of in-migration, limits the ability of the health care system to meet demands.

Fragility Statement and Climate Fragility Statement

Health care system is inadequate to meet the needs of the city at present, with several NGOs providing primary health care to supplement the government health care system. Lack of quality monitoring of health care services makes the system more fragile.

The climate fragility statements for this system are:

Climate Risk 1: Increased temperatures may cause heat stress and related health disorders, e.g. diarrhoea, thereby increasing demand of health infrastructure.

Climate Risk 2: Cyclones will increase stress on health infrastructure due to increased morbidity and mortality.

5.1.6. Storm Water Drainage

Situation Analysis

The natural drains of Barisal have been significantly reduced through encroachment of canals and their siltation. The storage capacity of ponds in the city and carrying capacity of storm water drains and natural drains is poor. With increasing population and poor drainage design, overflow becomes imminent. Furthermore, maintenance of drains is poor. Often, due to the above, the city is prone to events of artificial flooding. In summary, the main issues with the drainage system are:

- Sewage is released into drains
- Hotel waste released into drains
- Open drains at the household level
- Odour, vectors – mosquitoes, flies – impact health

Fragility Statement and Climate Fragility Statement

Closing natural drains and ponds by encroachment causes a reduction in the natural water storage capacity and siltation of drains causes reduction in carrying capacity, thereby leading to possibilities of overflow during heavy rain.

The climate fragility statement for this system is:

Climate Risk 1: High intensity rainfall or rain from cyclones can cause overflow of drains, leading to urban flooding and impact health."

The urban fragility statements are explained in Annexure 1.

5.2. Risk Assessment

The risks associated with the fragilities of these systems were calculated through a risk assessment exercise conducted by the stakeholder group during an SLD. The fragile urban systems with the highest risks as per the assessment were investigated further.

The risk score for each climate fragility statement is defined as a combination of the likelihood of an event to occur and the consequences faced if the event occurred.

The risk scoring is detailed in Annexure 2. Table 5 shows the risk status of the climate fragility statements.

Table 5: Risk Assessment of Climate Fragility Statements

Urban System	Impacts of Climate Change	Risk Status
Sanitation	Increased temperature may lead to an increase in the spread of disease causing vectors in river/canal water polluted by septic tank sludge which will impact the health of citizens.	Extreme
	High intensity rainfall may cause overflow of septic tanks, leading to greater water pollution and more health impacts.	
	Excessive rain and water logging caused by cyclones may cause septic tank overflow and water pollution, leading to health issues.	High

Urban System	Impacts of Climate Change	Risk Status
Water Supply	Increased temperature will lead to greater use of tubewells to meet increased water demand, depleting the ground water table and exacerbating arsenic pollution.	Extreme
	Excessive rainfall and water logging caused by cyclones will cause contamination of water sources - both surface and ground water, leading to drinking water scarcity and health impacts.	
Land use Change	High intensity rainfall in case of unplanned development will result in water logging and urban flooding, with related impacts on the health and socio-economic structure of the city.	High
	Cyclones will cause damage to urban service infrastructure resulting in financial losses to BCC and disrupting urban services.	
	Cyclones will cause greater damage to personal property, life and livelihood in case of unplanned development.	Extreme
Ecosystem	Increased temperatures may cause changes in crop pattern.	Extreme
	Increased intensity of rainfall can damage agriculture/livestock/ fishery impacting livelihood.	
	Cyclones can affect agriculture/fishery/livestock and impact livelihood.	
	Cyclones may result in deforestation, leading to damage to soil and water resources.	Medium
Health System	Increased temperatures may cause heat stress and related health disorders, e.g. diarrhoea, thereby increasing demand of health infrastructure.	High
	Cyclones will increase stress on health infrastructure due to increased morbidity and mortality.	Medium
Storm Water Drainage	High intensity rainfall or rain from cyclones can cause overflow of drains, leading to urban flooding and impact health.	Extreme

Based on this risk assessment, almost all the fragile urban systems show extreme to high risks and must be prioritised immediately. The fragility statements which show medium risks (ecosystem and health) can be put on a lower priority and in subsequent sections have been excluded from the analysis.

6. Vulnerability Assessment

6.1. Overview

In order to build resilience there is a need to understand the extent of vulnerability of the city to climate change. This vulnerability depends upon the geographical location, demography, infrastructure, socio economic condition, ecological condition of the city. The IPCC, 2007[13] defines vulnerability as a function of three parameters of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (Figure 14).

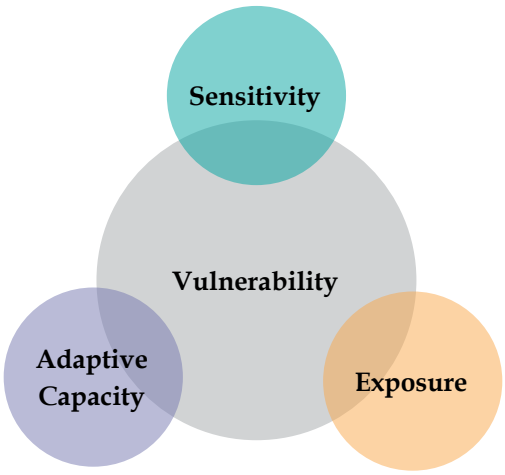

Figure 14: Vulnerability Constituents[13]

Vulnerability assessment through the IAP consists of identification of vulnerable areas and actors for all the prioritized climate fragility statements of the fragile urban systems and analysis of the adaptive capacities. Vulnerability assessment of Barisal city was carried out in consideration of the following elements:

1. **Identification of Vulnerable Places:** Highly vulnerable areas in context of identified fragile urban system of the city were identified and mapped to arrive at vulnerable hotspots affected by maximum number of fragile urban systems.
2. **Identification of Vulnerable Actors and their Adaptive Capacity:** In each of the vulnerable areas, the actors that play a critical role towards building urban resilience were identified and assessed in terms of their capacity to organize and respond to threat or disruption, access to resources necessary for response (manpower, technology, funds) and access to information necessary to develop effective plans and actions and to improve responses to disruptions. These determine the adaptive capacity/resilience of the identified actors for a particular fragile system.
3. **Assessment of Capacities of Urban Systems:** Adaptive capacity of urban systems is its capacity to absorb and respond to shocks that determines their resilience. The adaptive capacity was determined in the context of economy, technology/infrastructure, governance, social systems and ecosystems.

The sections below identify the vulnerable areas, vulnerable actors and adaptive capacity of the fragile urban systems using the climate fragility statements developed in consultation with the Stakeholder Committee.

13. IPCC. 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Annex I., M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK.

6.2. Identification of vulnerable areas of Fragile Urban Systems

6.2.1. Sanitation: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Increased temperature may lead to an increase in the spread of disease causing vectors in river/canal water polluted by septic tank sludge which will impact the health of citizens. High intensity rainfall may cause overflow of septic tanks, leading to greater water pollution and more health impacts. Excessive rain and water logging caused by cyclones may cause septic tank overflow and water pollution, leading to health issues.	Wards 5, 8, 9, 10, 13, 15, 16, 17, 18, 23, and partly in wards 6, 7, 11, 12, 14, 19, 20 (Figure 15).

