

City Resilience Strategy

Rajshahi City, Bangladesh



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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 Bank³. 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 impacts⁴. **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 it⁵.

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 potential⁶.

Table 1: Potential Benefits of Resilience Building

Economic Benefits	Environmental Benefits	Social Benefits
<ul style="list-style-type: none"> - Avoidance of runaway costs of climate change - Livelihood creation - Higher savings by population, businesses and government 	<ul style="list-style-type: none"> - Biodiversity conservation - Preservation of vital ecosystems and species - Conservation of water resources - Improved practices for 	<ul style="list-style-type: none"> - Improved public health - Decreased mortality - Increased benefits to low-income households - Reduced damage and loss due to natural

¹United Nations. 2014. World Urbanization Prospects, the 2014 revision. UN Department of Economic and Social Affairs, Population Division

²Islam N. 2015. Urbanization in Bangladesh: Challenges and Opportunities <http://www.shiree.org/wp-content/uploads/2015/04/NI-Paper.pdf>

³World 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

⁴Folke, C. 2006. "Resilience: The emergence of a perspective for social-ecological systems analyses". *Global Environmental Change*. **16**: 253–267.

⁵The 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.

⁶Tanner, 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

Rajshahi’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.

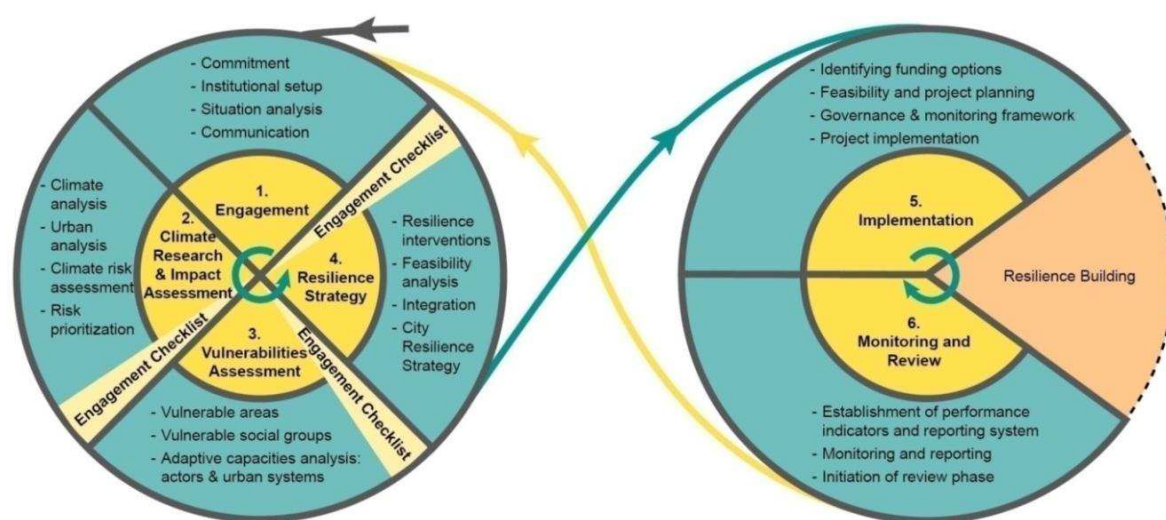


Figure 1: ICLEI ACCCRN Process

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 Rajshahi City

The Mayor, Chief Executive Officer, Chief Engineer and other engineers of Rajshahi City Corporation (RCC) spearheaded the IAP with support from ICLEI South Asia. Figure 2 illustrates the process and timeline followed in RCC.

To initiate the IAP, RCC engineers, councillors and other representatives from RCC, 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 and RCC Chief Engineer of the RCC.

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) Health, (iii) Biodiversity, (iv) Solid Waste Management and (v) Economy.

The five fragile urban systems identified were critically analyzed considering the direct and indirect impacts of identified climate risks.

Through another SLD, 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 Rajshahi. Interlinkages of these resilience interventions with on-going and planned projects were established and further integration into existing city-level plans was explored.

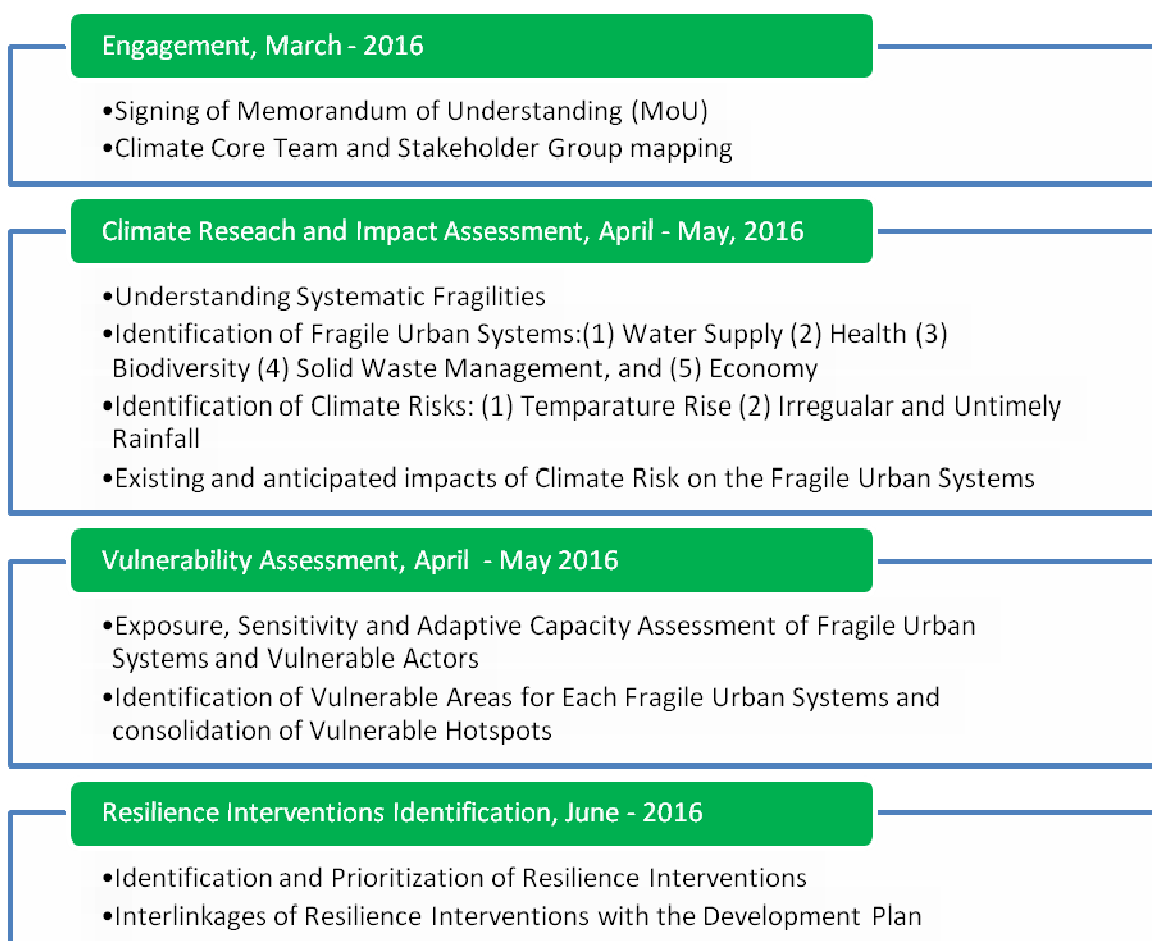


Figure 2: Methodology of IAP in Rajshahi

Using this City Resilience Strategy as a reference, the Rajshahi City Corporation can develop a more resilient city.

2. CITY PROFILE

The metropolitan city of Rajshahi is situated on the north bank of river Padma and is the headquarters of the Rajshahi Administrative Division of Bangladesh. Rajshahi is a centre of excellence for education with a large number of educational institutions and is often called the Education City of Bangladesh. The city is home to the Varendra Research Museum. The University of Rajshahi is the second oldest and one of the largest public universities in the country. The Rajshahi Agricultural Development Bank is based in the city. The city is served by the Shah Makhdum Airport. It is also famous for Rajshahi silk and is often referred to as the Silk City.

2.1 Location

Located on the north bank of the Padma River, near the Bangladesh-India border, **Rajshahi City Corporation** occupies an area of 97.18 sq. km. and is located between 24'20' and 24'24' north latitudes and in between 88'32' and 88'40' east longitudes. It is bound by Pabna upazila on all sides (Figure 3).

