City Resilience Strategy

Sirajganj City, Bangladesh

THE ROCKEFELLER FOUNDATION

ICLEI
Local Governments for Sustainability

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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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	- Biodiversity conservation - Preservation of vital ecosystems and species - Conservation of water resources - Improved practices for	- Improved public health - Decreased mortality - Increased benefits to low-income households - Reduced damage and loss due to natural

[1] United Nations. 2014. World Urbanization Prospects, the 2014 revision. UN Department of Economic and Social Affairs, Population Division.
[2] Islam, N. 2015. Urbanization in Bangladesh: Challenges and Opportunities http://www.shiree.org/wp-content/uploads/2015/04/NI-Paper.pdf
[3] World Bank, Climate Resilient Cities: A primer on reducing vulnerabilities to climate change impacts and strengthening disaster risk management in East Asian cities, 2008: Washington D.C
[4] Folke, C. 2006. "Resilience: The emergence of a perspective for social-ecological systems analyses". Global Environmental Change. **16**: 253–267.
[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.
[6] Tanner, T.M. and Rentschler, J. 2015. 'Unlocking the 'Triple Dividend' of Resilience: Why investing in disaster risk management pays off. Interim Policy Note'. Washington D.C.: GFDRR and London: Overseas Development Institute (www.odi.org/tripledividend).

Economic Benefits	Environmental Benefits	Social Benefits
- Reduced risks associated with current climate variability	disaster risk reduction	disaster - Enhanced well-being of all social groups

1.2 Methodology

Sirajganj's City Resilience Strategy was formulated using the ICLEI ACCCRN Process (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

The IAP toolkit consists of a set of sixteen 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.

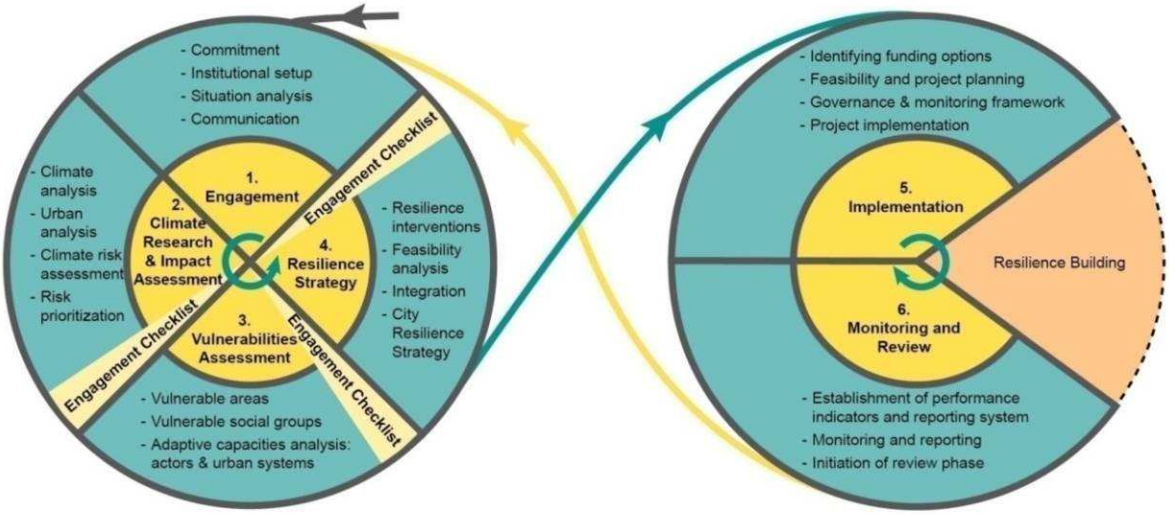

Figure 1: ICLEI ACCCRN Process

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 Shared Learning Dialogues (SLD) 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 SLD. The adaptive capacities of the urban systems are 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 Sirajganj City

The Mayor, town planner and engineers of Sirajganj Municipality spearheaded the IAP with support from the team from ICLEI South Asia. Figure 2 illustrates the process and timeline followed in Sirajganj. To initiate the IAP, municipal town planner, engineers, councillors and other representatives from Sirajganj Municipality, were oriented on the fundamentals of urban development and climate resilience. Simultaneously, members for the Climate Core team and the Stakeholder Committee were identified in consultation with the Mayor, Town Planner and Municipal Engineer of the Sirajganj Municipality. The potential climate risks were identified by an assessment of the trends of temperature and precipitation change in the area and desktop studies of secondary literature. These were validated by the Climate Core Team and Stakeholder Committee in an SLD.

Through the SLD and other consultations/discussions, a comprehensive Urban Systems Analysis was carried out that identified five urban systems as fragile, viz. (i) Water Supply, (ii) Biodiversity, (iii) Solid Waste Management, (iv) Economy, and (v) Drainage. The five fragile urban systems identified were critically analyzed considering the direct and indirect impacts of identified climate risks. Vulnerability Assessment was carried out to critically evaluate the sensitivity, exposure and adaptive capacity of the five 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 Sirajganj. Interlinkages of these resilience interventions with on-going and planned projects were established and further integration into existing city-level plans was explored.

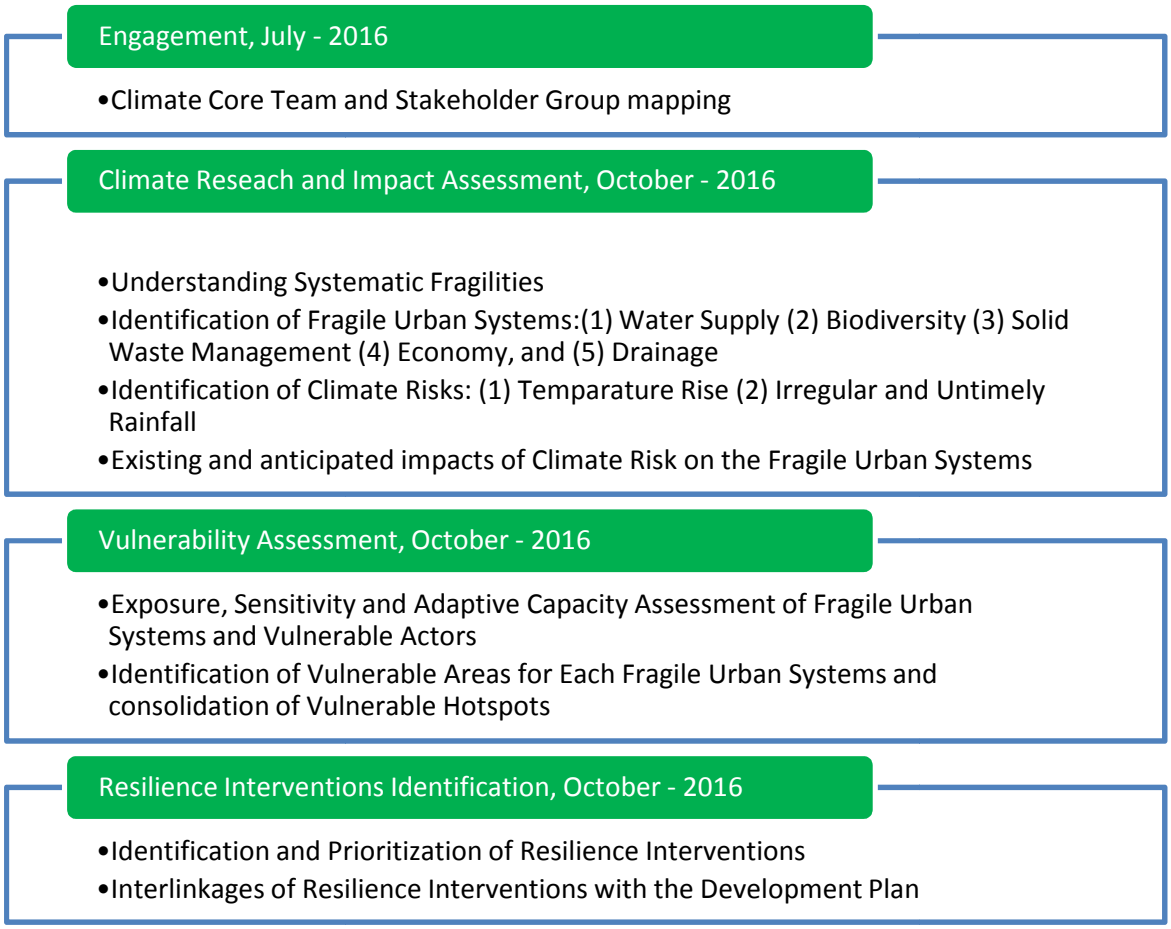

Figure 2: Methodology of IAP in Sirajganj

2. CITY PROFILE

The main city in Sirajganj district is Sirajganj which occupies an area of 28.49 sq. km. It is located between 24°22′and 24°37′north latitudes and between 89°36′ and 89°47′ east longitudes (refer Figure 3) situated on the banks of the Jamuna River and, west of the Brahmaputra River, about 110 kilometres northwest of Dhaka. The city is named after a landlord, Siraj Ali who founded Sirajganj city. It comprises a population of 158,913 distributed among 15 wards and 52 mohallas.