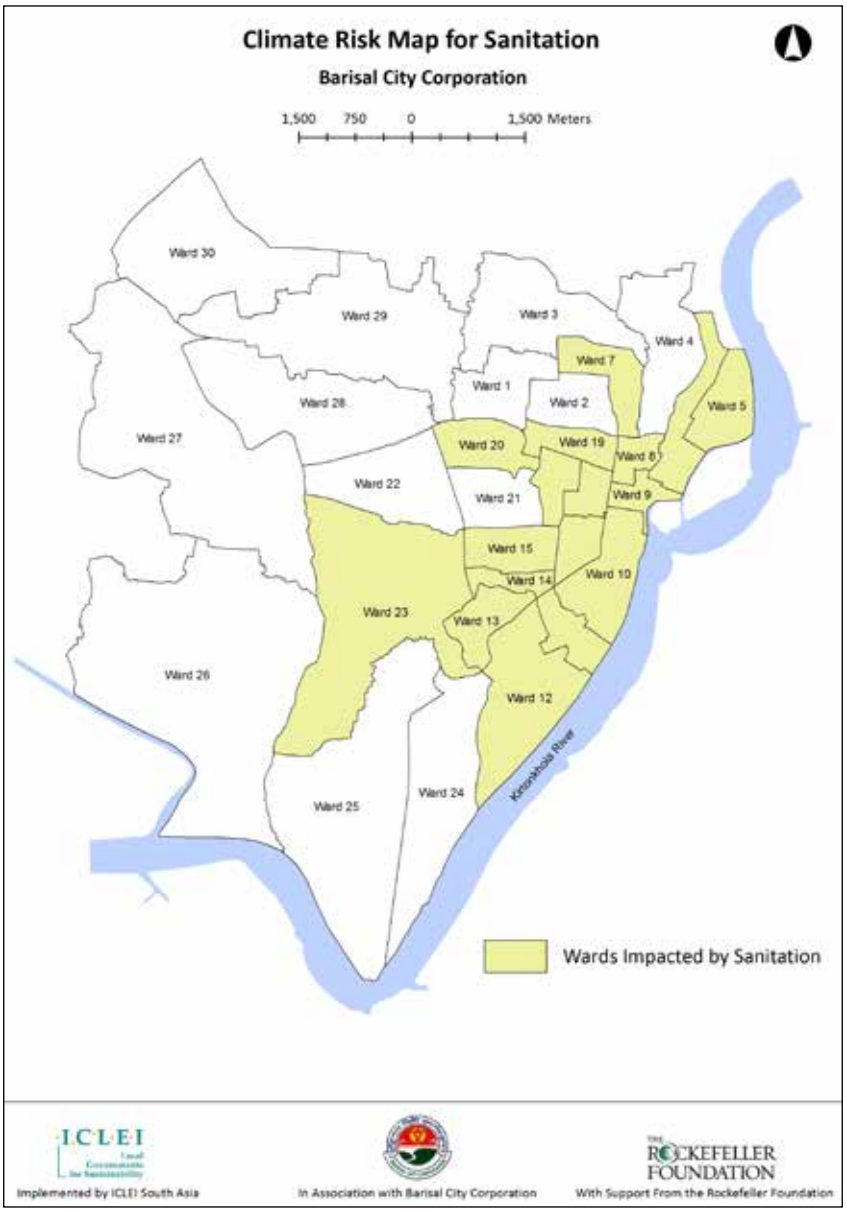

Figure 15: Wards most vulnerable to climate risks in the context of sanitation, Barisal

6.2.2. Water Supply: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Increased temperature will lead to greater use of tubewells to meet increased water demand depleting the ground water table and exacerbating arsenic pollution. Increased intensity of rainfall will cause greater run off leading to lower percolation and lower recharge of ground water, putting stress on drinking water resources. Excessive rainfall and water logging caused by cyclones will cause contamination of water sources - both surface and ground water, leading to drinking water scarcity and health impacts.	Wards 3, 24, 25, 26, 27, 28, 29, 30, and partly in wards 4 & 5 (Figure 16).

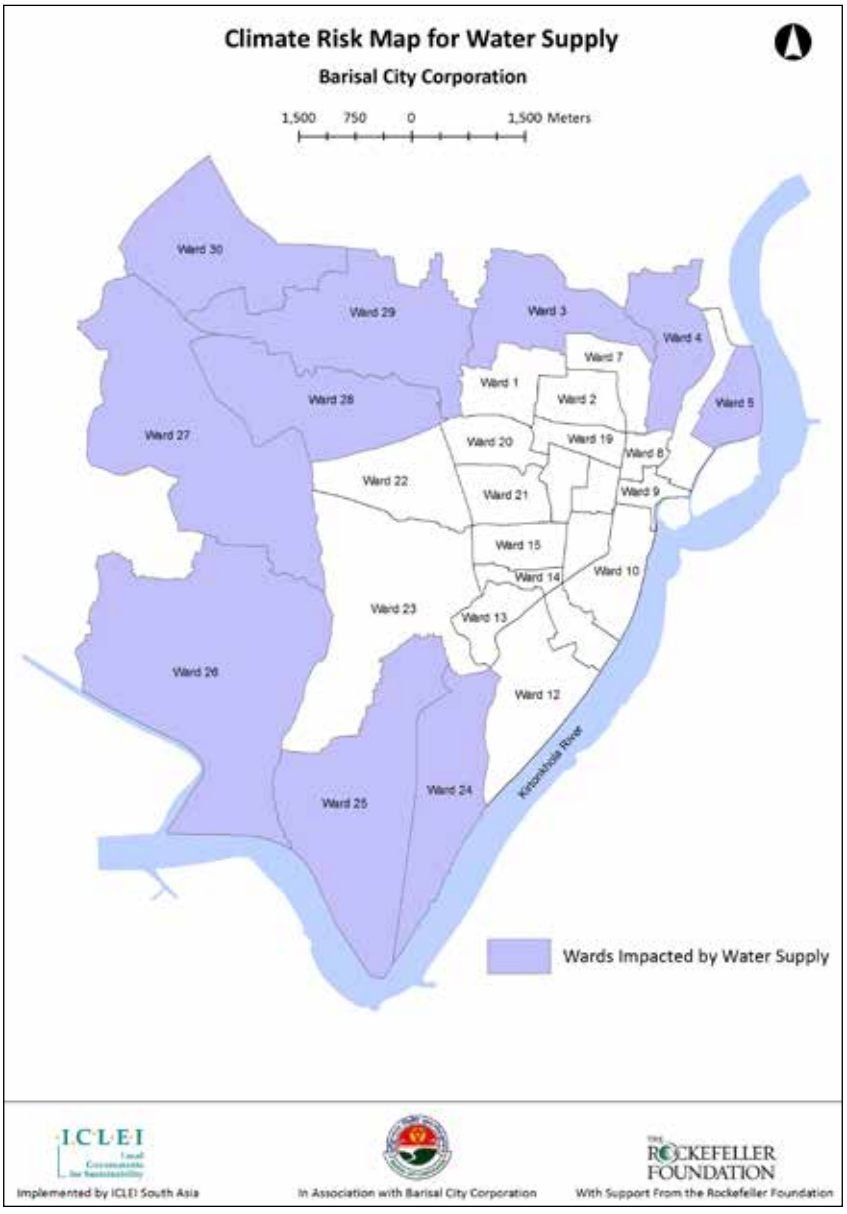

Figure 16: Wards most vulnerable to climate risks in the context of water supply, Barisal

6.2.3. Land Use Change: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
High intensity rainfall in case of unplanned development will result in water logging and urban flooding, with related impacts on the health and socio-economic structure of the city. Cyclones will cause damage to urban service infrastructure resulting in financial losses to BCC and disrupting urban services. Cyclones will cause greater damage to personal property, life and livelihood in case of unplanned development.	Wards 5, 9, 10, 11, slum areas of ward 6 and old areas of the city (Figure 17).

Figure 17: Wards most vulnerable to climate risks in the context of land use change, Barisal

6.2.4. Ecosystem: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Increased temperatures may cause changes in crop pattern. Increased intensity of rainfall can damage agriculture/ livestock/fishery impacting livelihood. Cyclones can affect agriculture/fishery/livestock and impact livelihood.	Extended areas of the city under ward 30, as well as wards 3, 5, 8, 10, 23, 24, 25, 26, 27, 28, 29 and partly in ward 4 (Figure 18).