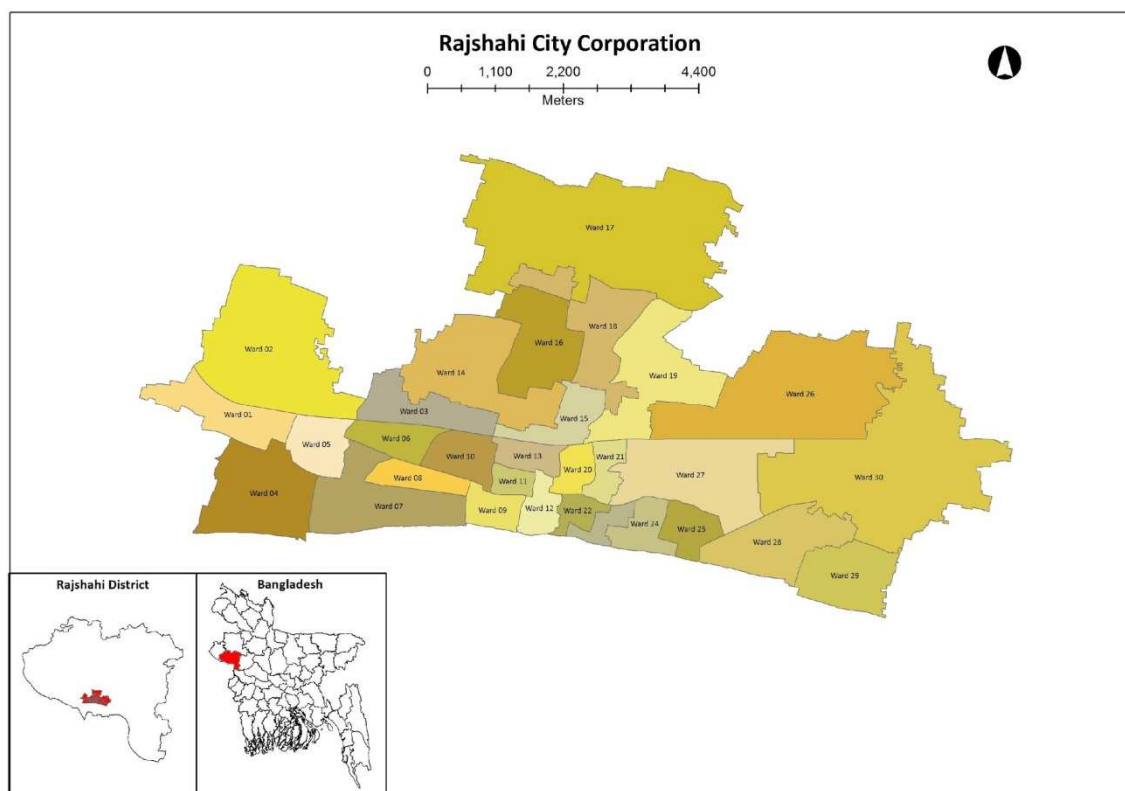


Figure 3: Location of Rajshahi City Corporation

2.2 Demography

According to Bangladesh Bureau of Statistics (BBS) population census 2011, the population of Rajshahi City Corporation was 448,087 made up of 231,700 males and 216,387 females. The number of total households was 99,097. The density of population was 2,487 persons/sq. km. The population is distributed among 30 wards. The following table (Table 2) represents the ward wise population of Rajshahi City Corporation and the population density.

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

Ward No.	Area of Ward (sq. km.)	Total Population	No. of Households	Population Density (Persons/sq. km.)
1	2.46	16032	3361	6517
2	7.62	17823	4134	2339
3	2.06	20132	4719	9773
4	4.11	13238	3109	3221
5	1.55	14128	3252	9115
6	1.32	15256	3456	11558

Ward No.	Area of Ward (sq. km.)	Total Population	No. of Households	Population Density (Persons/sq. km.)
7	3.72	12942	2311	3479
8	1.07	11011	2227	10291
9	0.95	14232	2671	14981
10	1.44	11057	1986	3622
11	0.54	12294	2264	22767
12	0.91	11349	2107	12471
13	0.94	9845	2218	10473
14	4.82	22070	5122	2289
15	1.51	13700	3369	9073
16	3.20	16610	3775	5191
17	15.02	19951	4730	1328
18	2.75	14547	3516	3328
19	4.36	22929	5482	5259
20	0.81	7857	1725	9700
21	0.84	9927	2274	11818
22	0.68	8414	1855	12374
23	0.97	8654	2064	8922
24	0.65	14513	3489	22328
25	1.25	12752	2912	10202
26	8.73	18586	4346	2129
27	5.01	17856	4249	3564
28	3.37	21697	4990	6438
29	2.86	14239	3150	4979
30	11.66	26236	4234	2250
Total	97.18	449877	99097	241779

The literacy rate of the city corporation is 73.96%.

2.3 Economy and Employment

Rajshahi and its neighbouring regions are specially suited from various crops such as watermelons, sugarcane, mangoes and litchis. In spite of being an important city and located on a riverbank, industrial development in Rajshahi has not taken place to any great extent. There is an *Industrial Park*, which is now mainly home to industries related to the famous Rajshahi silk. Rajshahi is also home to number of jute mills, textile mills, sugar mill, pharmaceutical and mango based industries.

2.4 City Administration

Rajshahi Municipality, one of the first municipalities in Bangladesh, was established in 1876 under the name Rampur Boalia Municipality. It functioned as a municipal committee under the Basic Democracies Order of 1959. Rajshahi Paurashava replaced the Rajshahi Municipal Committee under the Bangladesh Local Councils and Municipal Committees (Amendment) Order of 1972. It was declared Rajshahi City Corporation in 1991. Besides the City Corporation, the Rajshahi Unnayan Kortripokkhko (Rajshahi Development Authority or RDA) is responsible for planning the

development of the city and to coordinate all the development related work and Rajshahi Water Supply and Sewerage Authority (WASA) is responsible for the water supply, sewerage and drainage system within city area. At present, the City Corporation is formed with composition of an elected body headed by the Mayor and comprised of 30 Councillors, who are chaired by the process of election. Thus the Mayor and Councillors are responsible for all policy decisions. There is a Chief Executive Officer (CEO) and who is the administrative head of the City Corporation and is responsible for 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 Rajshahi City Corporation 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 corporation schools etc.

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

- a) **Rajshahi Development Authority** – responsible for preparing city master plan, and other development policies.
- b) **Rajshahi Water Supply & Sewerage Authority** – responsible for water supply & sewerage within the city corporation area
- c) Department of Public Health Engineering – responsible for conducting surveys to find out the water contamination level of chemicals like arsenic and the relevant solutions for the same.
- d) **Public Works Department** – Construction agency of Government of Bangladesh (GoB) responsible for the 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 regional 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** – provide electricity to the residents, commerce and industrial establishment on the basis of their priority and capacity.

3. PAST HAZARDS AND CLIMATIC EVENTS

Rajshahi experiences a number of natural disasters such as flood, drought and cold waves which have started to appear with an increased frequency and intensity compared to previous years⁷.

⁷ <http://kmp.dmic.org.bd/handle/123456789/369?show=full>

The city of Rajshahi is a part of the huge drought affected northern area. In a study⁸ where Standardized Precipitation Index (SPI) was used to analyse drought events, Rajshahi district was found to have experienced 23 drought events from 1991 to 2009. In the year 2009, there was a fall of 30% in mango production due to drought. A study⁹ on the effect of drought on some major crops in Bangladesh revealed that 62 percent of T. Aman yield reduction has occurred in Rajshahi, and 50 per cent wheat yield reduction at Rajshahi, Bogra and Jessore.

Heat waves in Rajshahi¹⁰, in 2015, lead to many people being hospitalised due to heat stress and adverse impacts on domestic animals and the environment.

In 2005, the Nor'wester¹¹, the Rajshahi Weather Office recorded 29.6 mm rainfall while the storm struck at a speed of 51.52 km/hr. The event left at least five killed with several others injured. Crop damage worth 10 crore BDT was incurred. In the 2015, Nor'wester¹²Rajshahi lost power for at least 20 hours, 5 people lost their lives and the city incurred a lot of infrastructural damage.

Details of major hydro-meteorological and geological hazard events in Rajshahi (city, upazila and district level) are highlighted in Table 3 below.

Table 3: Major Disaster Events in the past 30 years

Year	Hazard	Impacts
1988, 2003, 2009	Drought	<ul style="list-style-type: none"> - Crop damage - Damage to fisheries - Morbidity - Newborn child, cripple, pregnant women and elderly face problem - Scarcity of drinking water - Disrupted communication system - Damage to infrastructure - Scarcity of potable water
2013	River erosion	
2003, 2013	Tornado	
1988, 1992, 1995, 1997, 2005, 2006, 2009, 2011, 2015	Nor'wester	
1989, 1992, 1996, 1999, 2004, 2005, 2007, 2010, 2011, 2012	Heat wave	
1988, 1998, 1999, 2000, 2005, 2006, 2013	Flood	

⁸Rahman, A.T.M.S., Jahan, C.S., Mazumder, Q.H., Kamruzzaman, M., and Hosono, T. 2016. Drought Analysis and Its Implication in Sustainable Water Resource Management in Barind Area, Bangladesh. Journal of the Geological Society of India.

⁹In SAARC Workshop on Drought and Risk Management in South Asia, 8-10 August 2010. Organised by SAARC Disaster Management Centre, New Delhi and Afghanistan National Disaster Management Authority.

¹⁰<http://www.theindependentbd.com/printversion/details/3023>

¹¹<http://bdnews24.com/bangladesh/2005/05/16/nor-wester-kills-21-in-several-districts-launch-capsizes-in-aricha-with-200-passengers>

¹²<http://newagebd.net/109240/norwester-death-toll-reaches-31/>

4. CLIMATE SCENARIO IN THE CITY

Under the Köppen climate classification¹³, Rajshahi has a tropical wet and dry climate. The climate is generally marked with high temperature, considerable humidity and moderate rainfall. The hot season commences early in March and continues till the middle of July. The maximum mean temperature observed is about 32 to 36 °C during the months of April- July and the minimum temperature recorded in January is about 7 to 16 °C. The highest rainfall is observed during the months of monsoon. The annual rainfall in the district is about 1,448 mm¹⁴.

4.1 Past Climate Trends

Climate Change Cell of the Department of Environment in 2009 released a study on Climate Change and Health Impacts in Bangladesh¹⁵. The study analysed climatic data which comprised of monthly and annual average maximum and minimum temperature for the period of 1976-2005 and monthly and annual rainfall for the period of 1990-2004. It was found that the long-term changes of annual maximum temperature showed an increasing trend over the period of 1976-2005 with an annual increase of 0.003°C. The long-term changes in annual minimum temperature are also marked by a rising trend. It increased, on average, by 0.004°C. Annual rainfall in Rajshahi was marked by a declining trend. It declined, on average, by 3.7 mm.