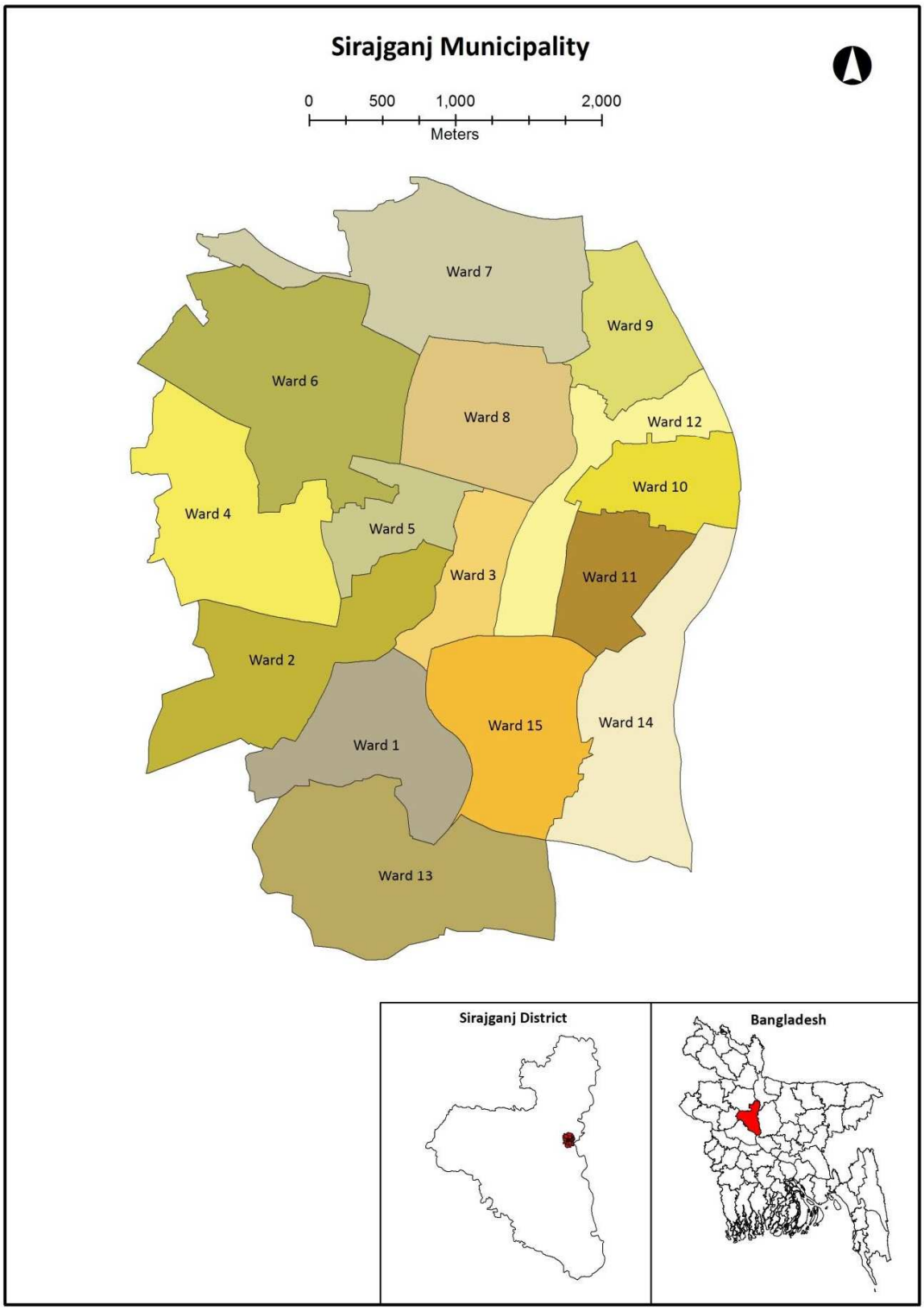

Figure 3: Location of Sirajganj Municipality

2.1 Demography

According to Bangladesh Bureau of Statistics (BBS) population census 2011[7], the population of Sirajganj Municipality was 158,913 comprising of 80,241 males and 78,672 females. There are

[7]Bangladesh Bureau of Statistics (BBS). 2011. District Statistics 2011: Sirajganj. Bangladesh Bureau of Statistics, Statistics and Information Planning, Government of Bangladesh

35,556 households. The population density was 5,577.9 persons/sq. km distributed among 15 wards spread over 28.49 sq. km. Of municipality area, ward 13 and 3 are the most and least congested wards, respectively. The following table (Table 2) represents the ward wise population of Sirajganj Municipality and their population density. The literacy rate in the area under the jurisdiction of the municipality is 63.2%.

Table 2: Ward-wise Area and Population of Sirajganj Municipality, 2011

Ward No.	Area of Ward (sq. km.)	Total Population	No. of Households	Population Density (Persons/sq. km.)
1	2.02	11247	2624	5567.8
2	2.64	13540	3063	5128.8
3	2.63	6540	1460	2486.7
4	1.47	10502	2400	7144.2
5	1.94	8795	2008	4533.5
6	1.13	9617	2075	8510.6
7	3.45	11211	2553	3249.6
8	2.56	12386	2614	4838.2
9	1.36	10713	2442	7877.2
10	1.63	8214	1888	5039.3
11	2.29	10942	2392	4778.2
12	1.61	10014	2099	6219.9
13	1.03	11193	2451	10866.9
14	1.49	10708	2417	7186.6
15	1.24	13291	3070	10718.5
Total	**28.49**	**158913**	**35556**	**5577.9**

2.2 Economy and Employment

Sirajganj was once considered a principal jute trade centre. It still has an important jute industry, with products traded via road, rail, and river. Its jute mills were among the first in the British Bengal era.

2.3 Municipal Administration

Sirajganj Municipality, established in 1869, regulates most of the civic function and services in the city. At present, the Municipality consists of elected members headed by a Mayor. 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 municipality administration and is responsible for the functioning of the municipality including tax collection, estates maintenance, projects, among other things. This is an administrative cadre service post and appointed by the central government. Sirajganj Municipality provides and maintains basic urban services which include water supply, sewage 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 municipality, 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. and also administering the local governments.

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

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

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

i) **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

Sirajganj is considered as the most disaster prone area for river flood and bank erosion. Floods are the main natural hazards in the city and occur due to excessive precipitation during the monsoon. The flooding situation is aggravated by the excessive siltation of the Jamuna River whose depth has considerably reduced, caused due to the opening of Jamuna Bridge. The city, regularly subject to floods, witnessed one of the biggest floods in 2007. Discussions in the city reflected an increasing intensity in the floods since 1981. In fact in 2007, the city was flooded twice and the city was submerged under 7 feet of water. Extensive floods greatly affect the marginal population, who lose whatever assets they have and suffer from lack of work and wages. People who live in perennial flood zones on the bank of the Jamuna River have low

indicators in all sectors of health, nutrition and education. However, floods also cause serious damage to crops, property, fisheries and livestock and other resources[8].

In 2010, the flood level exceeded that of 1988 in Sirajganj[9]. Flood protection dams in different locations were damaged and as a result a huge area including the district headquarters were inundated. Road communication was disrupted for Sirajgonj-Bogra, Sirajgonj-Kazipur and Kazipur-Dhunat road. Overall 49 districts of Bangladesh and tens of millions of people were affected.

Recently in 2016, heavy rainfall and the onrush of water caused floods, marooning more than 100,000 people and submerging 500 villages in the district[10].

4. CLIMATE SCENARIO IN THE CITY

Siraganj is located in north-western zone of Bangladesh which receives less rainfall. The annual rainfall is 1610 mm.

4.1 Past Climate Trends

The present project analysed the past climate trends of Sirajganj city using climate data collected from the Bangladesh Meteorological Department (BMD). The data spans 27 years from 1987 to 2014 for rainfall and 26 years from 1988 to 2014 for temperature.

Figure 4 shows that the average annual rainfall is decreasing by almost 100mm over the time period. This is due to a clear decrease in rainfall across all seasons (Figures 5-8) especially in summer (Figure 5). Rainfall received in 2014 has been very poor with post monsoonal rainfall (September to December) showing 0mm recorded (Figure 7 and Figure 8).

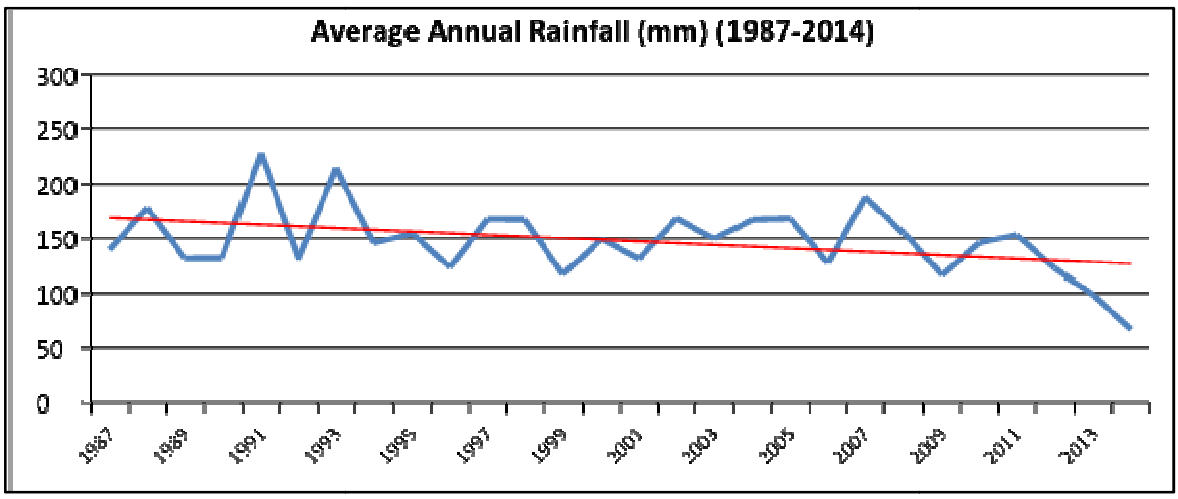

Figure 4: Average Annual Rainfall for Sirajganj City

[8] MZI Baki, R Khatun, AKhatun, S Akter, P Hazra and A Sultana. 2015. Impact of flood hazards on human life and environment in some selected upazilas of Sirajganj district. International Journal of Natural and Social Sciences, 2(1): 102-106.

[9] Bangladesh Water Development Board (BWDB). 2010. "A report on water level variation in previous year in Sirajganj, 2010".

[10] http://www.clickittefaq.com/flood-situation-in-sirajganj-and-kurigram-worsens/