Figure 18: Wards most vulnerable to climate risks in the context of Ecosystem, Barisal

6.2.5. Health System: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Increased temperatures may cause heat stress and related health disorders, e.g. diarrhoea, thereby increasing demand of health infrastructure.	Wards 5, 6, 10, 11, 24, 26, 27, and 30 mostly in riverside areas (Figure 19).

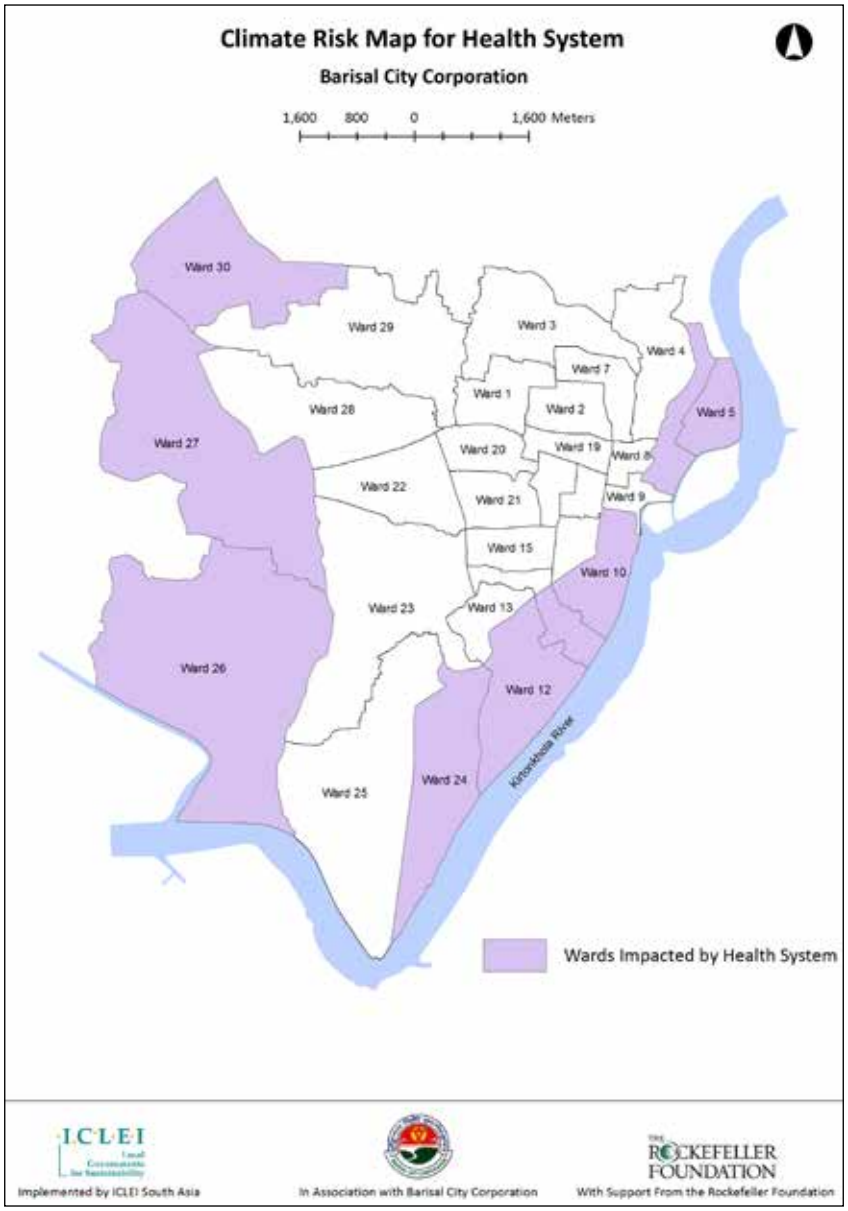

Figure 19: Wards most vulnerable to climate risks in the context of health system, Barisal

6.2.6. Storm Water Drainage: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
High intensity rainfall or rain from cyclones can cause overflow of drains leading to urban flooding and impacting health.	Wards 1, 2, 4, 5, 6, 7, 8, 9, 13, 19, 20, 29 (Figure 20).

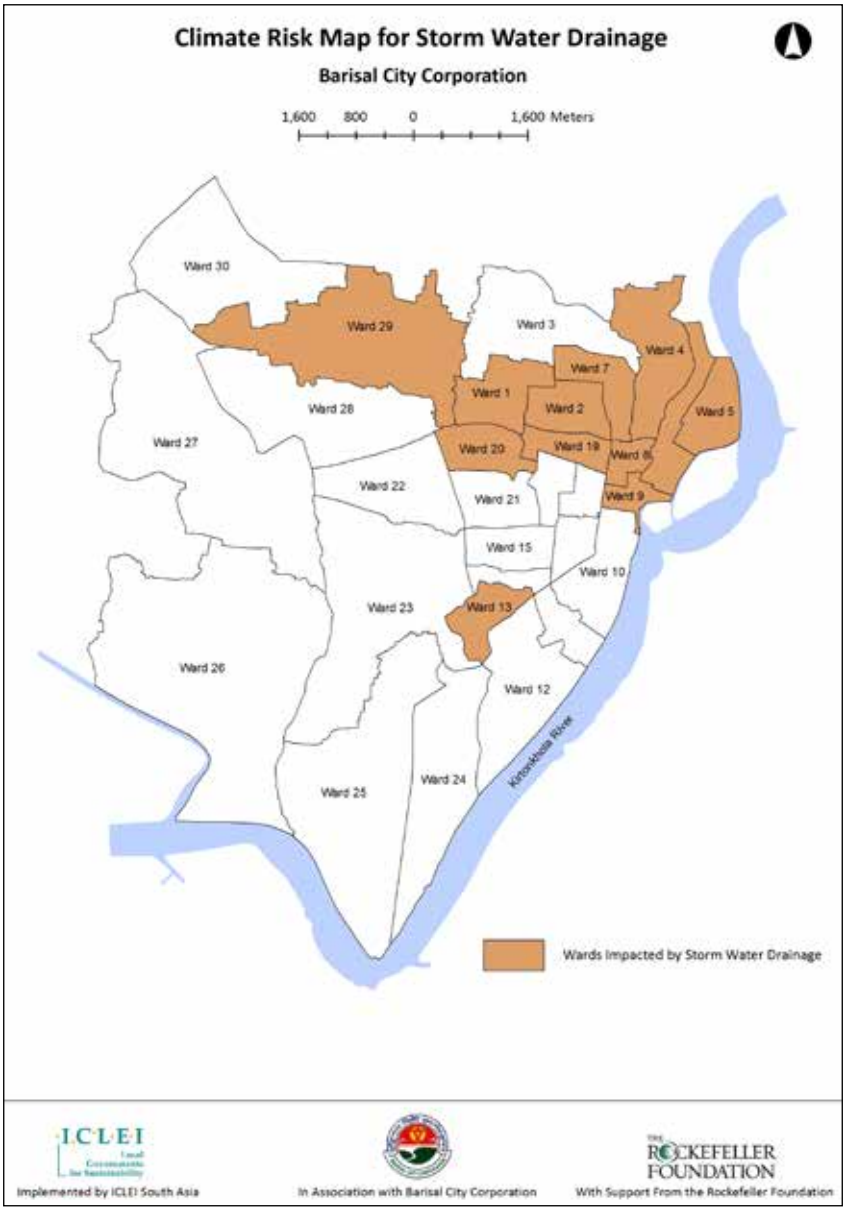

Figure 20: Wards most vulnerable to climate risks in the context of storm water drainage, Barisal

Through these assessments, the area that was found to be most vulnerable is ward 5 which is vulnerable to all six fragile urban systems, while wards 6 and 10 are vulnerable to four fragile urban systems. It is important to note that all three wards are situated near Kirtonkhola River and have substantial slum population. Other wards 4, 8, 9, 11, and fringe areas belonging to wards 24, 26, 27, 28, 29 and 30 are impacted by multiple fragile urban systems.