The current study also analysed past climate trends of Rajshahi city using climate data collected from the Bangladesh Meteorological Department (BMD). Rainfall data was analysed over a period of 45 years from 1962- 2007 while temperature data was analysed from 1995 to 2012.

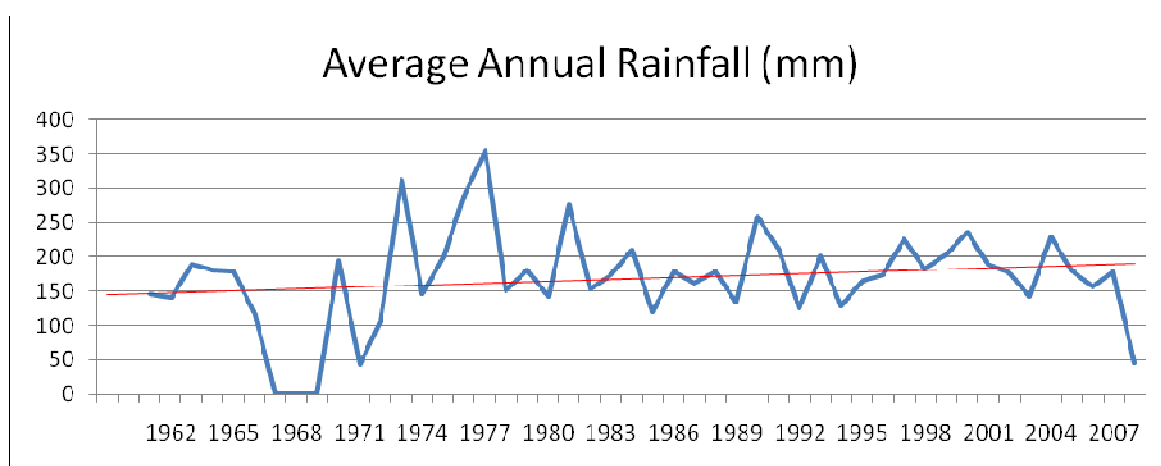


Figure 4: Average Annual Rainfall for Rajshahi City

¹³ <http://en.climate-data.org/region/2265/>

¹⁴ <http://www.bbsgov.org/urban/rajshahi.htm>

¹⁵ Climate Change Cell. 2009. *Climate Change and Health Impacts in Bangladesh*. Climate Change Cell, DoE, Ministry of Environment and Forests. Government of Bangladesh, Dhaka

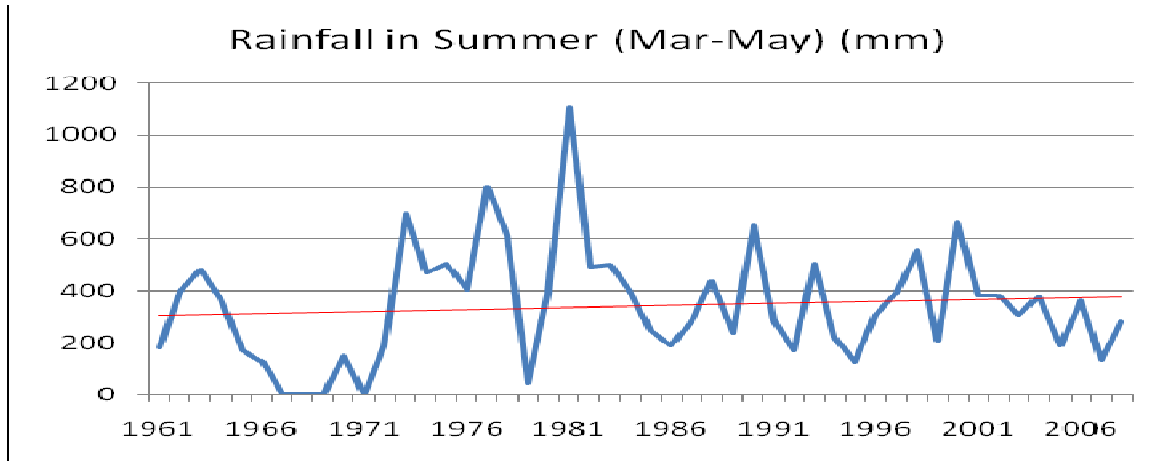


Figure 5: Rainfall in Summer for Rajshahi City

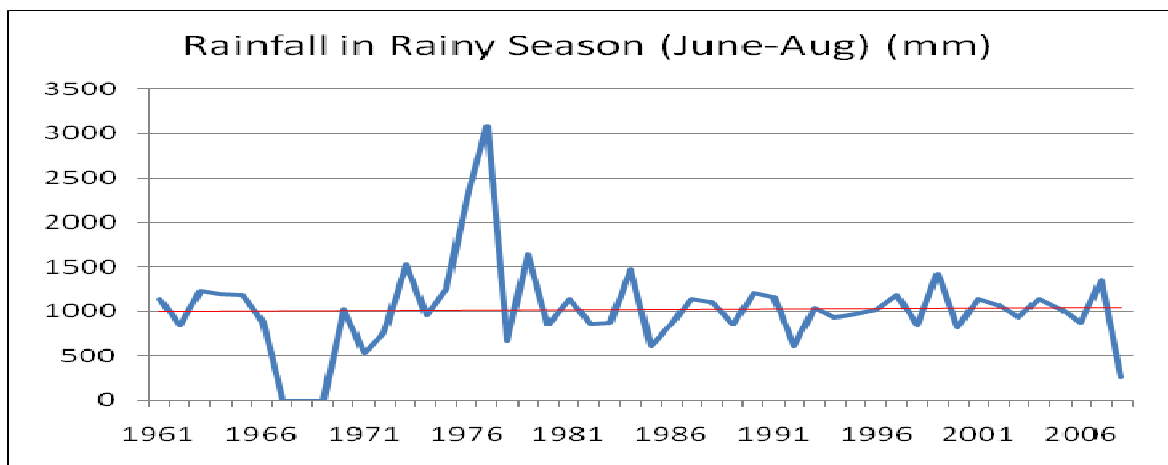


Figure 6: Rainfall in Rainy Season for Rajshahi City

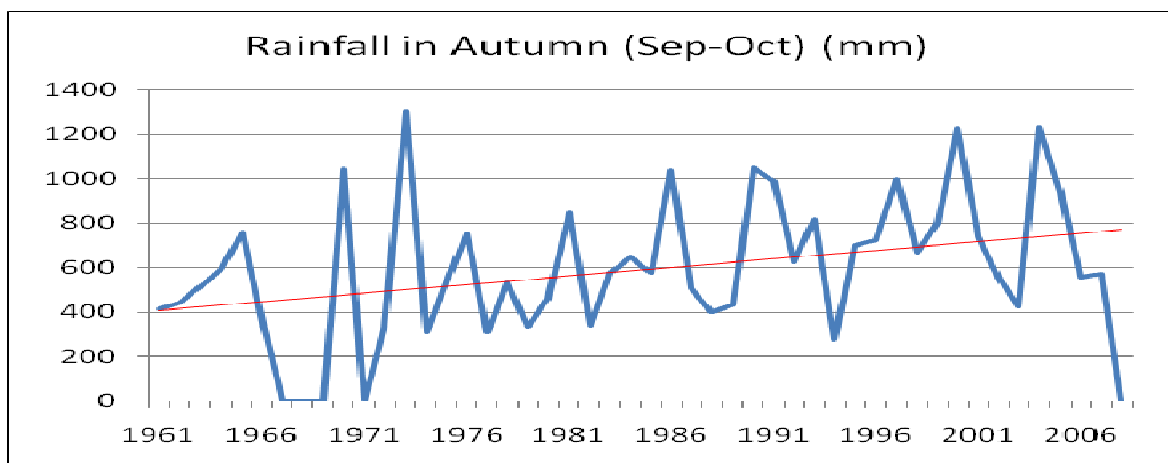


Figure 7: Rainfall in Autumn for Rajshahi City

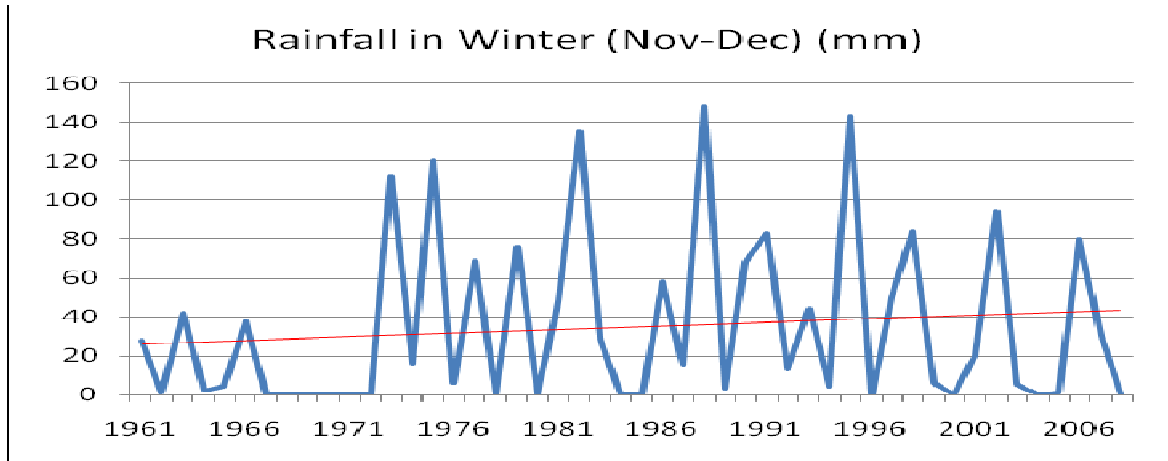


Figure 8: Rainfall in Winter for Rajshahi City

The trend line indicates that the annual average rainfall (Figure 4) is increasing over the 45 year period especially during September to December i.e. Post monsoon (Figure 7 and Figure 8), indicating a shift in the monsoon season.