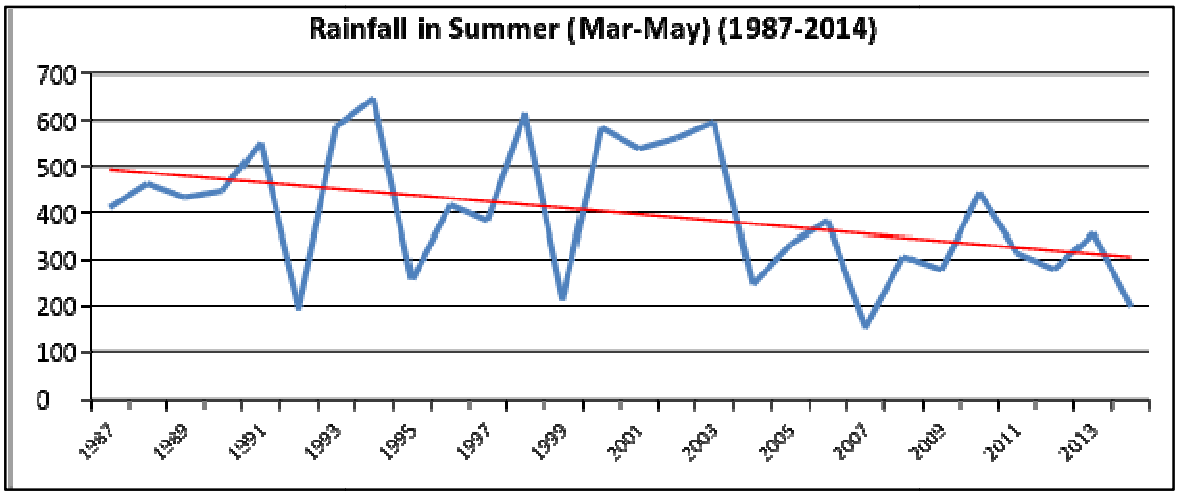

Figure 5: Rainfall in Summer for Sirajganj City

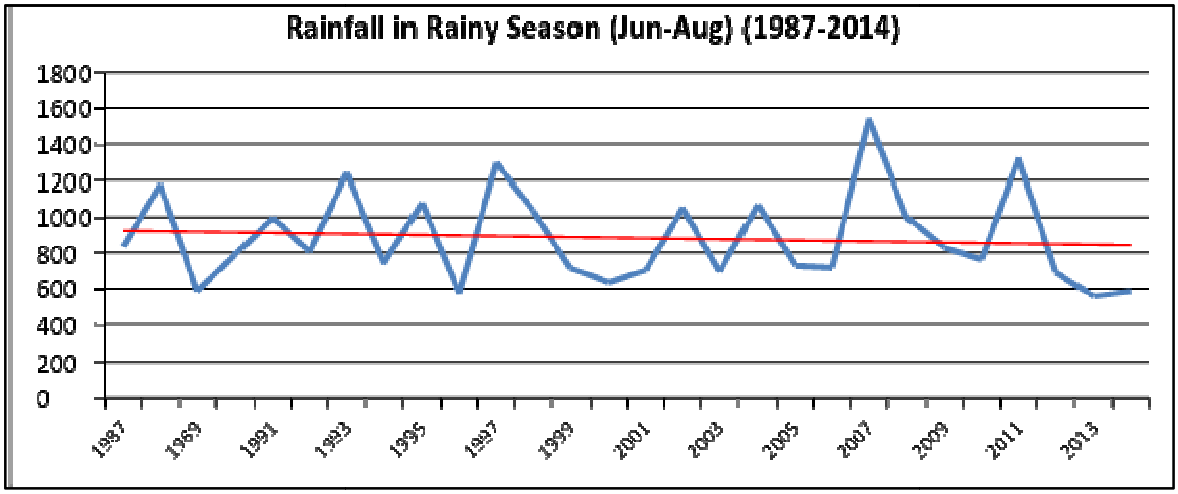

Figure 6: Rainfall in Rainy Season for Sirajganj City

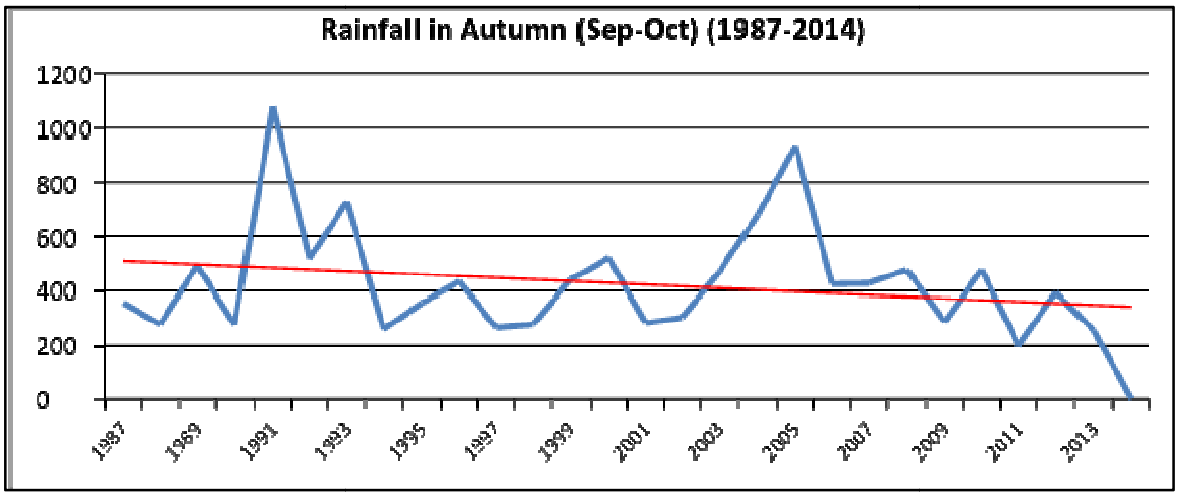

Figure 7: Rainfall in Autumn for Sirajganj City

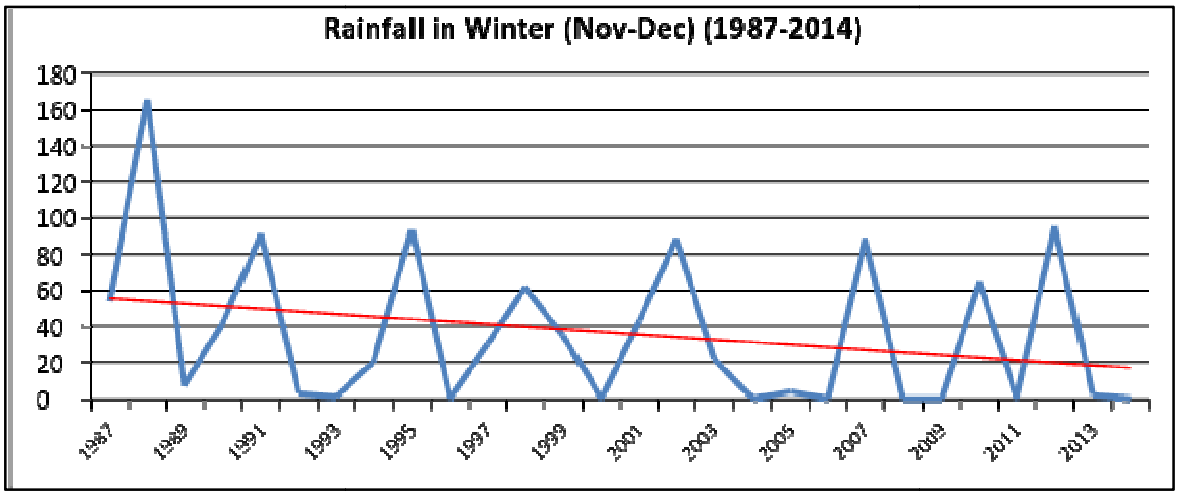

Figure 8: Rainfall in Winter for Sirajganj City

Temperature on the other hand has been steadily increasing over the data period (Figures 9- 10) and annual average temperature shows that the increase in the three decades is almost 0.4°C (Figure 9). Maximum annual temperature has the largest contribution to this showing a rise of almost 1°C when compared with 1988 (Figure 10). Annual minimum temperature shows decreasing trend (Figure 11).

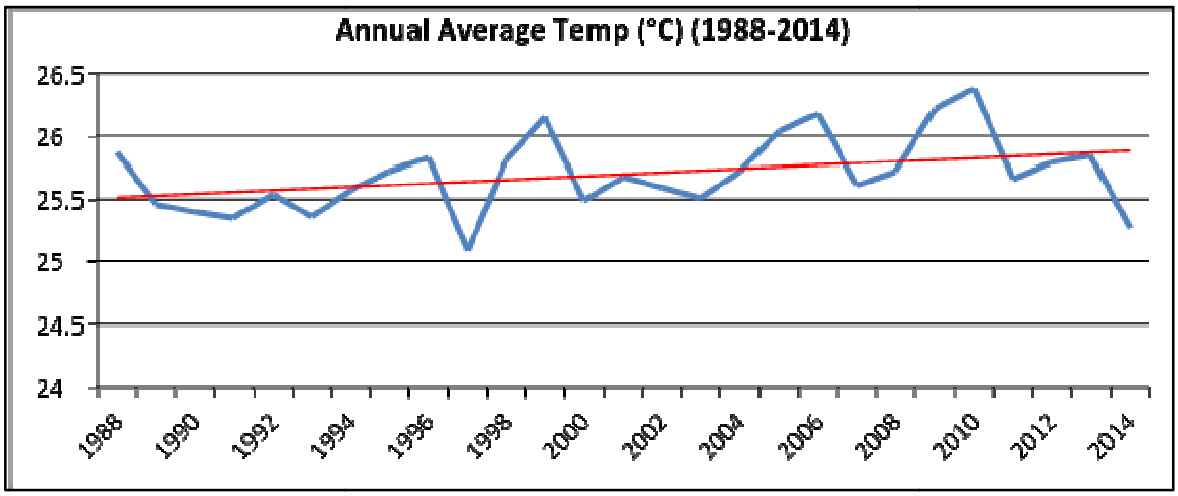

Figure 9: Annual Average Temperature for Sirajganj City

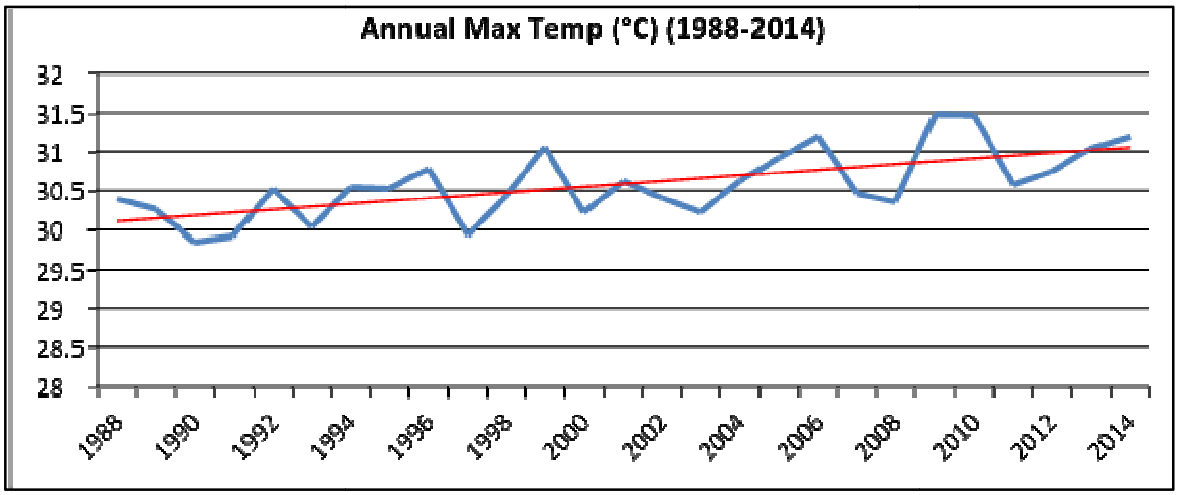

Figure 10: Annual Maximum Temperature for Sirajganj City

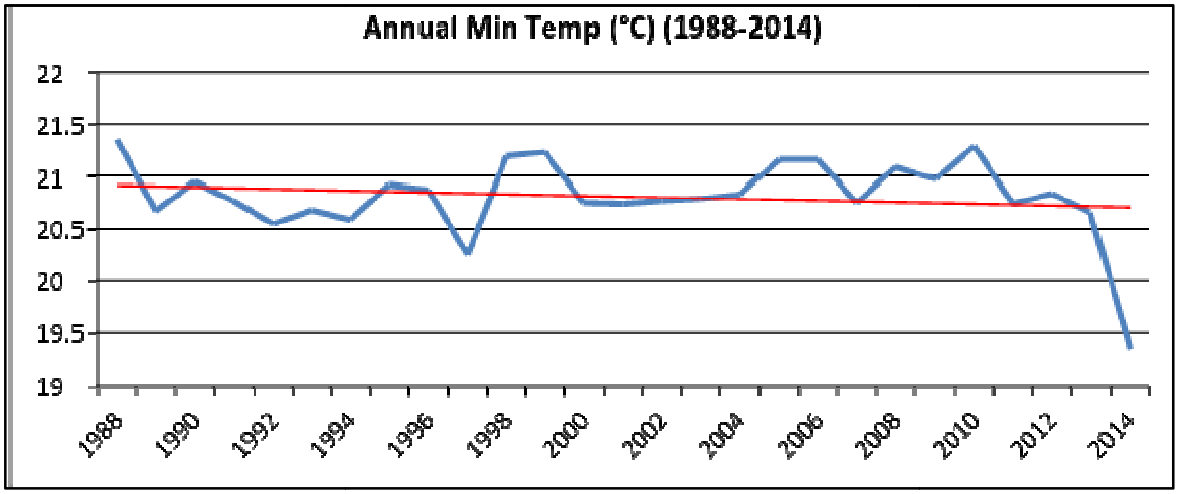

Figure 11: Annual Minimum Temperature for Sirajganj City

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 World Bank[12] is referred to for the climate projections of the region (Table 3). 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.
[12]The World Bank Group. 2011. Vulnerability, Risk Reduction and Adaptation to Climate Change. Climate Risk and Adaptation Country profile, Bangladesh. The World Bank Group, Global Facility for Disaster Reduction and Recovery, Climate Investment Funds.