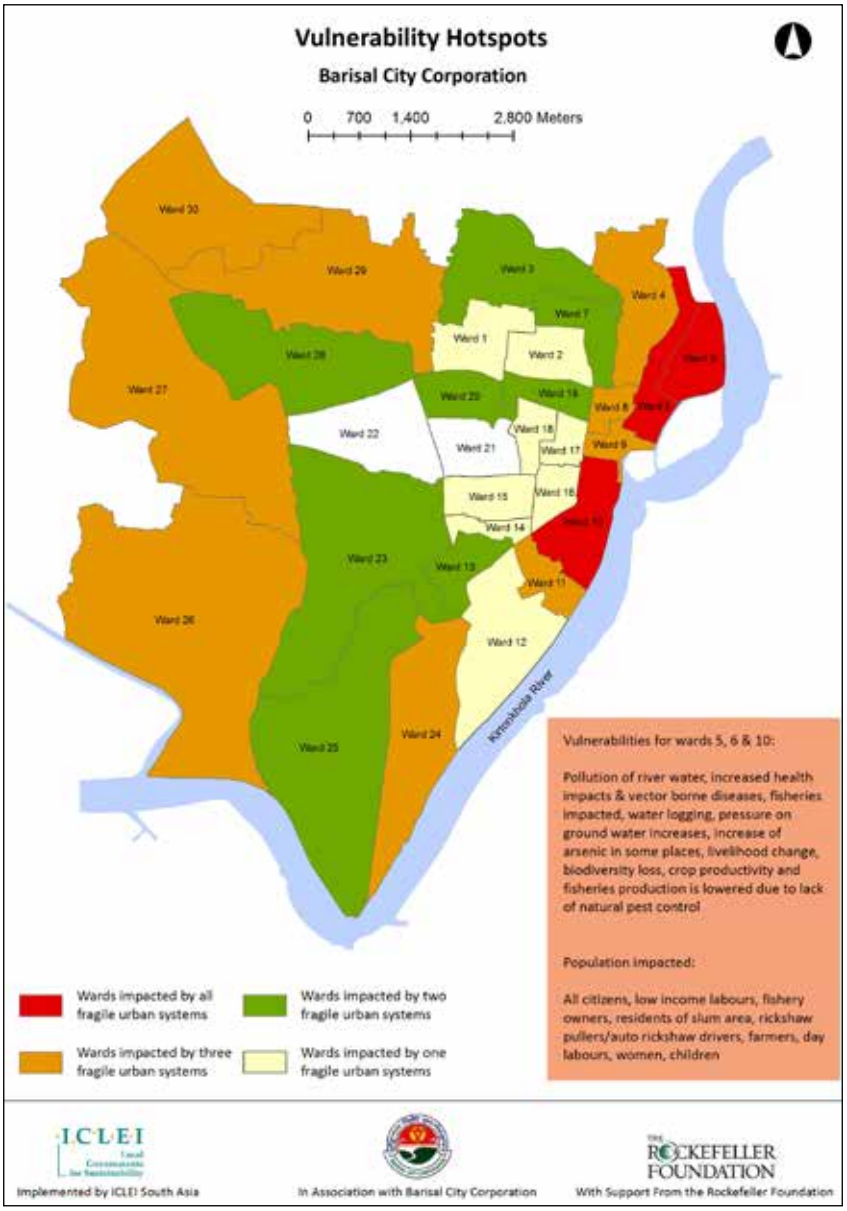

Figure 21: Consolidated Vulnerable Hotspots for Barisal city

The vulnerability hotspot map (Figure 21) helps to identify the wards which must be focused on for future interventions to build resilience that are identified in later chapters.

6.3. Actor Analysis

Identification of actors and their level of adaptive capacities were carried out through an SLD in Barisal. Among all these actors, BCC, DC office, Bangladesh Police, BPDB, DAE and operating NGOs are scored high because of their technical capacities and strength of manpower. As Barisal is a coastal city and experiences disasters almost annually, the aforementioned organizations are well equipped to deal with such events. Health and Conservancy departments of BCC scored medium as they still lack modern equipment and technologies due to fund shortage. Some fishery owners scored medium considering their capacities. Although they lack access to proper information they know how to keep themselves safe in the event of a disaster. Other low scoring actors are from the low income groups, women and children who are not able to properly respond in the case of disaster events. Their major limitations are their level of education, livelihood choices and economic conditions.

Table 6: Analysis of the adaptive capacities of local actors identified

Fragile Urban System	Climate Fragility Statements	Area/ ward most vulnerable	Actors	Level of Adaptive Capacity
Sanitation	Increased temperatures lead to more growth of disease causing vectors in river/canal water polluted by septic tank sludge which impacts health of citizens. High intensity rainfall may cause overflow of septic tanks, leading to greater water pollution and more health impacts. Excessive rain and water logging caused by cyclones may cause septic tank overflow and water pollution, leading to health issues.	Wards 5, 8, 9, 10, 13, 15, 16, 17, 18, 23, and partly in wards 6, 7, 11, 12, 14, 19, 20.	Health, conservancy department of BCC	Medium
			Citizens	Low
			Low income labourers	Low
			Fishery owners	Medium
Water Supply	Increased temperature will lead to greater use of tubewells to meet increased water demand, depleting the ground water table and exacerbating arsenic pollution. Increased intensity of rainfall will cause greater run off leading to lower percolation and lower recharge of ground water, putting stress on drinking water resources. Excessive rainfall and water logging caused by cyclones will cause contamination of water sources - both surface and ground water, leading to drinking water scarcity and health impacts.	Wards 3, 24, 25, 26, 27, 28, 29, 30, and partly in wards 4 & 5.	Health, conservancy department of BCC	Medium
			Citizens	Low
			Farmers	Low
			Residents of slum area	Low

Fragile Urban System	Climate Fragility Statements	Area/ ward most vulnerable	Actors	Level of Adaptive Capacity
Land use Change	High intensity rainfall in case of unplanned development will result in water logging and urban flooding, with related impacts on the health and socio-economic structure of the city. Cyclones will cause damage to urban service infrastructure resulting in financial losses to BCC and disrupting urban services. Cyclones will cause greater damage to personal property, life and livelihood in case of unplanned development.	Wards 5, 9, 10, 11, slum areas of ward 6 and old areas of the city.	BCC	High
			Residents of slum area	Low
			Rickshaw pullers, Auto rickshaw drivers	Low
			Citizens	Low
			Floating population	Low
			DC Office	High
			Bangladesh Police	High
			BPDB	High
			Department of Fire Service & Civil Defence	Medium
Ecosystem	Increased temperatures may cause changes in crop pattern. Increased intensity of rainfall can damage agriculture/livestock/fishery impacting livelihood. Cyclones can affect agriculture/fishery/ livestock and therefore livelihood is impacted.	Extended areas of the city under ward 30 as well as wards 3, 5, 8, 10, 23, 24, 25, 26, 27, 28, 29 and partly in ward 4.	Farmers	Low
			Fishery owners	Low
			Day labourers	Low
			Small shop owners	Low
			BCC	Medium
			Women	Low
			Children	Low
			DAE	High
			NGOs	High
			Department of Environment	Medium
Health System	Increased temperatures may cause heat stress and related health disorders, e.g. diarrhoea, thereby increasing demand of health infrastructure.	Wards 5, 6, 10, 11, 24, 26, 27, and 30 mostly in riverside areas.	Women	Low
			Children	Low
			Health conservancy department of BCC	Medium
			NGOs	High
			Citizens	Low
			Residents of slum area	Low

Fragile Urban System	Climate Fragility Statements	Area/ ward most vulnerable	Actors	Level of Adaptive Capacity
Storm Water Drainage	High intensity rainfall or rain from cyclones can cause overflow of drains leading to urban flooding and impacting health.	Wards 1, 2, 4, 5, 6, 7, 8, 9, 13, 19, 20, 29.	Residents of slum area	Low
			Women	Low
			Children	Low
			Health conservancy department of BCC	Medium

6.4. Adaptive Capacity of Fragile Urban Systems

The adaptive capacities of the six fragile urban systems were assessed against the five parameters of economy, technology, governance, societal and ecosystem services through discussions with the municipal staff.