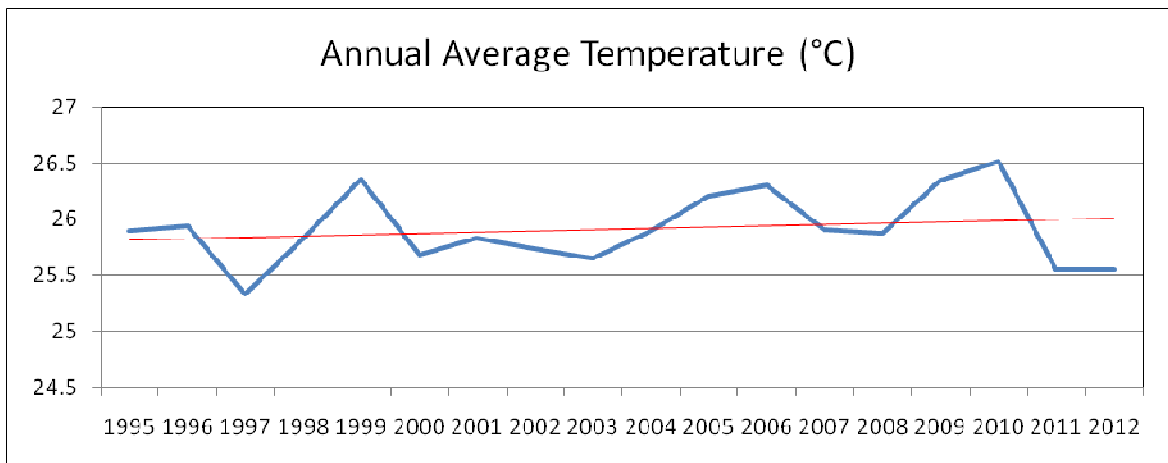


Figure 9: Average Annual Temperature for Rajshahi City

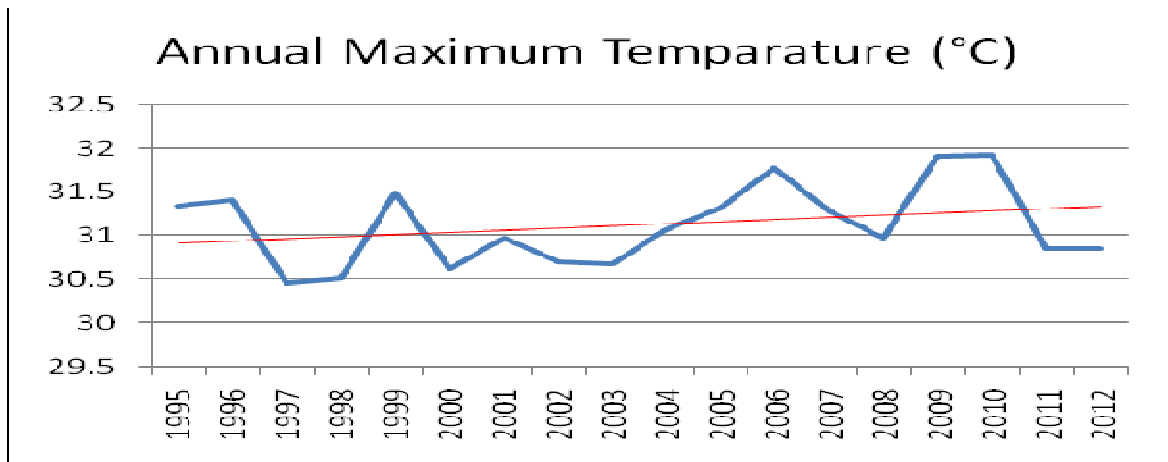


Figure 10: Average Annual Maximum Temperature for Rajshahi City

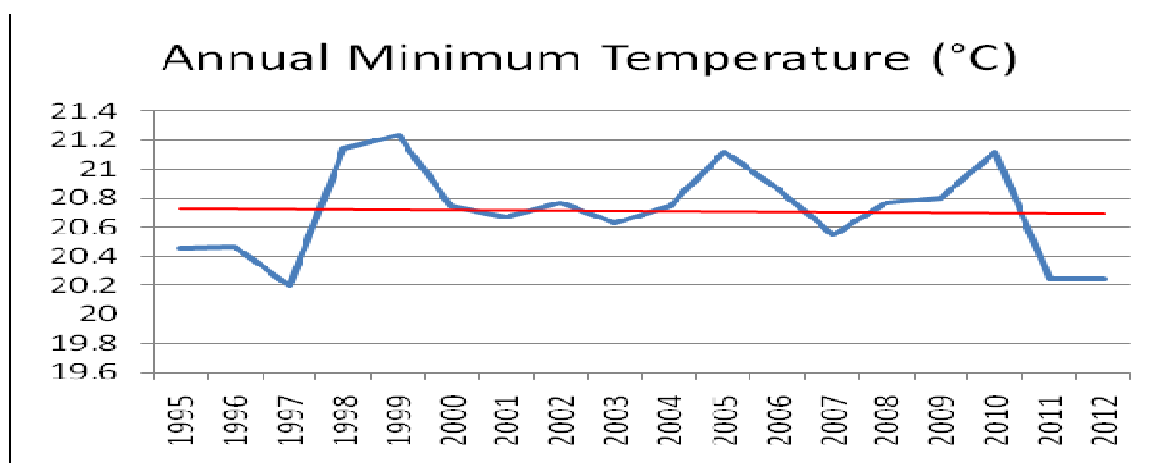


Figure 11: Average Annual Minimum Temperature for Rajshahi City

Annual average temperature also showed a rise of about 0.5°C (Figure 10) which can be attributed to the significant increase in the annual maximum temperature (Figure 12). Annual minimum temperature on the other hand shows a decrease (Figure 11). Overall, this analysis shows that both temperature and rainfall is showing an increasing trend for the time period over which data has been analysed.

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 Bangladesh¹⁶ and the Vulnerability, Risk Reduction and Adaptation to Climate Change, Climate Risk and Adaptation Country Profile¹⁷ (2011), published by World Bank is referred to. The National Plan for Disaster Management used a regional climate model PRECIS for Bangladesh.

Table 4: Climate Scenario Statement

Changing Climate Conditions	Assessments	Climate Scenario Summary Statements
Precipitation change	National Assessment ¹⁶	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 ¹⁷	There will be an increase in the amount of run-off, and rainfall intensity.
Temperature change	National Assessment ¹⁶	The monthly average maximum temperature will increase during the

¹⁶Government of Bangladesh. 2010. National Plan for Disaster Management, 2010 – 2015, Disaster Management Bureau Disaster Management & Relief Division, Government of Bangladesh.

¹⁷The 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.

http://sdwebx.worldbank.org/climateportal/countryprofile/doc/GFDRRCountryProfiles/wb_gfdr climate_change_country_profile_for_BGD.pdf

Changing Climate Conditions	Assessments	Climate Scenario Summary Statements
		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 ¹⁷	Mean temperatures across Bangladesh are projected to increase between 1.4°C and 2.4°C by 2050 and 2100, respectively.

During the stakeholder consultation, these projections were discussed in detail. The stakeholders observed that although temperature seems to be increasing over the years, the rainfall seems to be decreasing. It is possible that the shift in the monsoon as evidenced by the trend analysis in the previous section is leading to this perception of decreased rainfall since the usual rainfall months are not getting enough rain. The main climate risks are therefore taken as:

Climate risk 1: Increased temperature; Climate risk 2: Decreased rainfall and changing rainfall patterns

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 the running of the city and ‘**secondary systems**’ such as health, education, sanitation which rely on the core systems. The urban system analysis identified five fragile urban systems for Rajshahi through rigorous discussions in the SLDs:

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

5.1 Urban Systems Analysis

5.1.1 Water Supply

Situation Analysis

The Rajshahi Water Supply Master Plan was implemented by the Department of Public Health Engineering (PHED) with the support of the Dutch Government in 1981. The system supplies groundwater from 40 deep tube wells through piped networks of 200 km reticulated over an area of 93.34 square kilometres. The system was designed to serve the estimated population of 0.4 million in the year 2000. At present Rajshahi City Corporation (RCC) can supply only about 32,000

m³/day out of a total demand of 85,000 m³/day. About 55% of the population has access to pipe water and the rest take water from hand tube wells in the municipal area.

Rajshahi is located in a region which is highly water stressed and prone to drought. Presently groundwater remains the only source for the city. The conditions become very poor during the dry season. Surface ponds which can be used to capture and store rainwater are being filled up or encroached upon. If we consider the growth of the population, the demand of water would be 240,000 m³/day by 2017. The present ground water levels cannot even cater to the present population let alone catering to the future population.

Fragility Statement and Climate Fragility Statement

Considering the present situation of Water Supply in Rajshahi, the urban fragility statement for this system is 'The water resource in the city is reducing because of extraction of ground water and encroachment of ponds'.

The climate fragility statement for Water Supply is:

"With increasing temperature and decreasing or irregular rainfall in the region, the water resource in the city will be under greater stress, leading to health impacts and impacts on economy dependent on water such as agriculture."