Table 3: Climate Scenario Statement

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.

As per the discussions with the Stakeholder Committee, although temperature projections seem to agree with their perceptions, rainfall projections do not seem to be so true for Sirajganj. According to the stakeholders, the climate risks as for Sirajganj would be:

Climate Risk 1: Increased temperature
Climate Risk 2: Short duration high intensity rainfall

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 Sirajganj identified five fragile urban systems for through rigorous discussions in the SLD:

(i) Water Supply
(ii) Biodiversity
(iii) Solid Waste Management
(iv) Economy
(v) Drainage

5.1 Urban Systems Analysis

5.1.1 Water Supply[13]

A majority of the city depends on groundwater for its water supply however only 30 percent of the population is covered by a piped water supply network. Water which is pumped from the ground does not go through any form of treatment before supply. The average per capita requirement is 160 lpcd however the production capacity is only 81 lpcd which is distributed over the span of three hours every day. Of the 1898 connections, only 47% are metered. On an average 47 people are served by one water connection. The collection efficiency of revenue is 72%. The arsenic content in the water supply exceeds the standard at 0.062mg/l. As the population grows, the demand for water grows, leading to a decline in the quantity and quality of the groundwater table. This will create severe water stress in future and exacerbate arsenic contamination.

The priority needs of the water supply system are “increase of production capacity”, “improvement of O&M (production well and pump)”, and “expansion and replacement of distribution network”.

Fragility Statement and Climate Fragility Statement

Considering the present situation of Water Supply in Sirajganj, the urban fragility statement of this system is ‘The challenges of the water supply network in Sirajganj are low coverage, insufficient technical and managerial capacity of staff and limited financial resources to improve production and supply.’

The climate fragility statement for this system is:

“Climate Risk 1: Increasing temperature and decreasing rainfall (short duration high intensity rainfall) in the region will lead to a water deficit and increased concentration of Arsenic which will impact health.”

5.1.2 Biodiversity

With increasing urbanisation, deforestation and population, the biodiversity in the region is decreasing. Loss of habitat has led to a decrease in the different species of birds, animals, and fish.

Fragility Statement and Climate Fragility Statement

Considering the present situation of Biodiversity in Sirajganj, the urban fragility statement of this system is ‘Biodiversity loss is seen throughout the city with reduction in species of birds, animals, and fish due to loss of habitat.’

The climate fragility statement for this system is:

[13]Japan International Cooperation Agency. 2012. Data Collection Survey On Water Supply Sector In Local Municipalities In Bangladesh. Tokyo Engineering Consultants, Co., Ltd. Kokusai Kogyo Co., Ltd. The Government of the People’s Republic of Bangladesh Local Government Division Ministry of local Government and Rural Development and Cooperatives.

"Climate Risk 1: Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity."

5.1.3 Solid Waste Management

Waste segregation is not practiced in Sirajganj city. The city lacks a landfill site and there is no form of scientific management of the waste therefore waste ends up being dumped in an already over-capacity open dumpsite. The municipality has poor resources to collect, manage and process the waste which is compounded by a lack of public awareness and recycling facilities.

Fragility Statement and Climate Fragility Statement

Considering the present situation of Solid Waste Management in Sirajganj, the urban fragility statement of this system is 'Good solid waste management is crucial to maintenance of water bodies and drains, and is under stress from indiscriminate dumping of waste and poor collection facilities.'

The climate fragility statement for this system is:

"Climate Risk 1: Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) may cause waste to decompose in open dumps creating health hazards; choking of drains can affect drainage causing health hazards and water logging in the rainy season."

5.1.4 Economy

As with the rest of the country the economy in Sirajganj is principally agrarian. A proportion of the population is engaged in agriculture, in fisheries and employed in fruit orchards. These sectors are tightly linked to climate. Most of the urban poor is engaged as agricultural labour or daily wage earners and are therefore dependent on the natural resources for their livelihoods.

Although agriculture is the mainstay of its economy, Sirajganj earned fame for its handloom industry which produces saree, lungi and other clothes. In 2015, the Sirajganj Economic Zone Ltd, a consortium consisting of knitwear and readymade garment companies, received approval to develop the Economic Zone.

A large percentage of migrants make up the informal work sector. Thus, any change in the climate, is linked tightly with that of the economy especially in the context of the aforementioned population.

Fragility Statement and Climate Fragility Statement

Considering the present situation of the economy in Sirajganj, the urban fragility statement of this system is 'Agriculture, fishery and fruit orchards are important in providing economic support to the urban poor, the landless and middle class landowners.'

The climate fragility statement for this system is:

"Climate Risk 1: Increasing temperature and decreasing rainfall (short duration high intensity rainfall) will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. Heat stress will impact the daily labourers adversely."

5.1.5 Storm Water Drainage

River erosion and almost yearly flood attacks occur with different level of intensities in Sirajganj city. Only one third of the city is covered by drains. Lack of appropriately built sluice gates and poor drain coverage, results in water logging and stagnation of water during heavy rainfall events. Some of the water logged areas in the city are Goshala, Hazi barrack, Hossainpur, Dhanbandhi, Dattobari, Janpur, Mondolpara, Kobdashpara, Chok-Kobdashpara, Ekdala, Soyadhanghora, Diardhanghora, Mahmudpur, Masumpur, Railway Colony, Bhangabari, Bahirgola, Rahmotganj, Beparipara, Kazipur intersection, Shahidganj, Mirpur, Biralakuthi and Chand-Alirmorh area[14].

Fragility Statement and Climate Fragility Statement

Considering the present situation of the drains in Sirajganj, the urban fragility statement of this system is 'Limited drainage infrastructure and high vulnerability of the town to flooding and river bank erosion leads to permanent water logging in the city.'

The climate fragility statement for this system is:

"Climate Risk 1: Short duration high intensity rainfall will lead to excessive flooding due to clogged drains resulting in health hazards."

The urban fragility statements and climate 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 Committee during the 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 process followed for risk scoring is detailed in Annexure 2. Table 4 shows the risk status of the climate fragility statements.

Table 4: Risk Assessment of Climate Fragility Statements

Urban System	Impacts of Climate Change	Risk Status
Water Supply	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) in the region will lead to a water deficit and increased concentration of Arsenic which	High

[14] http://archive.thedailystar.net/newDesign/print_news.php?nid=1606

Urban System	Impacts of Climate Change	Risk Status
	will impact health.	
Biodiversity	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	High
Solid Waste Management	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) may cause waste to decompose in open dumps creating health hazards; choking of drains can affect drainage causing health hazards and water logging in the rainy season.	High
Economy	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. Heat stress will impact the daily labourers adversely.	High
Drainage	Short duration high intensity rainfall will lead to excessive flooding due to clogged drains resulting in health hazards	Extreme

Based on this risk assessment, water supply, biodiversity, the economy, and solid waste management are at high risk from climatic impacts. Storm water drainage scored extreme and should be an immediate priority for the city.

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 Intergovernmental Panel on Climate Change (IPCC, 2007)[15] 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.

[15]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.

Figure 12: Vulnerability Constituents[15]

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

1. **Identification of Vulnerable Places**: Areas that are highly vulnerable to the identified fragile urban systems of the city were identified and mapped to arrive at vulnerability 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 Adaptive 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.

6.2 Identification of vulnerable areas of Fragile Urban Systems

6.2.1 Water Supply: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Increasing temperature and decreasing rainfall (short duration high intensity rainfall) in the region will lead to a water deficit and increased concentration of Arsenic which	Ward 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 81 slums within city and river side slums are more vulnerable

Climate Fragility Statements	Area/ward most vulnerable
will impact health.	(Figure 13)

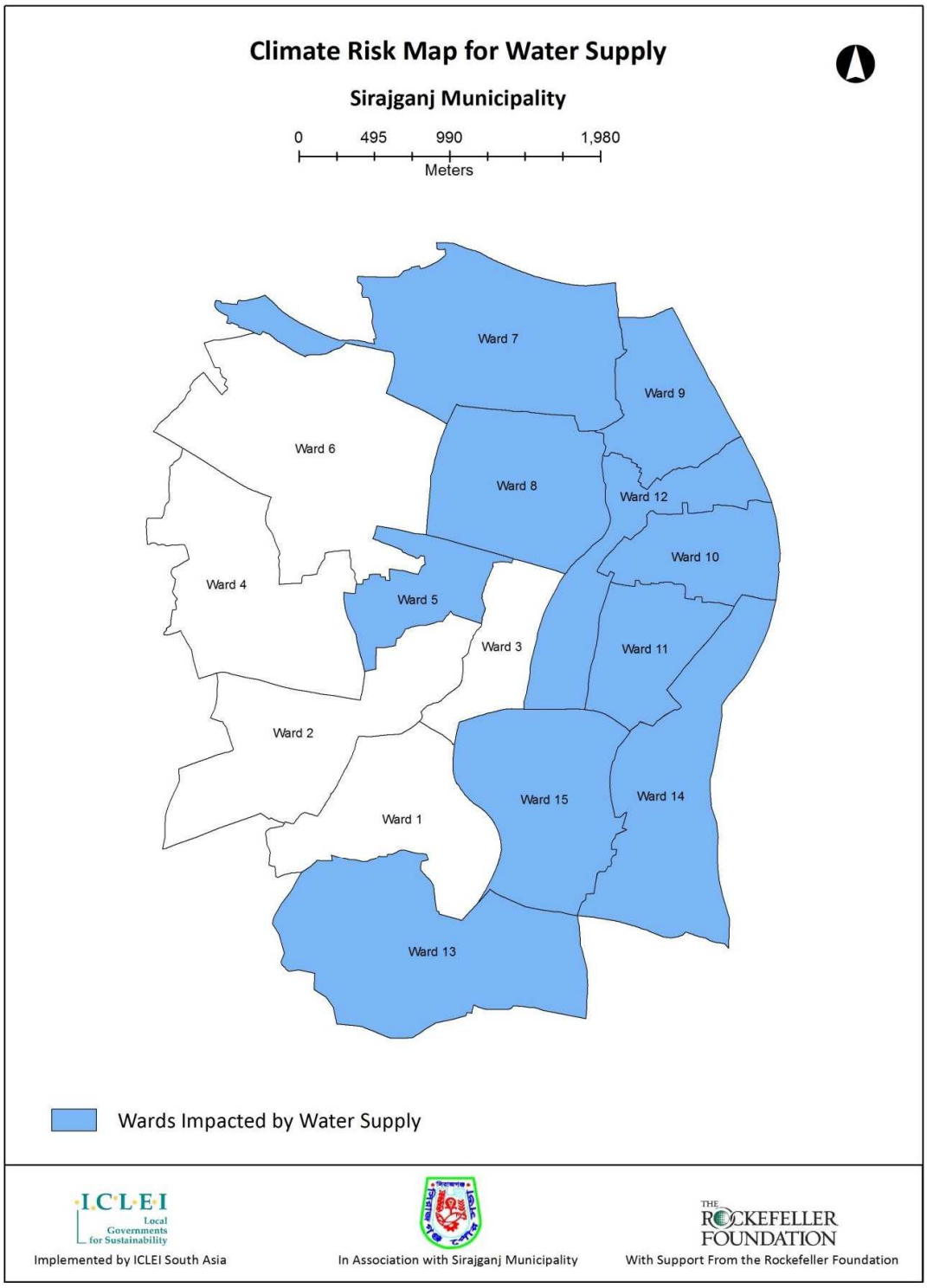

Figure 13: Wards most vulnerable to climate risks in the context of Water Supply, Sirajganj