Ecosystem, health system and storm water drainage scored low in all five parameters. It was identified that rapid urbanization is adversely affecting these systems and corresponding action on improving these systems is constrained by economic limitations and lack of willingness on the part of supporting actors.

There is a strong societal participation when it comes to the water supply system and sanitation facilities and citizens are actively involved. Therefore, these two systems are scored medium in governance and societal. Land use change scored high in technology/infrastructure, because of the availability of experts and technology.

Photo credit: ICLEI South Asia

Table 7: Consolidated vulnerability analysis of Fragile Urban Systems identified for Barisal city

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
			Vulnerable	Potential Supporting	Low	Medium	High
Sanitation	Increased temperatures lead to more growth of disease causing vectors in river/ canal water polluted by septic tank sludge which impacts health of citizens. High intensity rainfall may cause overflow of septic tanks, leading to greater water pollution and more health impacts. Excessive rain and water logging caused by cyclones may cause septic tank overflow and water pollution, leading to health issues.	Wards 5, 8, 9, 10, 13, 15, 16, 17, 18, 23, and partly in wards 6, 7, 11, 12, 14, 19, 20.	• Citizens • Low income labourers • Fishery owners	• Health & conserv-ancy de-partment of BCC	• Tech-nology/ Infra-structure	• Economic • Govern-ance • Eco-system Services	• Societal
Water Supply	Increased temperature will lead to greater use of tubewells to meet increased water demand depleting the ground water table and exacerbating arsenic pollution. Increased intensity of rainfall will cause greater run off leading to lower percolation and lower recharge of ground water, putting stress on drinking water resources. Excessive rainfall and water logging caused by cyclones will cause contamination of water sources - both surface and ground water, leading to drinking water scarcity and health impacts.	Ward 3, 24, 25, 26, 27, 28, 29, 30, and partly in wards 4 & 5.	• Citizens • Residents of slum • Farmers	• -Health & conserv-ancy de-partment of BCC	• Eco-system Services	• Economic • Tech-nology/ Infra-structure • Govern-ance • Societal	

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
			Vulnerable	Potential Supporting	Low	Medium	High
Land use Change	High intensity rainfall in case of unplanned development will result in water logging and urban flooding, with related impacts on the health and socio-economic structure of the city. Cyclones will cause damage to urban service infrastructure resulting in financial losses to BCC and disrupting urban services. Cyclones will cause greater damage to personal property, life and livelihood in case of unplanned development.	Wards 5, 9, 10, 11, slum areas of ward 6 and old areas of the city.	• Residents of slum area • Rickshaw pullers & auto rickshaw drivers • Citizens • Floating population	• BCC • DC Office • Bang-ladesh Police • BPDB • Depart-ment of Fire Service & Civil Defence	• Economic • Societal	• Govern-ance • Ecosys-tems Services	• Tech-nology/ Infra-structures
Ecosystem	Increased temperatures may cause changes in crop pattern. Increased intensity of rainfall can damage agriculture/livestock/fishery impacting livelihood. Cyclones can affect agriculture/fishery/ livestock and therefore livelihood is impacted.	Extended areas of the city under ward 30 as well as wards 3, 5, 8, 10, 23, 24, 25, 26, 27, 28, 29 and partly in ward 4.	• Farmers • Fishery owners • Day la-bourers • Small shop owners • Women • Children	• BCC • DAE • NGOs • Depart-ment of Environ-ment	• Economic • Tech-nology/ Infra-structure • Govern-ance • Societal • Eco-system Services		

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
			Vulnerable	Potential Supporting	Low	Medium	High
Health System	Increased temperatures may cause heat stress and related health disorders, e.g. diarrhoea, thereby increasing demand of health infrastructure.	Ward 5, 6, 10, 11, 24, 26, 27, 30 mostly in riverside areas	• Women • Children • All citizens • Residents of slum area	• Health and conservancy department of BCC • NGOs	• Economic • Technology/ Infrastructure • Governance • Societal • Ecosystem Services		
Storm Water Drainage	High intensity rainfall or rain from cyclones can cause overflow of drains leading to urban flooding and impacting health.	Ward 1, 2, 4, 5, 6, 7, 8, 9, 13, 19, 20, 29	Women Children All citizens Residents of slum area	Health and conservancy department of BCC	Economic Technology/ Infrastructure Governance Societal Ecosystem Services		

7. Resilience Interventions

Possible adaptation interventions were identified for the six fragile urban systems in Barisal on the basis of their climate risks and vulnerabilities, the vulnerable areas and the vulnerable actors to adapt to the possible impacts of climate change on these systems. Once the interventions were determined, their resilience score was calculated as high, medium, average and low on the basis of their resilience potential assessed in terms of their redundancy, flexibility, responsiveness and ability to increase access to information. If the interventions improved only one indicator mentioned above, their score was low, if they addressed two, their score was average, if they addressed three, their score was medium and if they addressed all four, their score was high. The climate resilience interventions were also assessed qualitatively for their technical, financial and political feasibility. The overall feasibility was calculated as an average of the qualitative feasibility for all three indicators. Finally their impact on the overall resilience of the city (short, medium or long term) was considered to assess the average time taken for the impacts to be felt on the resilience of the city.

Another consultation was conducted to link these interventions to existing city plans and schemes so as to determine whether the required interventions can be integrated with little or no additional resources into existing departmental programs or projects.

A total of 26 resilience interventions have been identified in the process as listed in Table 8. The interventions are grouped by fragile urban system and as infrastructural or non-infrastructural measures. The overall resilience score, overall feasibility and impact on the resilience of the city is given in the table. The table also gives an indicative duration for implementing the intervention as short (0-3 years needed), medium (3-5 years needed) or long term (more than 5 years needed) and an indicative cost requirement for the intervention as high (requiring substantial financial support), medium (requiring partial financial support) or low (can be covered by city budget). Each intervention's possible co-benefits are also outlined in the table.

Photo credit: ICLEI South Asia

Table 8: Prioritised Resilience Interventions against Resilience Indicators

Prioritised	Overall Resilience Score	Overall Feasibility	Time taken for Impact on Resilience of City	Duration of Implementation Short/ Medium/ Long term	Indicative Cost (Low/ Medium/ High)	Potential Co-benefits
Sanitation						
Policy / Non-infrastructural Measures						
Increase monitoring and supervision for usage of safe and well designed sanitary latrines by all and encourage people not to connect their latrine outlets with open drains, any ponds or canals. BCC could publish a regulatory notice mentioning a penalty or fine if any open linkage is found. DPHE can be engaged for joint monitoring.	Average	High	Medium Term	Medium	Low	Will improve the system of water resources management.
Awareness building and education programmes on sanitary latrines and the harmful effects of linking septic tank outlets with open drains.	High	High	Long Term	Long	Low	Can be used for awareness generation on related issues such as health, water, and environment.
Guidelines on septic tank construction.	High	High	Long Term	Long	Medium	Can reduce water pollution and its health impacts from human excreta.
Infrastructural Measures						
Ensure sanitary latrines to all citizens.	High	Medium	Medium Term	Medium	High	Will improve health.
Maintenance of sanitary latrines and timely sewerage management.	Average	High	Medium Term	Medium	High	Will improve drainage, pollution levels in water and health.
Decoupling septic tank outlets from storm water drains.	Average	Low	Short Term	Short	Medium	Can help reduce incidences of vector borne diseases in places with water logging problems.