5.2 Health

Situation Analysis

The health system of the city includes public and private facilities, primary health centres are also available. Health care facilities are reasonably good in the RCC area. There is one general hospital, the Rajshahi Medical College Hospital, with 550 beds; and three specialized hospitals, including a 150 bed TB hospital and a 20 bed infectious diseases hospital. The RCC has also established seven Primary Health Care Centres, which are run by NGOs, as part of a project with the Asian Development Bank (ADB), to provide health services to women and children. There is a Nursing Training Institute and a Family Welfare Visitors Training Institute. In addition to the government facilities there were 25 private clinics in the city in 1998 and this number has been increasing¹⁸. At present, there are sufficient facilities catering to the residents Rajshahi. However, as the surrounding regions also depend on these facilities, they are under stress, unable to meet the demand.

Fragility Statement and Climate Fragility Statement

Considering the present situation of Health in Rajshahi, the urban fragility statement for this system is 'Health care facilities in the region cater to the city and its surrounding regions, and are therefore under stress due to lack of space of housing patients. However, modern facilities are available in the city for health care.'

If the number of patients increases drastically due to climatic events, then the health system may not be able to take the additional pressure.

¹⁸Clemett, A., Amin, M.M., Ara, S., and Akan, M.M.R. 2006. Background Information for Rajshahi City, Bangladesh. WASPA Asia Project Report, accessed from <https://core.ac.uk/download/pdf/6405035.pdf>

The climate fragility statement for this system is:

“Climate Risk 1: In case of health risks due to sudden climatic impacts of increasing temperature and decreasing rainfall, the health system may fail in the city if there are suddenly more patients.”

5.2.1 Biodiversity

Situation Analysis

With the expansion of the city due to urbanisation and population growth, and a loss of wooded areas and ponds, biodiversity is steadily decreasing. The different species of birds, animals, fish are in decline due to loss of habitat. Local orchards are also declining.

Fragility Statement and Climate Fragility Statement

Considering the present situation of Biodiversity in Rajshahi, the urban fragility statement for 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 statements for this system are:

“Climate Risk 1: Increasing temperatures and decreasing or irregular rainfall can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.”

5.2.2 Solid Waste Management

Situation Analysis

About 350 tonnes of waste is produced each day, while the amount increases to 400 tonnes during summer, in Rajshahi City. Of the total amount, 12 tonnes are hazardous wastes¹⁹. Solid wastes are produced from different sources such as residential, medical, industrial, construction and demolition, agricultural, institutional and municipal. Less than 50% (15) of the city’s wards are covered by ‘door to door waste collection’ facilities however RCC is trying to provide this service to all the wards in the near future. The remainder of houses not covered by the collection system dump the waste near lampposts in roads, in ponds, in drains, etc.

There is one dumping site with a 3.5 ft. depth and an area of 15.98 acre at ‘Nawdapara’ and 35 secondary collection points. Of the total waste generated in the city, 280 MT/day is collected and disposed-off in the waste disposal area, while 120 MT is composted for use in the agricultural fields. Scientific management of waste does not take place and improper land filling²⁰ results in the waste spreading all over the disposal site, producing unpleasant odours and fouling the air.

A dearth of resources hinders the complete collection of waste and poor public awareness make waste disposal in sustainable manner difficult.

Fragility Statement and Climate Fragility Statement

¹⁹Atik, S.M. 2013. Rajshahi waste management in disarray, online edition, The Daily New Age, 7 March 2013, Dhaka, Bangladesh.

²⁰Halder, P.K., Paul, N., Hoque, M.E., Hoque, A.S.M., Pravez, M.S., Rahman, M.H. and Ali, M. 2014. Municipal Solid Waste and its Management in Rajshahi City, Bangladesh: A Source of Energy. International Journal of Renewable Energy Research. 4(1): 168-175.

Considering the present situation of Solid Waste Management in Rajshahi, the urban fragility statement for this system is ‘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.’

The climate fragility statement for this system is:

“Increasing temperatures and decreasing 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.”

5.2.3 Economy

Situation Analysis

The main source of income for the urban poor and the landless is the primary sector (agriculture, fishery, fruit cultivation) where they work as agricultural labour. Women especially are very dependent on agriculture.

In an economy which is dependent on agriculture and natural resources (fishery and fruit orchards), periods of drought or climatic disaster events can severely impact the livelihood of these people.

Fragility Statement and Climate Fragility Statement

Considering the present situation of the economy in Rajshahi, the urban fragility statement for this system is ‘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. Any impact on the productivity can impact a large section of population.’

The climate fragility statements for this system are:

“Climate Risk 1: Increasing temperature and decreasing rainfall will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. It can also increase immigration to the city from surrounding areas. Daily labourers and vendors will be impacted since they will be unable to work in harsh climate.”

The urban fragility statements and climate fragility statements are explained in Annexure 1.

5.3 Risk Assessment

The climate 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 process followed for 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
Water Supply	With increasing temperature and decreasing or irregular rainfall in the region, the water resource in the city will be under greater stress, leading to health impacts and impacts on economy dependent on water such as agriculture.	Extreme
Health	In case of health risks due to sudden climatic impacts of increasing temperature and decreasing rainfall, the health system may fail in the city if there are suddenly more patients.	Extreme
Biodiversity	Increasing temperatures and decreasing or irregular rainfall can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	Extreme
Solid Waste Management	Increasing temperatures and decreasing 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.	High
Economy	Increasing temperature and decreasing rainfall will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. It can also increase immigration to the city from surrounding areas. Daily labourers and vendors will be impacted since they will be unable to work in harsh climate.	Extreme

Based on this risk assessment, four fragile urban systems water supply, health, biodiversity and economy show extreme risk scores while solid waste management shows a high risk. All of these urban systems require urgent attention and should be put on high priority.

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)²¹ 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.

²¹IPCC, 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.

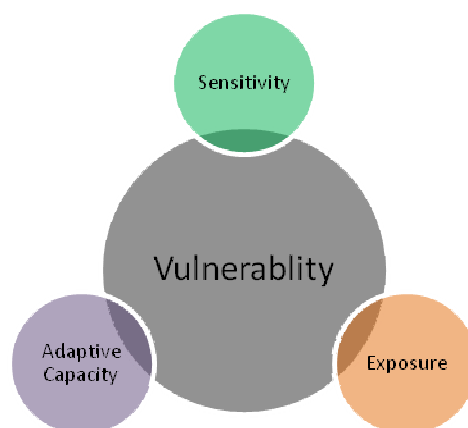


Figure 12: Vulnerability Constituents²¹

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 Rajshahi 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 group.

6.2 Identification of vulnerable areas of Fragile Urban Systems

6.2.1 Water Supply: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
With increasing temperature and decreasing or irregular rainfall in the region, the water resource in the city will be under greater	All wards in the city are affected; Water level is going down in all areas to a similar extent (Figure 13).

Climate Fragility Statements	Area/ward most vulnerable
stress, leading to health impacts and impacts on economy dependent on water such as agriculture.	

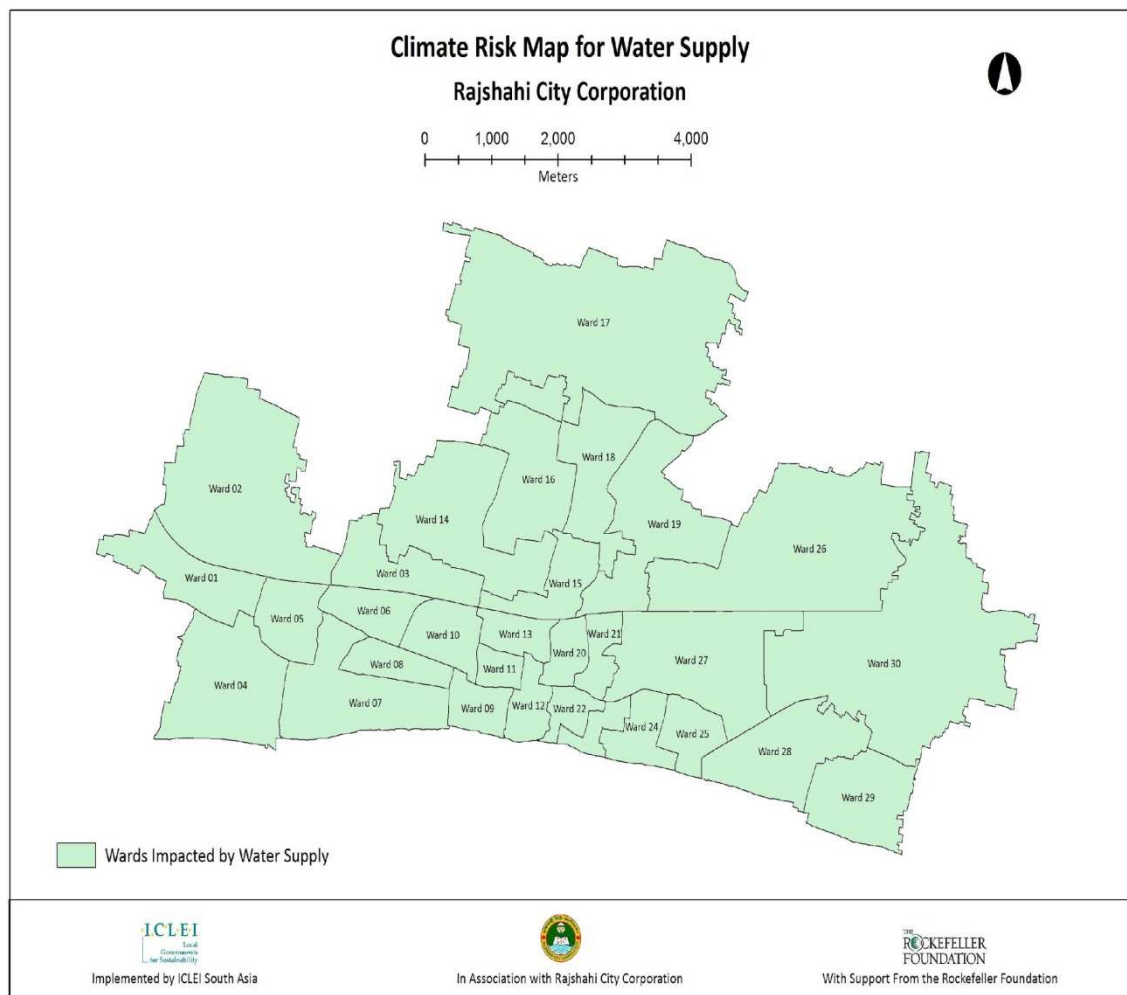


Figure 13: Wards most vulnerable to climate risks in the context of water supply, Rajshahi

6.2.2 Health: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
In case of health risks due to sudden climatic impacts of increasing temperature and decreasing rainfall, the health system may fail in the city if there are suddenly more patients.	Slums and low income communities in ward 1, 4, 7, 9, 17, 19, 22, 23, 24, 25, 28, 29, 30 (Figure 14).