6.2.2 Biodiversity: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable

Climate Fragility Statements	Area/ward most vulnerable
Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	River side wards 7, 8, 9, 10, 11, 12, 13, 14, 15 (Figure 14)

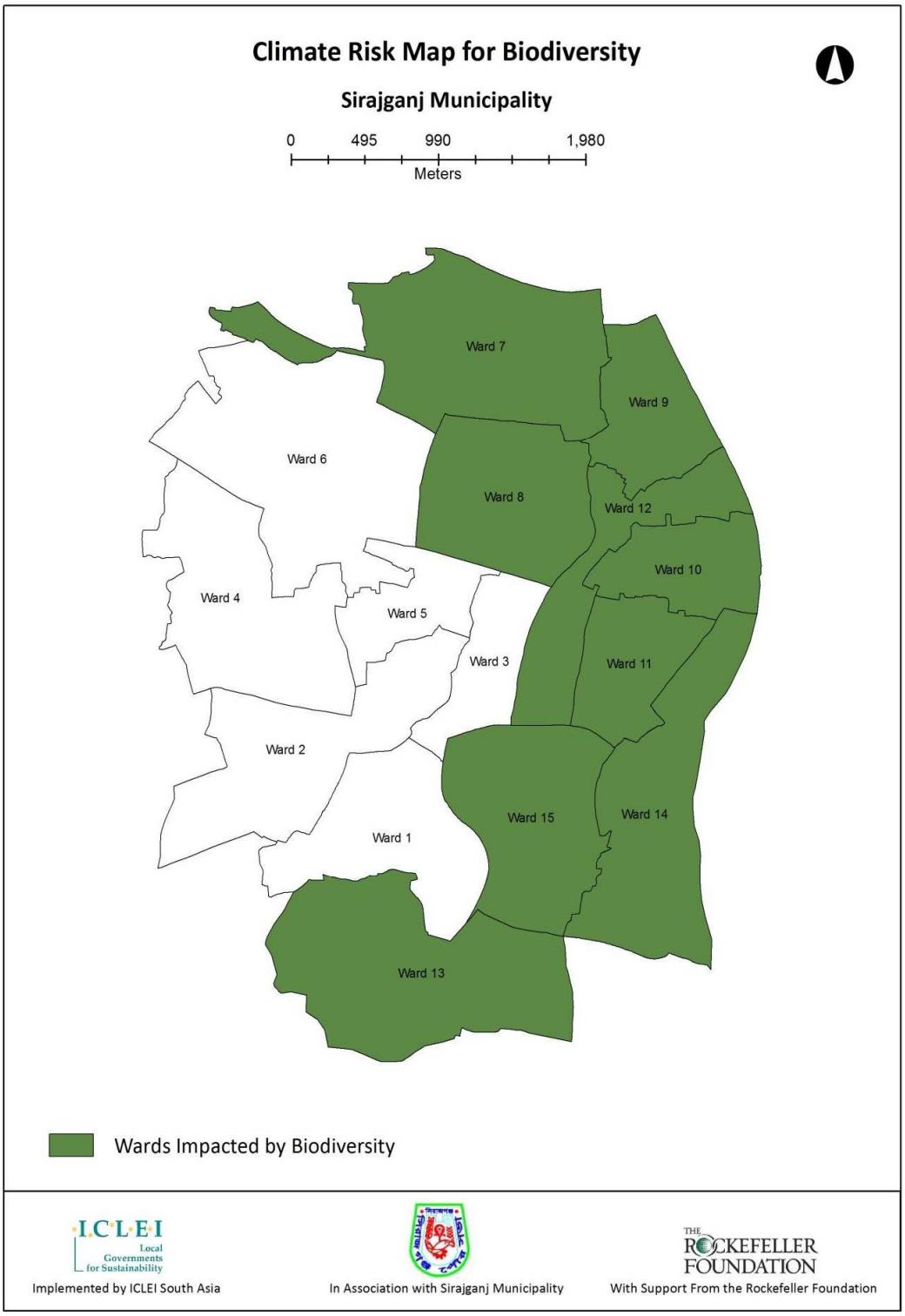

Figure 14: Wards most vulnerable to climate risks in the context of Biodiversity, Sirajganj

6.2.3 Solid Waste Management: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) may cause waste to decompose in open dumps creating health hazards; choking of drains can affect drainage causing health hazards and water logging in the rainy season.	Ward 2, 3, 4, 5, 8, 12 (Figure 15).

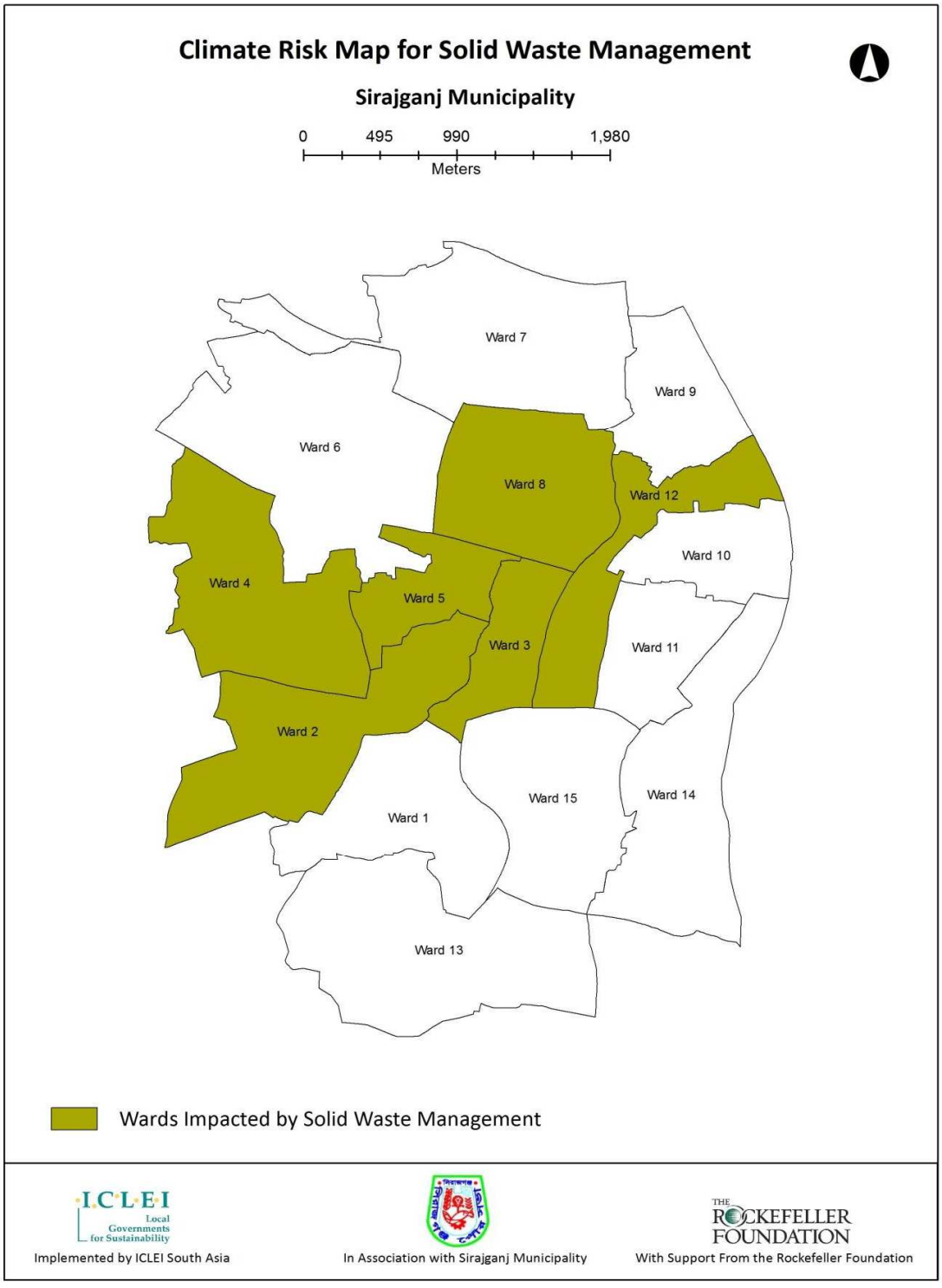

Figure 15: Wards most vulnerable to climate risks in the context of Solid Waste Management, Sirajganj

6.2.4 Economy: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable

Climate Fragility Statements	Area/ward most vulnerable
Increasing temperature and decreasing rainfall (short duration high intensity rainfall) will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. Heat stress will impact the daily labourers adversely.	Ward 4, 6, 7, 8, 9, 13 (Figure 16).

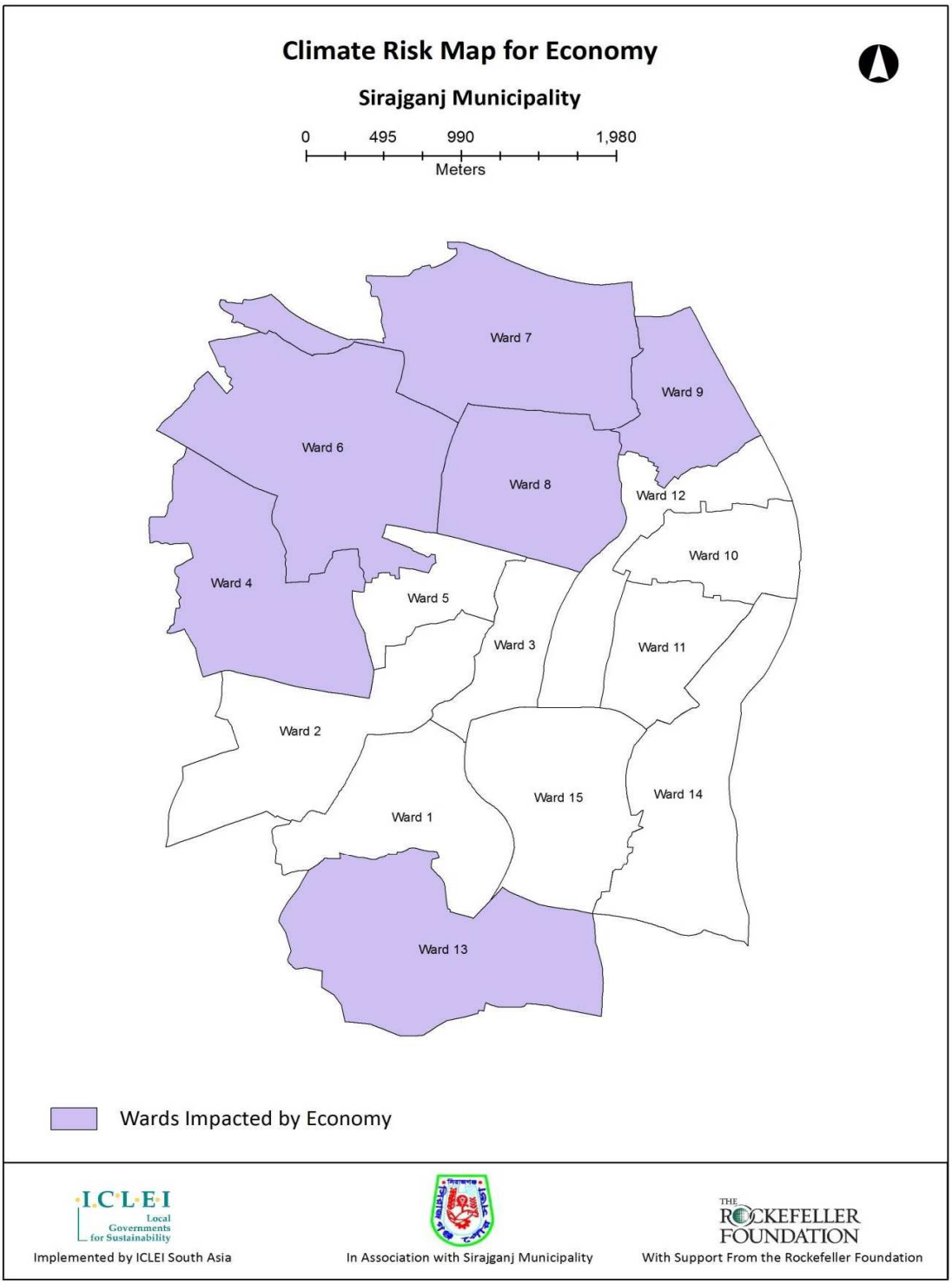

Figure 16: Wards most vulnerable to climate risks in the context of Economy, Sirajganj