Prioritised	Overall Resilience Score	Overall Feasibility	Time taken for Impact on Resilience of City	Duration of Implementation Short/ Medium/ Long term	Indicative Cost (Low/ Medium/ High)	Potential Co-benefits
Water Supply						
Policy / Non-infrastructural Measures						
Awareness building activities on how to access and store potable water during floods.	High	High	Long Term	Long	Low	Can be used for awareness generation on related issues such as health, water, and environment.
Infrastructural Measures						
Construction of a Water Treatment Plant (WTP) for surface water in a location where it will remain safe during cyclones or any disaster event.	Medium	High	Medium Term	Medium	High	Will reduce pressure on ground water.
Extension of existing water supply network and regular maintenance of installed pipelines. The extension should follow the existing city master plan. Supply and demand calculation and a feasibility study must be carried out before plan preparation or any extension.	Medium	Medium	Long Term	Long	High	
Implementation of a rainwater harvesting program with collaboration of city water supply department for both reuse and recharging of water where appropriate.	Medium	High	Long Term	Long	Medium	Can help reduce runoff and prevent soil degradation.
Land Use Change						
Policy / Non-infrastructural Measures						
Community based disaster management measures – forming informal groups for relief and rehabilitation after disasters, providing disaster management training to these groups, mock drills.	Medium	High	Short Term	Short	Medium	Can help to increase social cohesiveness.

Prioritised	Overall Resilience Score	Overall Feasibility	Time taken for Impact on Resilience of City	Duration of Implementation Short/ Medium/ Long term	Indicative Cost (Low/ Medium/ High)	Potential Co-benefits
Strictly following the existing land use plan and its application. BCC must ensure awareness with regular publicity, meetings and circulation of information. After completion of plan implementation period, BCC should review the progress and its drawbacks. If necessary a new land use plan should be prepared. UDD and LGED can help with this process.	High	Medium	Long Term	Long	Low	Can help in better developmental planning.
Regulation and monitoring of structures in low lying areas in accordance with planning principles of height clearance and flood safety.	Average	High	Long Term	Long	High	Will reduce the building maintenance cost after floods.
Ecosystem						
Policy / Non-infrastructural Measures						
Communication and coordination with concerned agricultural/fisheries/ livestock departments to protect existing variety of crops, animals, birds etc.; or promotion of new species.	Medium	High	Long Term	Long	Low	Employment opportunities will be regained.
Infrastructural Measures						
Improved sewerage management by treating waste water and sludge for reuse.	Average	Medium	Medium Term	Medium	High	Sludge can be used as soil conditioner in farming.
Tree plantation drive.	High	High	Long Term	Long	High	Can provide livelihood options.
Canal re-excavation.	Medium	Low	Medium Term	Medium	High	Will increase scope of employment with fish cultivation.

Prioritised	Overall Resilience Score	Overall Feasibility	Time taken for Impact on Resilience of City	Duration of Implementation Short/ Medium/ Long term	Indicative Cost (Low/ Medium/ High)	Potential Co-benefits
Health System						
Policy / Non-infrastructural Measures						
Awareness building programs and IEC activities on health risks due to climate change, and adaptation/ resilience building behaviours that can be undertaken. These programs could be implemented by NGOs and health institutions led by the ULB like BCC, Medical Institutions, and DPHE etc.	High	High	Long Term	Long	High	Can be used for different sectors like water, sanitation etc.
Preparation of a health emergency response plan jointly by BCC and city hospitals to respond to climate and disaster emergency events. This may include – regular drill/practice sessions with local emergency response organizations, staff specific emergency situation guidelines, containment of risks, check lists for post emergency situation and treatment etc.	High	Medium	Long Term	Long	Medium	Will establish a planned and organized health service system and people will be benefited around all over the year.
Infrastructural Measures						
Establishment of Primary Health-care Centres.	Medium	Medium	Long Term	Long	High	Will increase the storage of medicine.
Provision of resilient health care infrastructure – building hospitals at elevated locations, with facilities to meet challenges of water related and heat related diseases and stresses.	High	Low	Long Tern	Long	High	
Storm Water Drainage						
Policy / Non-infrastructural Measures						
Awareness among the citizens on the effects of dumping waste in the open and in drains. Education programs can be undertaken which must be aimed at encouraging the sharing of lessons	High	High	Long Term	Long	Low	Can be used for awareness generation on related issues such as health, water, and environment.

learned with families.						

Prioritised	Overall Resilience Score	Overall Feasibility	Time taken for Impact on Resilience of City	Duration of Implementation Short/ Medium/ Long term	Indicative Cost (Low/ Medium/ High)	Potential Co-benefits
Regulation of the floor area ratio (FAR) by BCC to allow for more space for storm water discharge and prevention of water logging.	High	Medium	Long Term	Long	Low	Will increase light and air circulation and reduce risks from earthquake.
Infrastructural Measures						
Maintenance of drains.	Average	Medium	Long Term	Long	High	
Re-excavation of canals and maintenance of water reservoirs.	Medium	Low	Medium Term	Medium	High	Will increase scope of employment with fish cultivation.

7.1. Integration into City Plans

Table 9 gives information regarding the different ongoing or upcoming schemes and projects under the identified urban systems. These projects can be leveraged to implement some of the interventions identified above so as to improve the resilience of the city.

Table 9: Ongoing city projects in Barisal

Sector	Project	Duration	Achievements
Water Supply	Barisal City Surface Water Treatment Projects		Establishment of two surface WTPs
Health	Urban Primary Health Care Service Delivery Project which focuses on free primary health care for urban poor	2012-2017	One city maternity clinic and four city Health-care Centres have been established
Waste Management	Urban Public and Environmental Health Sector Development Project	2011-2016	Two transfer stations have been established
Climate Change adaptation	Climate Change Adapted Urban Development Program for Barisal	2016-2035	Urban vulnerability assessment and feasibility study completed

A summary of the issues, climate impacts, vulnerable areas and resilience actions sector-wise is given below.

7.1.1. Sanitation

Issues:	• There is no existing sewerage system in Barisal. Households have septic tanks, but toilets which often bypass the tanks and empty into rivers or drains leading to rivers directly causing water pollution and adverse impacts on health.	
Potential Climate Impacts:	• Increased temperatures lead to more growth of disease causing vectors in river/ canal water polluted by septic tank sludge which impacts health of citizens. • High intensity rainfall may cause overflow of septic tanks, leading to greater water pollution and more health impacts. • Excessive rain and water logging caused by cyclones may cause septic tank overflow and water pollution, leading to health issues.	
Potentially Impacted Prabhags / Areas:	• Wards 5, 8,9, 10, 13, 15,16,17, 18, 23, and partly in wards 6, 7, 11, 12, 14, 19, 20.	
Risk Status:	**Extreme**	
Actors:	**Vulnerable** • Common people • Low income labourers • Fishery owners	**Supporting** • Health & conservancy department of BCC

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		
Increase monitoring and supervision for usage of safe and well designed sanitary latrines by all and encourage people not to connect their latrine outlets with open drains, any ponds or canals. BCC could publish a regulatory notice mentioning a penalty or fine if any open linkage is found. DPHE can be engaged for joint monitoring.	Staff costs, staff training, formulation of policy, meetings.	USD 1,000
Infrastructural Measures		
Decoupling septic tank outlets from storm water drains.	Staff costs, staff training, equipment costs.	USD 50,000