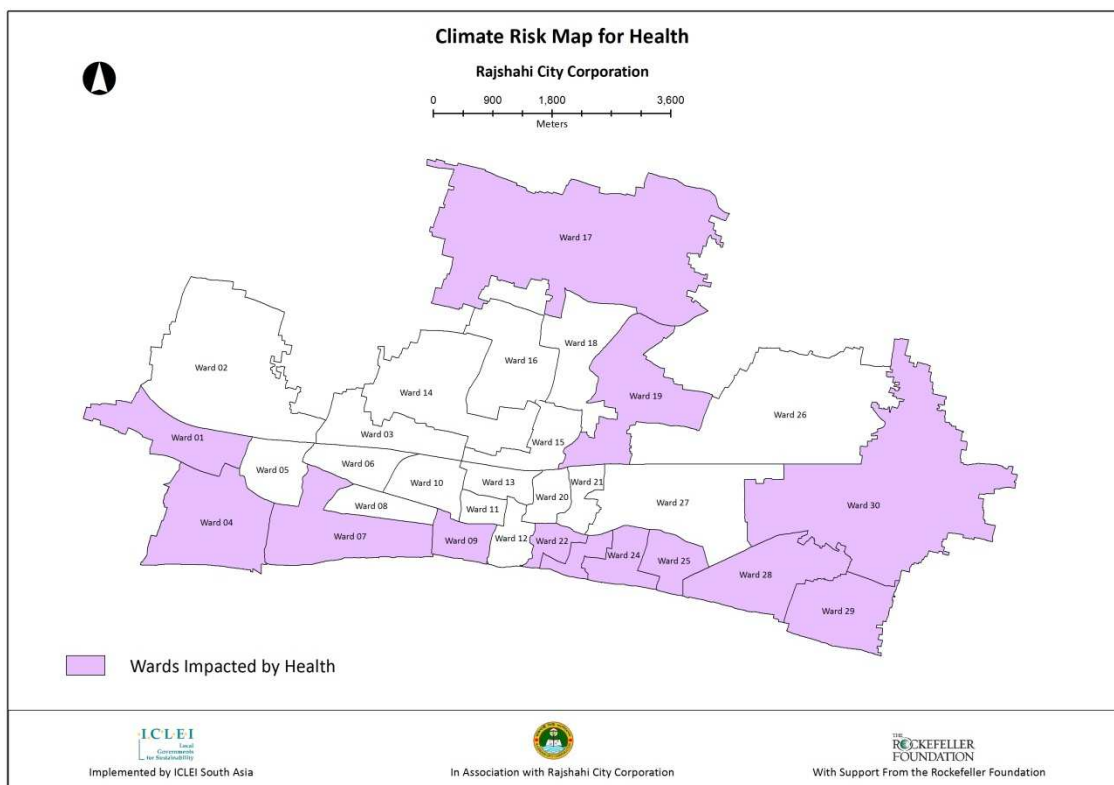


Figure 14: Wards most vulnerable to climate risks in the context of health, Rajshahi

6.2.3 Biodiversity: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Increasing temperatures and decreasing or irregular rainfall can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	All wards, particularly Rajshahi University area, Central Park and Zoo and river bank (Figure 15).

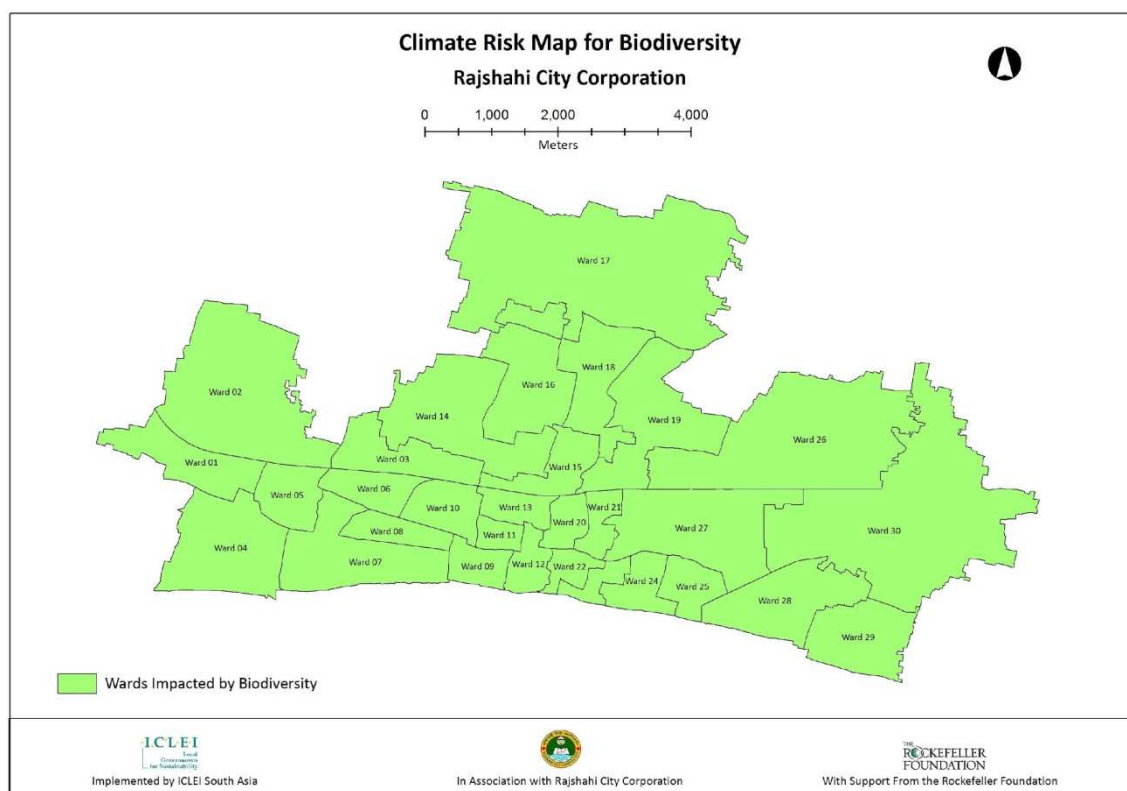


Figure 15: Wards most vulnerable to climate risks in the context of biodiversity, Rajshahi

6.2.4 Solid Waste Management: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Increasing temperatures and decreasing 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.	Ward 1, 4, 7, 9, market areas of ward 12, 17, 22, 23, 24, water logged area of ward 25, 28 29 (Figure 16).

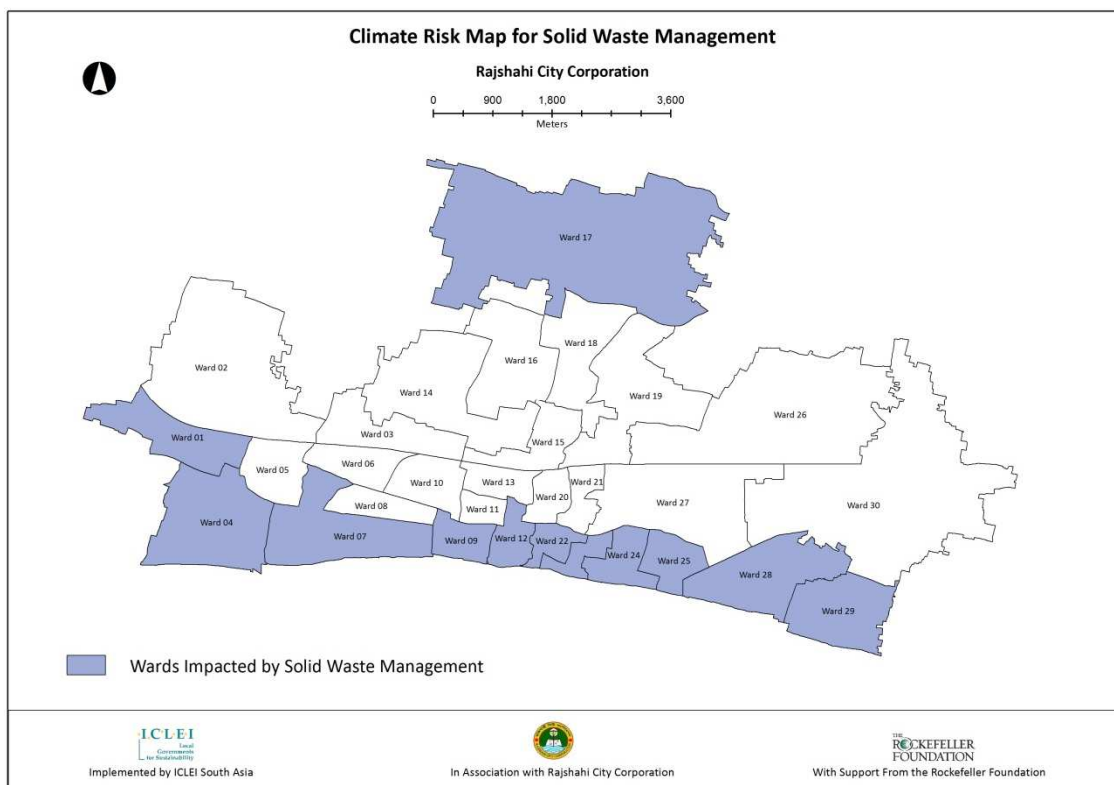


Figure 16: Wards most vulnerable to climate risks in the context of solid waste management, Rajshahi