6.2.5 Drainage: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Short duration high intensity rainfall will lead to excessive flooding due to clogged drains resulting in health hazards	Ward 1, 4, 5, 7, 12, 13, 14, 15 (Figure 17)

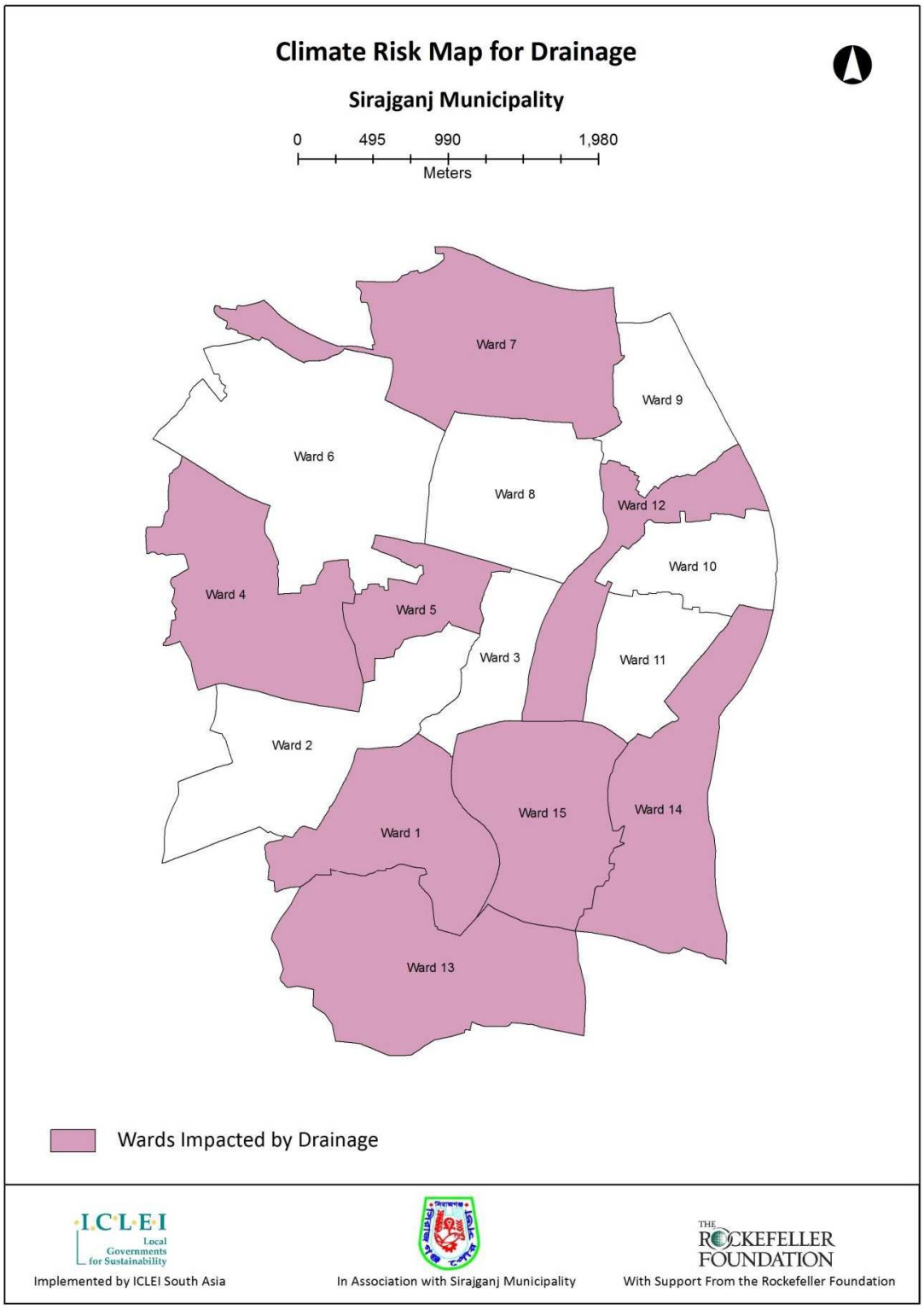

Figure 17: Wards most vulnerable to climate risks in the context of Drainage, Sirajganj

Many areas in the city are impacted by more than one fragile urban system. These areas need more attention as they face threats from multiple fragile urban systems and are referred to as the vulnerability hotspots. In Sirajganj ward 7, 8, 12, and 13 were identified as the vulnerable hotspots and was affected by four urban systems.

Wards 4, 5, 9, 14 and 15 are affected by three urban systems. These wards are mostly located close to the river and have a substantial slum population. The vulnerability hotspot map (Figure 18) helps to identify the wards which must be focused on for future interventions to build resilience that are identified in later chapters.

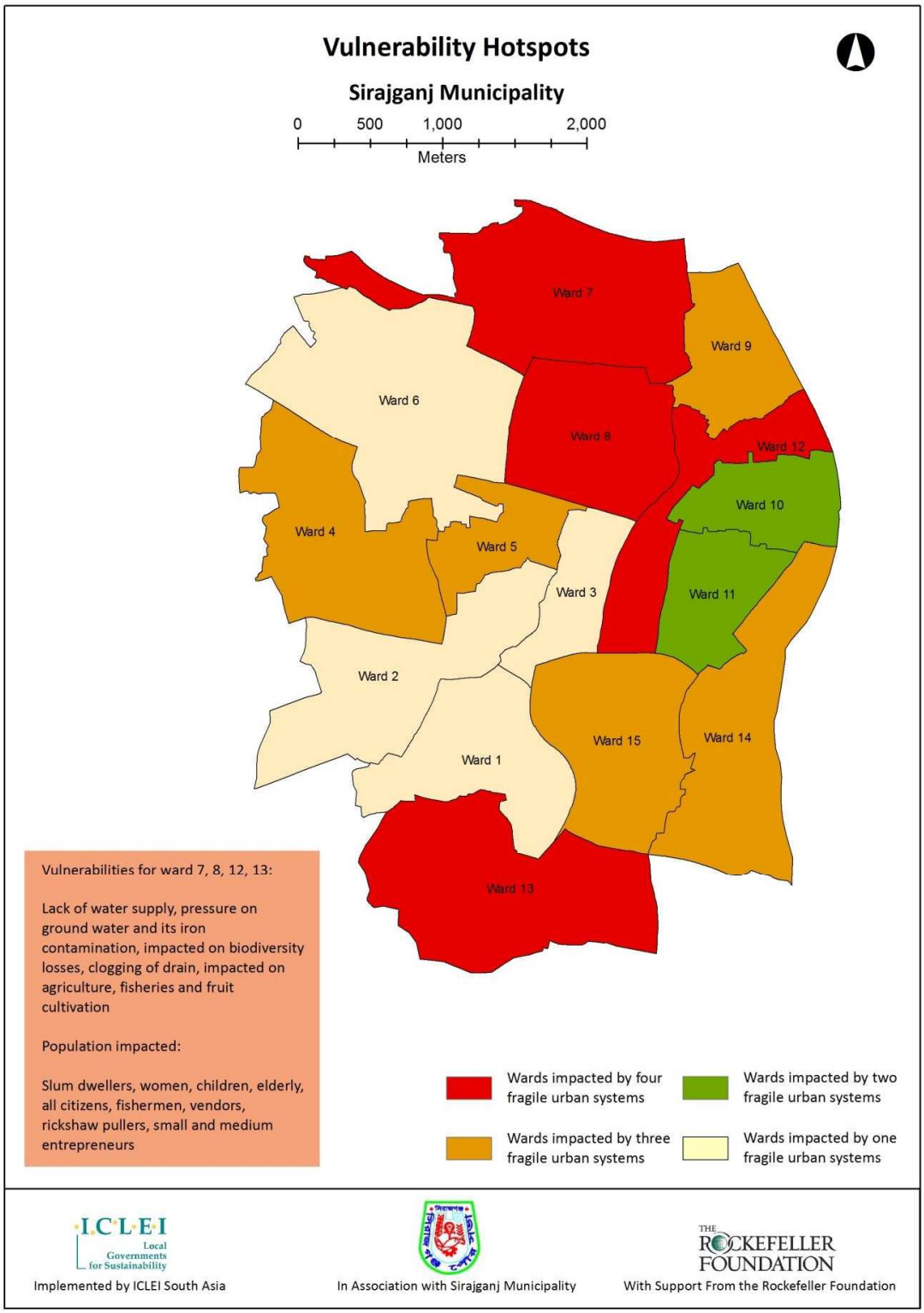

Figure 18: Consolidated Vulnerable Hotspots for Sirajganj City

6.3 Actor Analysis

This section focuses on the analysis of the adaptive capacities of urban actors identified within the vulnerable wards. This section focuses on the analysis of the adaptive capacities of urban actors identified within the vulnerable wards. On the basis of their capacity to respond to climatic

impacts, the actors are divided into vulnerable actors or supporting actors. Table 5 below shows the adaptive capacities of the actors for each fragile urban system.

Overall only the Local Government Engineering Department (LGED), the Department of Disaster Management, District Information Office and the media were scored high in the analysis and can be supportive to resilience building activities in the city. The Municipality lack trained technical staff who can deal with the impacts of climate change on their systems. Capacity building of the existing staff is urgently needed. Hence they were scored low. Residents have low economic resources to be able to tackle climate impacts on their lives and livelihoods. Other government departments also lack the resources to assist the municipality or residents to tackle climate change.