7.1.2. Water Supply

Issues:	• Water supply system is fragile because of poor maintenance of water supply system, which does not ensure supply of good quality water, thereby leading to excessive use of tubewells, causing ground water depletion and arsenic pollution, impacting health.	
Some Existing / Planned Measures:	• Two surface water treatment plants have been established	
Potential Climate Impacts:	• Increased temperature will lead to greater use of tubewells to meet increased water demand depleting ground water table and exacerbating arsenic pollution. • Increased intensity of rainfall causing grater run off leading to lower percolation and lower recharge of ground water, putting stress on drinking water resource. • Excessive rainfall and water logging caused by cyclones will cause contamination of water sources - both surface and ground water, leading to drinking water scarcity and health impacts.	
Potentially Impacted Areas:	• Wards 3, 24, 25, 26, 27, 28, 29, 30, and partly in wards 4 & 5.	
Risk Status:	**High**	
Actors:	**Vulnerable** • Common people • Residents of slum • Farmers	**Supporting** • Health & conservancy department of BCC

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		
Awareness building activities on how to access and store potable water during floods.	Training costs.	USD 2,500 per training
Infrastructural Measures		
Implementation of a rainwater harvesting program with collaboration of city water supply department for both reuse and recharging of water where appropriate.	Cost of construction, training, maintenance.	USD 10,000 per unit

7.1.3. Land use Change

Issues:	• There is a lack of information among public regarding the existing land use policy in master plan. Not considering the policy while purchasing land for specific purposes, encroachment and filling up of water bodies cause unplanned development and environmental damage.	
Potential Climate Impacts:	• High intensity rainfall in case of unplanned development will result in water logging and urban flooding, with related impacts on the health and socio-economic structure of the city. • Cyclones will cause damage to urban service infrastructure resulting in financial losses to BCC and disrupting urban services. • Cyclones will cause greater damage to personal property, life and livelihood in case of unplanned development.	
Potentially Impacted Areas:	• Wards 5, 9, 10, 11, slum areas of ward 6 and old areas of the city.	
Risk Status:	**Extreme**	
Actors:	**Vulnerable** • Residents of slum area • Rickshaw pullers & auto rickshaw drivers • All citizens • Floating population	**Supporting** • BCC • DC Office • Bangladesh Police • BPDB • Department of Fire Service & Civil Defence

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		
Community based disaster management measures – forming informal groups for relief and rehabilitation after disasters, providing disaster management training to these groups, mock drills.	Training costs, materials, staff costs.	USD 7,500 per training

7.1.4. Ecosystem

Issues:	• Since local livelihood is strongly based on ecosystem services, damage to ecosystems impacts productivity and economic well-being of citizens and natural resources (air, water, forests).	
Some Existing / Planned Measures:	• Climate Change Adapted Urban Development Program for Barisal	
Potential Climate Impacts:	• Increased temperatures may cause changes in crop pattern. • Increased intensity of rainfall can damage agriculture/livestock/fishery impacting livelihood. • Cyclones can affect agriculture/fishery/livestock and therefore livelihood is impacted. • Cyclones may result in deforestation, leading to damage to soil and water resources.	
Potentially Impacted Areas:	• Extended areas of the city under wards 30, as well as wards 3, 5, 8, 10, 23, 24, 25, 26, 27, 28, 29 and partly in ward 4.	
Risk Status:	**Extreme**	
Actors:	**Vulnerable** • Farmers • Fishery owners • Day labourers • Small shop owners • Women • Children	**Supporting** • BCC • DAE • NGOs • Department of Environment

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		
Communication and coordination with concerned agricultural/fisheries/livestock departments to protect existing variety of crops, animals, birds etc.; or promotion of new species.	Meeting costs, formulation of policies.	USD 10,000
Infrastructural Measures		
Tree plantation.	Cost of plants, staff costs, materials, maintenance costs, labour.	USD 30,000 per drive

7.1.5. Health System

Issues:	• Health care system is inadequate to meet the needs of the city at present, with several NGOs providing primary health care to supplement the government health care system. Lack of quality monitoring of health care services makes the system more fragile.	
Some Existing/ Planned Measures:	• One city maternity clinic and four city Health Centres are operational under the Urban Primary Health-care Service Delivery Project.	
Potential Climate Impacts:	• Increased temperatures may cause heat stress and related health disorders, e.g. diarrhoea. • Increased temperatures cause greater demand of health infrastructure for heat related diseases. • Cyclones will increase stress on health infrastructure due to increased morbidity and mortality.	
Potentially Impacted Areas:	• Ward 5, 6, 10, 11, 24, 26, 27, 30 mostly in riverside areas.	
Risk Status:	**High**	
Actors:	**Vulnerable** • Women • Children • All citizens • Residents of slum area	**Supporting** • Health and conservancy department of BCC • NGOs

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		
Preparation of a health emergency response plan jointly by BCC and City Hospitals to respond to climate and disaster emergency events. This may include – regular drill/practice sessions with local emergency response organizations, staff specific emergency situation guidelines, containment of risks, check lists for post emergency situation and treatment etc.	Cost of meetings, cost of policy formulation, policy ratification, trainings, staff costs.	USD 40,000
Infrastructural Measures		
Establishment of Primary Health-Care Centres.	Construction costs, materials, staff costs, training.	USD 75,000

7.1.6. Storm Water Drainage

Issues:	• Closing natural drains and ponds by encroachment causes a reduction in the natural water storage capacity and siltation of drains causes reduction in carrying capacity, thereby leading to possibilities of overflow during heavy rain.	
Some Existing / Planned Measures:	• Two Secondary transfer stations have been set up to enable better management of solid waste.	
Potential Climate Impacts:	• High intensity rainfall or rain from cyclones can cause overflow of drains and create urban flooding and cause health impacts.	
Potentially Impacted Areas:	• Wards 1, 2, 4, 5, 6, 7, 8, 9, 13, 19, 20, 29.	
Risk Status:	**Extreme**	
Actors:	**Vulnerable** • Women • Children • All citizens • Residents of slum area	**Supporting** • Health and conservancy department of BCC

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		
Awareness among the citizens on the effects of dumping waste in the open and in drains. Education programs can be undertaken which must be aimed at encouraging the sharing of lessons learned with families.	Material costs, training, staff costs, logistics.	USD 10,000 per training
Infrastructural Measures		
Maintenance of drains.	Per km costs of staff, materials, repair.	USD 2,500 per km

8. Conclusion

The implementation of the IAP toolkit in the city of Barisal revealed that the city is vulnerable to climate change impacts of increased temperature, high intensity rainfall and increased frequency of cyclones. The city needs to adapt to possible impacts of the same.

Barisal, one of the oldest municipalities of the country has a large migrant population some of whom are climate refugees from neighbouring areas. This population is often found in slums. The geographic location of the city leaves it vulnerable to water logging especially in low lying areas. Using the IAP, the urban systems of sanitation, water supply, drainage, health, ecosystem, land use change were identified as fragile urban systems. Each of these systems is impacted by the climate risks. The vulnerability map of the city shows wards 5, 6, and 10 as the vulnerable hotspots in the city being affected by 4 or more of the fragile urban systems. The BCC and other government departments have a higher adaptive capacity than the common public in general. There is however a perceived need to increase coordination between departments and agencies so that interventions have a more holistic impact on the city's development. Some of the major areas that should be looked into for Barisal city are:

1. **Land Use Change –** The land use pattern is changing in Barisal and government regulations need to be strictly implemented so as to manage and regulate indiscriminate construction. This will also lead to better drainage, health and ecosystem services in the city.

2. **Water supply, sanitation and drainage –** Planned construction with timely O&M of these systems will help to reduce their vulnerability. Service delivery also needs to be improved in the city.

3. **Ecosystem Management –** A large population, especially poor and marginalised sector, depend on the ecosystem for their livelihood through agriculture, livestock, fishery, etc. In order to protect their livelihood, it is essential to take action to protect the ecosystems in and around the city, the forests, gardens, water bodies, farmlands, etc.