6.2.5 Economy: Vulnerable Areas

Climate Fragility Statements	Area/ward most vulnerable
Increasing temperature and decreasing rainfall will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. It can also increase immigration to the city from surrounding areas. Daily labourers and vendors will be impacted since they will be unable to work in harsh climate.	Peri-urban areas of ward 1, and ward 2, 17, 30, 26, 27 & 29 (Figure 17).

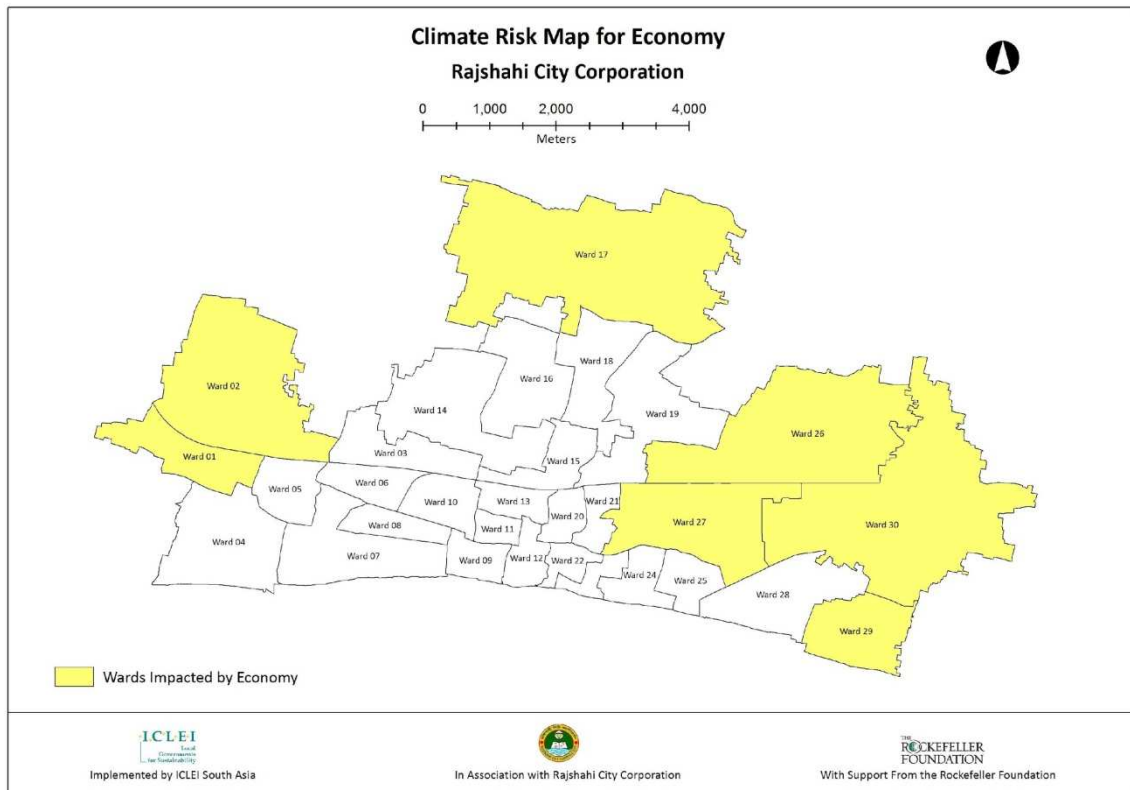


Figure 17: Wards most vulnerable to climate risks in the context of economy, Rajshahi

Through these assessments, the areas that were found to be most vulnerable were wards 1, 17 and 29 which are vulnerable to all five fragile urban systems, while wards 4, 7, 9, 22, 23, 24, 25, 28 and 30 are vulnerable to four fragile urban systems. Ward 1, 17 and 29 are located on the peripheral edges of the city and lacks coverage of the basic services. The wards which are affected by four systems are mostly close to the river and have slum population.

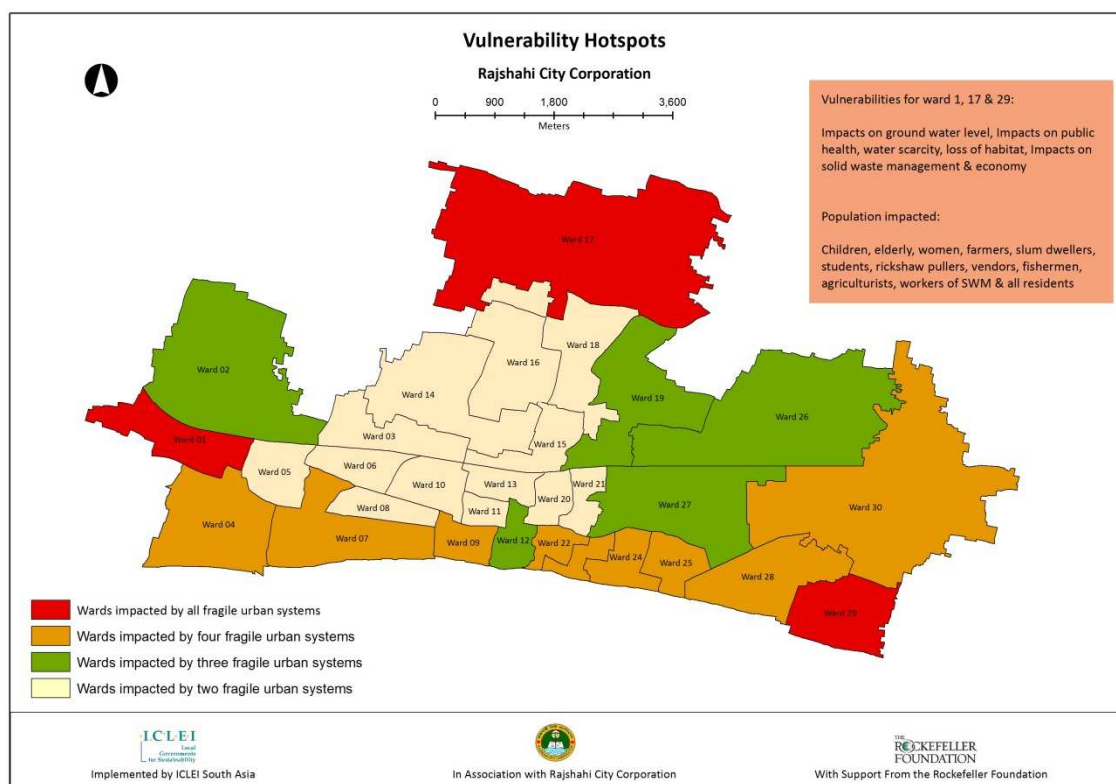


Figure 18: Consolidated Vulnerable Hotspots for Rajshahi city

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.

6.3 Actor Analysis

An analysis of the actors within the wards identified as vulnerable revealed that they had very poor levels of adaptive capacities. The RCC has high adaptive capacity since they have access to resources, information and ability to respond to stress. This is also true for government agencies like WASA or the non-government organisations. However, common citizens including farmers, daily labourers, fishermen, vendors, women, children, elderly, and others due to either a lack of information and education, or a lack of financial resources lack the capacity to adequately respond to stress and therefore have low adaptive capacity. Most of them are also dependent heavily on ecosystem based employment, and therefore are easily impacted by climatic changes. Table 6 shows the adaptive capacities of the actors for each fragile urban system.

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
Water Supply	With increasing temperature and decreasing rainfall in the region, the water resource in the city will be under greater stress, leading to health	All wards in the city affected, water level is going down in all areas to a	Children	Low
			Elderly	Low
			Women	Low
			Farmers	Low
			Slum dwellers	Low

Fragile Urban System	Climate Fragility Statements	Area/ward most vulnerable	Actors	Level of Adaptive Capacity
	impacts and impacts on economy dependent on water such as agriculture.	similar extent	WASA	High
RCC			High	
City Development Committee (CDC)			Medium	
Health	In case of health risks due to sudden climatic impacts of increasing temperature and decreasing rainfall, the health system may fail in the city if there are suddenly more patients.	Slums and low income communities, ward 1, 4, 7, 9, 17, 19, 22, 23, 24, 25, 28, 29, 30	Children	Low
			Elderly	Low
			Women	Low
			Daily labours	Low
			Slum dwellers	Low
			Health staff	Medium
			Rickshaw pullers	Low
			Vendors	Low
			NGOs/CBOs	High
CDC	Medium			
Biodiversity	Increasing temperatures and decreasing rainfall can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	All wards, particularly Rajshahi University area, Central Park and Zoo and river bank	Fishermen	Low
			Residents	Low
			RCC	High
Solid Waste Management	Increasing temperatures and decreasing 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.	Ward 1, 4, 7, 9, market areas of ward 12, 17, 22, 23, 24, water logged area of ward 25, 28 29	RCC	High
			SWM Workers	Low
			Children	Low
			Elderly	Low
Economy	Increasing temperature and decreasing rainfall will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. It can also increase immigration to the city from surrounding areas. Daily labour and vendors will	Peri-urban areas of ward 1, and ward 2, 17, 30, 26, 27 & 29	Farmers	Low
			Farm labourers	Low
			Women	Low
			Entrepreneurs	Medium
			Slum dwellers	Low
			Daily labours	Low
			Vendors	Low

Fragile Urban System	Climate Fragility Statements	Area/ward most vulnerable	Actors	Level of Adaptive Capacity
	be impacted since they will be unable to work in harsh climate.		Rickshaw pullers	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 (Table 7).