Table 5: Analysis of the adaptive capacities of local actors identified

Fragile Urban System	Climate Fragility Statements	Area/ward most vulnerable	Actors	Level of Adaptive Capacity
Water Supply	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) in the region will lead to a water deficit and increased concentration of Arsenic which will impact health.	Wards 5, 7, 8, 9, 10, 11, 12, 13, 14, 15.	Slum dwellers	Low
			Municipality	Low
			Women	Low
			Children	Low
			Elderly	Low
			NGOs	Low
			LGED	High
			Town Level Coordination Committee (TLCC)	Low
Biodiversity	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	Wards 7, 8, 9, 10, 11, 12, 13, 14, 15.	Citizens	Low
			Municipality	Low
			Department of Forest	Low
			Department of Livestock	Low
			Department of Fisheries	Low
			Department of Agriculture	Low
			NGOs	Low
			Farmers	Low
			TLCC	Low
			District Information Office	Medium
			Media	Medium

Fragile Urban System	Climate Fragility Statements	Area/ward most vulnerable	Actors	Level of Adaptive Capacity
Solid Waste Management	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) may cause waste to decompose in open dumps creating health hazards; choking of drains can affect drainage causing health hazards and water logging in the rainy season.	Wards 2, 3, 4, 5, 8, 12	Municipality	Low
			Citizens	Low
			NGOs	Low
			Department of Health	Low
			Sanitary Workers	Low
			TLCC	Low
			LGED	High
			Schools & Colleges	Low
			Media	Medium
Economy	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. Heat stress will impact the daily labourers adversely.	Wards 4, 6, 7, 8, 9, 13	Farmers	Low
			Municipality	Low
			Labour Association	Low
			Department of Livestock	Low
			Department of Fisheries	Low
			Fishermen	Low
			NGOs	Low
			Department of Disaster Risk Management	High
			Department of Cooperative Societies	Low
Drainage	Short duration high intensity rainfall will lead to excessive flooding due to clogged drains resulting in health hazards.	Wards 1, 4, 5, 7, 12, 13, 14, 15	Municipality	Low
			LGED	High
			Ward Committee	Low
			CBOs	Low
			Drainage Cleaners	Low
			Children	Low
			Elderly	Low
			Citizens	Low
			Media	Medium

Fragile Urban System	Climate Fragility Statements	Area/ward most vulnerable	Actors	Level of Adaptive Capacity
			Schools & Colleges	Low
			Religious Institutions (mosque, temple)	Low
			TLCC	Low
			Department of Cooperative Societies	Low

6.4 Adaptive Capacity of Fragile Urban Systems

The adaptive capacities of the five fragile urban systems were assessed during the SLD against the five parameters of economy, technology, governance, societal and ecosystem services. The adaptive capacities in terms of societal and governance aspects are low for all systems, with little policy level interventions at the city level and lack of awareness among citizens especially with regard to solid waste management and drainage. Economic adaptive capacity is high for all systems, since the Sirajganj Municipality has sufficient funding available for different projects on the various fragile systems. However technological adaptive capacity varies for the different systems since availability of technological resources for the systems vary for the municipality.

The table 6 provides the details of the adaptive capacity of the fragile urban systems in the consolidated vulnerability analysis.

Table 6: Consolidated vulnerability analysis of Fragile Urban Systems identified for Sirajganj city

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
			Vulnerable	Potential Supporting	Low	Medium	High
Water Supply	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) in the region will lead to a water deficit and increased concentration of Arsenic which will impact health.	Ward 5, 7, 8, 9, 10, 11, 12, 13, 14, 15	• Slum dwellers • Municipality • Women • Children • Elderly • NGOs • Town Level Coordination Committee (TLCC)	• LGED	- Societal - Governance	- Technological/ Infrastructure - Ecosystem Services	- Economic
Biodiversity	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	Wards 7, 8, 9, 10, 11, 12, 13, 14, 15	• Citizens • Municipality • Department of Forest • Department of Livestock • Department of Fisheries • Department of Agriculture • NGOs	• District Information Office • Media	- Societal - Governance - Ecosystem Services - Technological/ Infrastructure		-Economic

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
			Vulnerable	Potential Supporting	Low	Medium	High
			• Farmers				
Solid Waste Management	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) may cause waste to decompose in open dumps creating health hazards; choking of drains can affect drainage causing health hazards and water logging in the rainy season.	Wards 2, 3, 4, 5, 8, 12	• Municipality • Citizens • NGOs • Department of Health • Sanitary Workers • Schools and Colleges	• LGED • Media	- Societal - Governance	- Technological/ Infrastructure	- Economic
Economy	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. Heat stress will impact the daily labourers adversely.	Ward 4, 6, 7, 8, 9, 13	• Farmers • Municipality • Labour Association • Department of Livestock • Department of Fisheries • Fishermen • NGOs	• Department of Disaster Risk Management	- Societal - Governance - Ecosystem Services	- Technological/ Infrastructure	- Economic

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
			Vulnerable	Potential Supporting	Low	Medium	High
			• Department of Cooperative Societies				
Drainage	Short duration high intensity rainfall will lead to excessive flooding due to clogged drains resulting in health hazards.	Ward 1, 4, 5, 7, 12, 13, 14, 15	• Municipality • Ward Committee • CBOs • Drainage Cleaners • Children • Elderly • Citizens • Schools & Colleges • Religious Institutions (mosque, temple) • Department of Cooperative Societies	• Media • LGED	- Societal - Governance - Technological/ Infrastructure	- Ecosystem Services	- Economic

7. RESILIENCE INTERVENTIONS

Possible adaptation interventions were identified for the five fragile urban systems in Sirajganj 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.

These interventions were linked 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 31 resilience interventions have been identified in the process as listed in **Table 7.**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.

Table 7: Prioritized Resilience Interventions against Resilience Indicators

Prioritized Resilience Interventions	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 System						
Policy/Non-Infrastructural Measures						
Awareness building programs for the citizens using campaign, rally, placards, announcement in religious institution, billboards, workshops, school programs etc. for water conservation. Capacity building of municipal staff on the same.	High	Medium-Low	Long term	Short term	Low	Can be used for other systems together
Infrastructural Measures						
Construction of 2 overhead tanks in Municipality area for facilitating water supply in areas that don't receive enough water	Average	Medium	Short term	Short term	High	
Construction of 2 water treatment plants in Ranigram and Mirpur	High	Medium-high	Medium term	Short term	High	Improved health from better water

Prioritized Resilience Interventions	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
						supply
Extension of existing piped water network by Municipality	Medium	High-Medium	Medium term	Medium term	High	Improved health from better water supply
Use of properly treated river water	Medium	Medium	Medium term	Medium term	High	Improved health from better water supply
Rain Water Harvesting in public buildings	Medium	Medium	Long term	Short term	Low	Improved health from better water supply
Installation of drinking water supply posts where piped water supply is absent	Average	High-Medium	Short term	Medium term	High	Improved health from better water supply
Biodiversity						
Policy/Non-Infrastructural Measures						
Preparation of a master plan on biodiversity with the help of the LGED	High	Medium	**Long term**	Short term	Low	
Awareness building among	High	Medium	**Long term**	Short term	Low	Can be used

Prioritized Resilience Interventions	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
the farmers to limit use of chemical fertilizers by arranging councils/advocacy meetings with the help Department of Agricultural Extension, Fishery and Forest						for other systems together
Infrastructural Measures						
Use of renewable energy including solar with the help of Department of Forest & Environment, and NGOs.	Medium	High-Medium	Short term	Medium term	High	Can reduce carbon emissions of the city as a whole, alternate job creation
Tree plantation drive	Average	High-Medium	Long term	Medium term	Medium	Alternate jobs creation, carbon Sinks
Solid Waste Management						
Policy/Non-Infrastructural Measures						
Preparation of a comprehensive and	High	Medium	Long term	Short term	Low	

Prioritized Resilience Interventions	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
integrated waste management plan with the help of DPHE						
Training for municipal staff on safety and waste handling procedures.	High	Medium-high	Long term	Short term	Low	Can be used for other systems together
Awareness building programs for all stakeholders on Solid Waste Management with support from NGOs	High	Medium-high	Long term	Short term	Low	Can be used for other systems together
Infrastructural Measures						
Establishment of a faecal sludge management system with the help of DPHE	Medium	Medium	Medium term	Short term	High	Recycling of Sludge for compost, agricultural input
Augmentation of municipal infrastructure	Medium	Medium	Medium term	Medium term	High	
Production of compost from organic solid waste with support from LGED, DPHE and the community.	Medium	Medium-high	Short term	Short term	Medium	Creation of jobs, material recovery

Prioritized Resilience Interventions	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
Producing biogas from organic waste	Medium	Medium-high	Short term	Short term	Medium	Creation of jobs, material recovery
Economy						
Policy/Non-Infrastructural Measures						
Trainings, skill development and provision of incentives for low income earners& community.	High	Medium-high	Long term	Short term	Low	Alternate skill development
Engagement of the low income earners in economic zone coordinating with BEPZA	Medium	Medium-low	Long term	Medium term	Medium	
Provision of some commercial spaces in markets with special consideration for the low income people	Medium	Medium-high	Long term	Short term	Low	
Infrastructural Measures						
Construction of low income housing for slum dwellers.	Medium	Medium-high	Long term	Medium term	High	Scope for low emission development in the city

Prioritized Resilience Interventions	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
Development of Tourism based activities on riverside which will generate employment.	Average	Medium	Long term	Medium term	High	Alternate skill development
Drainage						
Policy/Non-Infrastructural Measures						
Preparation of a comprehensive drainage master plan with the help of LGED	High	Medium	Long term	Short term	Medium	
Monitoring of drains with a focus on market areas (Ward 3, 12) to ensure choking of drains does not occur	Medium	High-medium	Long term	Short term	Low	
Regulation and monitoring of encroachment and land filling of ponds by Municipality with the help of DC office	Medium	Medium	Long term	Long term	Low	Better urban biodiversity
Strengthening the capacities of staff in the monitoring and complaint centre	Average	Medium-high	Short term	Short term	Low	

Prioritized Resilience Interventions	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
Awareness building programs using media (local channel), workshop, billboards, community meetings, *potogaan*/ cultural programs, religious institutions with CBOs, NGOs. Capacity building of municipal staff.	High	High-Medium	Long term	Short term	Low	Can be used for other systems together
Infrastructural Measures						
Extension of drainage network	Medium	Medium-low	Long term	Medium term	High	
Removal of encroachment of illegal settlements in Katakhal with support from the DC office	Average	Medium	Long term	Short term	High	Land-use implications
Regular cleaning of drains	Average	High-medium	Short term	Short term	High	

7.1 Integration into City Plans

Several projects are being implemented in the Sirajganj Municipality. Through the Urban Partnership for Poverty Reduction Project (UPPR), 83 Community Development Committees that represent 13840 members involved in the savings and credit scheme have been set up. Main tangible physical achievements are the construction of 1950 latrines, over 19 kms of roads and ways with footpaths, 3.5 kms of drains, and 53 water facilities. Additionally, the municipality is receiving funds for urban works through the Municipal Services Project (MSP), Bangladesh Municipal Development Fund (BMDF), Secondary Towns Infrastructure Development Project (STIDP), Secondary Towns Integrated Flood Protection Project (STIFPP), Emergency Disaster Damage Rehabilitation Project (EDRP), and the Emergency Flood Damage Rehabilitation Project (EFDRP).

Dredging of the Jamuna River from upstream of Sirajganj Hard Point (through Bangabandhu Bridge) to near Dhaleswari Off take[16] is being done as well.