The list of interventions identified in this CRS includes both hard and policy / non-infrastructural measures. These measures directly or indirectly contribute to climate change adaptation while making the city more resilient. The finances required for implementation of the interventions can be obtained through assessment of the existing financial statements, existing projects, other national and state schemes, and also international programs. Improving the coordination among different departments should take precedence for the city. Awareness generation programmes that have been suggested across the different urban sectors can be taken up immediately as they have long term effects and do not require large amounts of finance. BCC and other implementing agencies can pick projects according to their priority and need for implementation. Integration of all prioritised interventions into other plans of the city is also important in order to avoid duplicity of efforts and enhance coordination.

Annexure 1 : Fragile Urban System Analysis and corresponding Fragility Statements

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement
Sanitation	**Flexibility & Diversity:** No sewerage system, individual lines emptying into rivers, septic tanks not effective. **Safe failure:** No proper design of septic tanks or soak pits.	• Pollution of river water • Vector borne diseases – mosquitoes • Fisheries impacted • Clogging of drains due septic tanks opening directly into them	BCC	No existing sewerage system. Households have septic tanks, which often bypass the tanks and empty into rivers or drains leading to rivers directly causing water pollution and adverse impacts on health.
Water Supply	**Flexibility & Diversity:** Generally use tubewells which are impacted by extreme events. Tankers used for supply if municipal supply fails. Possibly of using ponds which can be renovated and used. **Redundancy:** Tankers used for supply if municipal supply fails. **Safe failure:** Municipal supply of water is not reliable for good health of citizens, use of tubewells. Encroachments of ponds lead to reduced ground water level.	• Daily work impacted if water supply is affected • Pressure on ground water increases, causing depletion of water table, increase of arsenic in some places • Pollution due to industries – shift of industries from the city to outskirts	BCC	Water supply system is fragile because of poor maintenance of water supply system, which does not ensure supply of good quality water, thereby leading to excessive use of tubewells, causing ground water depletion and arsenic pollution, impacting health.

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement
Change in land use	**Safe failure:** Master plan is not followed; industrial and commercial areas within residential area. Public spaces reducing. No policy of regulation of land use. In-migration causing stress on land resources.	• River/canal bank encroachment • Livelihood Change • Unplanned development • Filling up of ponds • Water logging of certain areas	BCC, DC Office (Bhumi/Land Office), Zila Parishad	Land use policy is weak, with little control of city corporation on implementation of land use plan. These results in unplanned development, stress on limited land resources and environmental damage.
Ecosystem	**Safe failure:** Ever-increasing siltation in the canals, river pollution, deforestation causing destruction of ecosystems. Land use changes, unplanned development, climate changes-temperature rise is causing impacts.	• Biodiversity loss • Air pollution • Temperature rise • Crop productivity is lowered, Fisheries production is lowered due to lack of natural pest control • Ecosystem services reduced, causing changes in livelihood	City Corporation, Department of Environment	Since local livelihood strongly based on ecosystem services, damage to ecosystems impacts productivity and economic well-being of citizens and natural resources (air, water, forests).
Health system	**Flexibility & Diversity:** Primary health care by NGOs. Government hospitals not linked to city corporation. **Redundancy:** Rapid urbanization, not able to meet demands. **Safe failure:** Integration of different governments and NGOs for health services is needed, not available at present. No quality monitoring of health service.	• Food quality control and hygiene • Food safety security • Health impacts of different sectors need to be integrated with city corporation	Civil Surgeon Office, Department of Health, City Corporation, NGOs, Private Clinics	Health care system is inadequate to meet the needs of the city at present, with several NGOs providing primary health care to supplement the government health care system. Lack of quality monitoring of health care services makes the system more fragile.

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement
Storm water drainage	**Redundancy:** Natural drains reduced through canals encroachment, siltation. **Safe failure:** Poor storage capacity of ponds in the city and carrying capacity of storm water drains and natural drains. Overflow is imminent. Population increase. Drainage design is poor, does not follow land gradient. Maintenance of drains poor.	• Sewage released in drains • Hotel waste released in drains • Open drains at household level – tertiary level • Artificial flood • Odour, vectors – mosquitoes, flies • Water logging and urban flooding • Health impacts	BCC	Closing natural drains and ponds by encroachment causes a reduction in the natural water storage capacity and siltation of drains causes reduction in carrying capacity, thereby leading to possibilities of overflow during heavy rain.

Annexure 2: Risk Prioritisation

Climate Risk Statements		Likelihood	Consequence	Risk score (Likelihood X Consequence)	Risk Status
Urban System	**Impacts of Climate Change**				
Sanitation	Increased temperatures lead to more growth of disease causing vectors in river/canal water polluted by septic tank sludge which impacts health of citizens.	5	4	20	**Extreme**
	High intensity rainfall may cause overflow of septic tanks, leading to greater water pollution and more health impacts.	5	4	20	**Extreme**
	Excessive rain and water logging caused by cyclones may cause septic tank overflow and water pollution, leading to health issues.	4	4	16	**High**
Water Supply	Increased temperature will lead to greater use of tubewells to meet increased water demand, depleting ground water table and exacerbating arsenic pollution.	5	4	20	**Extreme**
	Increased intensity of rainfall causing grater run off leading to lower percolation and lower recharge of ground water, putting stress on drinking water resource.	5	4	20	**Extreme**
	Excessive rainfall and water logging caused by cyclones will cause contamination of water sources - both surface and ground water, leading to drinking water scarcity and health impacts.	5	5	25	**Extreme**
Land Use Change	High intensity rainfall in case of unplanned development will result in water logging and urban flooding, with related impacts on the health and socio-economic structure of the city.	4	3	12	**High**
	Cyclones will cause damage to urban service infrastructure resulting in financial losses to BCC and disrupting urban services.	5	3	15	**High**
	Cyclones will cause greater damage to personal property, life and livelihood in case of unplanned development.	5	5	25	**Extreme**

Climate Risk Statements		Likelihood	Consequence	Risk score (Likelihood X Consequence)	Risk Status
Urban System	**Impacts of Climate Change**				
Eco System	Increased temperatures may cause changes in crop pattern.	5	4	20	**Extreme**
	Increased intensity of rainfall can damage agriculture/livestock/ fishery impacting livelihood.	5	4	20	Extreme
	Cyclones can affect agriculture/ fishery/livestock and therefore livelihood is impacted.	5	4	20	Extreme
	Cyclones may result in deforestation, leading to damage to soil and water resources	3	2	6	Medium
Health System	Increased temperatures may cause heat stress and related health disorders, e.g. diarrhoea.	5	3	15	High
	Increased temperatures cause greater demand of health infrastructure for heat related diseases.	4	3	12	High
	Cyclones will increase stress on health infrastructure due to increased morbidity and mortality.	3	3	9	Medium
Storm Water Drainage	High intensity rainfall or rain from cyclones can cause overflow of drains and create urban flooding and cause health impacts.	5	4	20	Extreme

Annexure 3: Members of the Climate Core Team, their position, and proposed responsibilities

Name	Position	Responsibility
Mr. Eng. Khan Muhammad Nurul Islam	Chairperson	Supervise the overall works and management issues of the core team.
Dr. Md. Matiur Rahman	Project Nodal Officer	Ensure the coordination and implementation of the project.
Ms.Nandita Basu	Member	Coordination and implementation of the project works in specific to the sectors.
Mr.Kazi Monirul Islam	Member	Coordination and implementation of the project works in specific to the sectors.
Mr.Dipak Lal Mridha	Member	Coordination and implementation of the project works in specific to the sectors.

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ICLEI – Local Governments for Sustainability, South Asia
C-3 Lower Ground Floor, Green Park Extension, New Delhi - 110 016, India
Tel: +91-11-4974 7200; Fax: +91-11-4974 7201; Email: iclei-southasia@iclei.org

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