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

7.1.1 Water Supply

Issues:	The priority challenges of the water supply network in Sirajganj are low coverage, insufficient technical and managerial capacity and limited financial resources.	
Potential Climate Impacts:	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) in the region will lead to a water deficit and increased concentration of Arsenic which will impact health.	
Potentially Impacted Areas:	Wards 5, 7, 8, 9, 10, 11, 12, 13, 14, 15.	
Risk Status:	High	
Actors:	Vulnerable - Slum dwellers - Municipality - Women - Children - Elderly - NGOs - TLCC	Supporting - LGED

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		

[16]Bangladesh National Committee of the International Commission on Irrigation and Drainage (BANCID), 2015.BANCID Yearly Newsletter 2015. ICID CIID. Dhaka http://jrcb.gov.bd/bangla/images/pdf/BANCID_Newsletter_2015.pdf

Type of Measures	Cost per unit and description	Cost Estimate
Awareness building programs for the citizens using campaign, rally, placards, announcement in religious institution, billboards, workshops, schooling programs etc. for water conservation. Capacity building of Municipal staff on the same	IEC materials, publishing costs, logistics of meetings, trainings	USD 2500 per training of 20-25 people
Infrastructural Measures		
Rain Water Harvesting in public buildings	Civil costs, construction costs, labour, materials, meetings, training	USD 10000 per unit

7.1.2 Biodiversity

Issues:	Biodiversity loss is seen throughout the city with reduction in species of birds, animals, and fish due to loss of habitat	
Potential Climate Impacts:	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	
Potentially Impacted Areas:	Wards 7, 8, 9, 10, 11, 12, 13, 14, 15.	
Risk Status:	High	
Actors:	Vulnerable - Citizens - Municipality - Department of Forest - Department of Livestock - Department of Fisheries - Department of Agriculture - NGOs - Farmers	Supporting - District Information Office - Media

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		

Awareness building among the farmers to limit use of chemical fertilizers by arranging councils/advocacy meetings with the help Department of Agricultural Extension, Fishery and Forest	IEC materials, cost of publishing, meetings, trainings, logistics	USD 2500 per training of 20-25 people
Infrastructural Measures		
Tree Plantation drive	Cost of plants, labour, materials, site	USD 10000 for one plantation drive

7.1.3 Solid Waste Management

Issues:	Solid waste management is under stress from indiscriminate dumping of waste and poor collection facilities	
Potential Climate Impacts:	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) may cause waste to decompose in open dumps creating health hazards; choking of drains can affect drainage causing health hazards and water logging in the rainy season.	
Potentially Impacted Areas:	Wards 2, 3, 4, 5, 8, 12	
Risk Status:	High	
Actors:	Vulnerable - Municipality - Citizens - NGOs - Department of Health - Sanitary Workers - Schools and Colleges	Supporting - LGED - Media

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		
Preparation of a comprehensive and integrated waste management plan with the help of DPHE	Cost of consultant, staff costs, meetings	USD 20,000
Infrastructural Measures		
Production of compost from organic solid waste with support from LGED, DPHE and the community.	Civil costs, construction costs, labour, materials, trainings, staff cost	USD 25,000 per composting facility

7.1.4 Economy

Issues:	- Agrarian economy affected by climate change - Large informal sector	
Potential Climate Impacts:	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. Heat stress will impact the daily labourers adversely.	
Potentially Impacted Areas:	Wards 4, 6, 7, 8, 9, 13	
Risk Status:	High	
Actors:	**Vulnerable** - Farmers - Municipality - Labour Association - Department of Livestock - Department of Fisheries - Fishermen - NGOs - Department of Cooperative Societies	Supporting - Department of Disaster Risk Management

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		
Trainings, skill development and provision of incentives for low income earners & community.	Cost of training, meetings, logistics, IEC, staff costs	USD 5000 for each training for 30-50 people
Infrastructural Measures		
Development of Tourism based activities on riverside which will generate employment.	Cost of planning, construction and civil costs, Labour, Materials, training	A detailed project report is needed for the estimation of costs

7.1.5 Storm Water Drainage

Issues:	Limited drainage infrastructure and high vulnerability of the town to flooding and river bank erosion leads to permanent water logging in the city
Potential Climate Impacts:	Short duration high intensity rainfall will lead to excessive flooding due to clogged drains resulting in health hazards.

Potentially Impacted Areas:	Wards 1, 4, 5, 7, 12, 13, 14, 15	
Risk Status:	Extreme	
Actors:	**Vulnerable** - Municipality - Ward Committee - CBOs - Drainage Cleaners - Children - Elderly - Citizens - Schools & Colleges - Religious Institutions (mosque, temple) - Department of Cooperative Societies	Supporting - LGED - Media

Prioritized Actions

Type of Measures	Cost per unit and description	Cost Estimate
Policy and Institutional Measures		
Awareness building programs using media (local channel), workshop, billboards, community meetings, *potogaan*/ cultural programs, religious institutions with CBOs, NGOs. Capacity building of municipal staff.	IEC materials, publication costs, meetings, trainings, staff costs	USD 2500 per training of 30-50 people
Infrastructural Measures		
Removal of encroachment of illegal settlements in Katakhal with support from the DC office	Policy formulation costs, meetings, trainings, staff cost	USD 2500 for preparation of policy and ratification

8. CONCLUSION

The implementation of the IAP toolkit in the city of Sirajganj revealed that the city is very vulnerable to projected climate change impacts of higher temperatures and decreased rainfall. The city needs to adapt to possible impacts of the same. The economy is largely agrarian and basic urban services are limited in the city. Therefore the city has a greater need to adapt to climatic changes that may be faced by the already fragile urban systems. The ICLEI ACCCRN Process helped identify two climate risk scenarios of increased temperature and decreased and irregular precipitation. Five urban systems were identified as fragile - water supply, solid waste management, economy, drainage and biodiversity - and climate fragility statements were formulated for all of them corresponding to the two climate scenarios.

The vulnerability map of the city shows wards 7, 8, 12, and 13 as the vulnerable hotspots in the city affected by four fragile urban systems. Wards 4, 5, 9, 14 and 15 are affected by three urban systems. These wards are mostly located close to the river and have substantial slum population. Sirajganj Municipality itself is rated low on adaptive capacity in all the systems 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. Although the Municipality has financial resources, they have low technical capacity. The Local Government Engineering Department (LGED) has high adaptive capacity, but it is a central government agency and has little coordination with the municipality regarding planning of its development. Residents need awareness on managing water, waste and maintaining hygiene.

The list of interventions identified in this CRS includes both hard and Policy/Non-Infrastructural Measures. These measures either 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 schemes, and also international programs. Sirajganj Municipality and other implementing agencies can pick projects according to their priority and need within a specific fragile urban system as well as the different climate scenarios agreed upon during initial stages of IAP. Integration of all prioritised interventions into other plans of the town is also important in order to avoid duplicity of efforts and enhance coordination. The way forward for the city to build resilience includes:

- **Inter-departmental coordination:** Building coordination between the LGED and the Municipality for better integration of developmental activities with urban resilience.
- **Capacity Building**: Since the Municipal staff lacks technical capacity regarding the management and technological issues of different systems, there is a need to build this capacity. Planning for different systems is also essential. Capacity building for the residents to encourage alternate means of livelihood will go a long way to improve resilience in the city.
- **Service level improvement:** Basic urban services in the city are limited and needs substantial improvement. Structural and policy measures can be undertaken as outlined in the resilience interventions to improve, water resource management, sanitation and drainage, and solid waste management. Decentralised systems for water and waste management are useful for the city to improve redundancy of their urban systems.

It is essential for the municipality to start collaboration with different agencies to build their technical capacity to undertake resilience building projects in the city. Planning in advance can not only help to avoid future threats but also provide opportunities to better social, economic and environmental development in the city.

Annexure 1

Urban System analysis

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Fragility statement	Climate Fragility Statement
Water Supply	*Flexibility & Diversity:* Water supply is dependent on ground water for majority of the city. *Redundancy:* Only 20-25 percent covered with piped water supply; Iron treatment plants (2) disfunctional and only 1 is functional *Safe failure:*	Only 30 percent of the region is covered with piped supply. Ground water is full of iron. Tube wells need dug very deep. The region is a dry region with water stress, ponds are being filled up, and ground water level is going down. This will create severe water stress in future.	'The challenges of the water supply network in Sirajganj are low coverage, insufficient technical and managerial capacity of staff and limited financial resources to improve production and supply.'	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) in the region will lead to a water deficit and increased concentration of Arsenic which will impact health.
Biodiversity	*Flexibility & Diversity:* Biodiversity - birds, bats, frogs, squirrels, snakes - have reduced over time due to lack of habitation. Ponds are reducing in number affecting fish species. Local orchards are also lost. *Redundancy:* *Safe failure:*	At present the different species of birds, animals, fish are reducing with increasing urbanisation and loss of habitat.	Biodiversity loss is seen throughout the city with reduction in species of birds, animals, and fish due to loss of habitat.	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.

Solid Waste Management	*Flexibility & Diversity:* *Redundancy:* *Safe failure:* All solid waste is dumped at a place which is overloaded now; no waste segregation happens; no landfill site	Lack of resources hinder waste management. Lack of public awareness and recycling facilities make waste disposal in sustainable manner difficult.	Good solid waste management is crucial to maintenance of water bodies and drainage, and is under stress from indiscriminate dumping of waste and poor collection facilities	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) may cause waste to decompose in open dumps creating health hazards; choking of drains can lead to improper drainage and health hazards to population by water logging in rainy season
Economy	*Flexibility & Diversity:* Economy is dependent on agriculture, fishery and fruit orchards, that are dependent on climate. High level of migrants who depend on informal work sector. *Redundancy:* *Safe failure:* Failure in case of climatic changes, can cause severe impacts on income of urban poor.	Urban poor and landless are dependent on agriculture, fishery, fruit cultivation as agricultural labour. 5-10 % of the population is dependent on agriculture	Agriculture, fishery and fruit orchards are important in providing economic support to landless, women, and urban poor. Middle class is also dependent on agriculture and own land.	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. Heat stress will impact daily labourers adversely.

Drainage	City lacks drains. Separate drains for Solid waste and storm water missing	City drains are not networked. covers only 1/3rd of the city.	Limited drainage infrastructure and high vulnerability of the town to flooding and river bank erosion leads to permanent water logging in the city.	Short duration high intensity rainfall will lead to excessive flooding due to clogged drains resulting in health hazards.

Annexure 2

Risk Prioritisation

Urban Systems	Climate fragility statement	Likelihood	Consequence	Risk Score (Likelihood X Consequence)	Risk Status
Water Supply	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) in the region will lead to a water deficit and increased concentration of Arsenic which will impact health.	4	3	12	High
Biodiversity	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	5	3	15	High
Solid Waste Management	Increasing temperatures and decreasing rainfall (short duration high intensity rainfall) may cause waste to decompose in open dumps creating health hazards; choking of drains can lead to improper drainage and health hazards to population by water logging in rainy season	4	4	16	High
Economy	Increasing temperature and decreasing rainfall (short duration high intensity rainfall) will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. Heat stress will impact daily labourers adversely.	5	3	15	High
Drainage	Short duration high intensity rainfall will lead to excessive flooding due to clogged drains resulting in health hazards.	5	4	20	Extreme