Overall the adaptive capacities of all the urban systems score low or medium. The medium score for the technological/infrastructural parameter indicates that across the five systems, the city has good access to and/or knowledge of technology and infrastructure to adapt to the climate impacts. The leadership in the RCC is consistent and visionary, there is a good amount of inter departmental coordination especially for the systems of solid waste management and water supply where governance has been given a medium score. There is low inherent economic adaptive capacity for the systems of water supply, biodiversity and economy to adapt to the impacts of the climate risk. Ecosystem services was scored low for solid waste management, economy and water supply indicating that the city should focus integrated management of its water resources which impact both water supply and the productivity of the economy as well as improve the sustainability of the current system of solid waste management.

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

Fragile Urban System	Climate Statements	Fragility	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
				Vulnerable	Potential Supporting	Low	Medium	High
Water Supply	With increasing temperature and decreasing rainfall in the region, the water resource in the city will be under greater stress, leading to health impacts and impacts on economy dependent on water such as agriculture.		All wards in the city affected, water level is going down in all areas to a similar extent	<ul style="list-style-type: none"> - Children - Elderly - Women - Farmers - Slum dwellers 	<ul style="list-style-type: none"> - WASA - RCC - CDC 	<ul style="list-style-type: none"> - Economic - Societal - Ecosystem Services 	<ul style="list-style-type: none"> - Technological/infrastructural - Governance 	
Health	In case of health risks due to sudden climatic impacts of increasing temperature and decreasing rainfall, the health system may fail in the city if there are suddenly more patients.		Slums and low income communities, ward 1, 4, 7, 9, 17, 19, 22, 23, 24, 25, 28, 29, 30	<ul style="list-style-type: none"> - Children - Elderly - Women - Daily labours - Slum dwellers - Rickshaw pullers - Vendors 	<ul style="list-style-type: none"> - Health staff - NGOs/CBOs - CDC 	<ul style="list-style-type: none"> - Governance - Societal 	<ul style="list-style-type: none"> - Economic - Technological/infrastructural - Ecosystem Services 	
Biodiversity	Increasing temperatures and decreasing rainfall can exacerbate habitat loss caused by		All wards, particularly Rajshahi University	<ul style="list-style-type: none"> - Fishermen - Residents 	<ul style="list-style-type: none"> - RCC 	<ul style="list-style-type: none"> - Economic 	<ul style="list-style-type: none"> - Technological/infrastructural - Governance 	

Fragile Urban System	Climate Statements	Fragility	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
				Vulnerable	Potential Supporting	Low	Medium	High
	urbanisation that will further reduce urban biodiversity.		area, Central Park and Zoo and river bank				- Societal - Ecosystem Services	
Solid Waste Management	Increasing temperatures and decreasing 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.		Ward 1, 4, 7, 9, market areas of ward 12, 17, 22, 23, 24, water logged area of ward 25, 28 29	- SWM Workers - Children - Elderly	- RCC	- Ecosystem Services	- Economic - Technological/infrastructural - Governance - Societal	
Economy	Increasing temperature and decreasing rainfall will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. It can also increase immigration to the city from surrounding		Peri-urban areas of ward 1, and ward 2, 17, 30, 26, 27 & 29	- Farmers - Farm labourers - Women - Entrepreneurs - Slum dwellers - Daily labours	- Entrepreneurs	- Economic - Ecosystem Services	- Technological/infrastructural - Governance - Societal	

Fragile Urban System	Climate Fragility Statements	Vulnerable Areas	Urban Actors		Adaptive Capacity of the System		
			Vulnerable	Potential Supporting	Low	Medium	High
	areas. Daily labour and vendors will be impacted since they will be unable to work in harsh climate.		- Vendors - Rickshaw pullers				

7. RESILIENCE INTERVENTIONS

Possible adaptation interventions were identified for the five fragile urban systems in Rajshahi 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 22 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.

Table 8: Prioritised Resilience Interventions against Resilience Indicators

Prioritised 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						
Infrastructural Measures						
Rainwater harvesting – Implementation of a rainwater harvesting program with the collaboration of the city water supply department i.e. Rajshahi WASA, for storing rainwater on surface (public) ponds/tanks and recharging ground water where appropriate. RCC can also encourage citizens to apply this rainwater harvesting program in their building rooftops for both potable and non-potable usage.	High	High	Long term	Medium	Low	Can help to revive soil conditions and greenery.
Conservation of water bodies – RCC can identify the public ponds located within the city area immediately and protect	High	Medium	Long term	Medium	Medium	Can help to revive soil conditions and greenery.

Prioritised 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
those from filling with earth, surface water pollution, and illegal occupancy. Other private ponds can be and acquired as necessary. Concretization of pond banks, setting up of cautionary notice boards at pond sites (reserved/designated pond), regular maintenance – these initiatives may be undertaken by RCC under ‘Water Body Conservation Act, 2000’ for conservation of water bodies with collaboration of RDA.						
Policy/Non-Infrastructural Measures						
Awareness building program for residents and community groups which may be in the form of arranging workshops, seminars, school programs, ward level visits and campaigns for preservation of	High	Medium	Long term	Short	Low	Can be used for different urban systems awareness together

Prioritised 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, publication and dissemination of leaflets and posters, exhibition etc. These programs could be implemented by NGOs and sectoral representatives with initiatives and leads taken by the ULBs like RCC, WASA, etc.						
Health						
Infrastructural Measures						
Improvement of RCC Hospital and Urban Primary Health Care Centers (UPHCC) in terms of increasing beds, specialists, number of nurses and other staff, availability of medicines, diagnostic and operational equipment.	Medium	Medium-Low	Medium term	Medium	High	
Policy/Non-Infrastructural Measures						
Training of city hospital staff in emergency response procedures.	Medium	Low	Medium term	Short	Low	Better healthcare during emergencies
Awareness building programs	High	Medium	Long term	Short	Low	Can be used for

Prioritised 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
for residents, community groups and health practitioners through workshops, seminars, and school programs, ward level visit and campaigns wherein health risks due to climate change and adaptation responses could be discussed. IEC materials such as publications, leaflets, posters, could be created. These programs would be implemented by NGOs and health institutions with initiatives and leads taken by the ULBs like RCC, Medical Institutions, and DPHE etc.						different urban systems awareness together
Preparation of a health emergency response plan jointly by RCC and City Hospitals to respond to climate and disaster	High	Medium	Long term	Short	Medium	Improved local governance and public participation in disaster

Prioritised 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
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.						management
Publishing a health research bulletin which would outline city health impacts due to climate change and disasters. Health practitioners/ researchers should be engaged to contribute to the bulletin.	Medium	Low-Medium	Short term	Short	High	Better healthcare during emergencies
Solid Waste Management						
Infrastructural Measures						
Establish a sustainable waste collection system. Segregation of waste at source should be enforced and RCC could take	Medium	Medium	Long term	Short	High	Alternate income generating opportunities from recycling of

Prioritised 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
initiatives to collect both residential and commercial waste against a service charge by engaging NGOs or any other private organizations. Covered vans with closed detachable containers to easily transport the waste could be used. Moreover, the vans should be modified with a number of bins into which the separated waste is collected and transported. A composting facility should be created along with the aforementioned infrastructure.						waste
Policy/Non-Infrastructural Measures						
Development of an Integrated Solid Waste Management Plan for the city.	High	Medium-Low	Medium Term	Short	Medium	Better health of citizens, aesthetic enhancement of city

Prioritised 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
Capacity development for both the monitoring and implementing staff of RCC regarding SWM processes, waste handling and use of equipment.	High	Medium	Medium term	Short	Medium	Better management of waste
Setting up of a monitoring and complaint centre by RCC.	Medium	Low-Medium	Short term	Medium	High	Improved governance
Awareness building programs should be undertaken by RCC with the help of local partners and NGOs. These programs would be consisting of spreading information and awareness regarding Hygiene, the 3Rs, and so on. This can be integrated into school curriculum across the city.	High	Medium	Long term	Short	Low	Can be used for different urban systems awareness together
Biodiversity						
Infrastructural Measures						
Afforestation along roads and riversides wherever appropriate.	High	High	Long term	Medium	Medium	Beautification of city and control of microclimate

Prioritised 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
Policy/Non-Infrastructural Measures						
Preparation of a comprehensive master plan on Biodiversity management.	High	Low	Medium term	Short	Low	Better urban planning
As the RCC is planning on setting up a biodiversity park in the city, training on the same is required.	High	High	Short term	Short	Low	
Identify, establish and protect ecological zones. RCC and Department of Environment (DoE) can collaborate.	High	Low	Medium term	Short	Low	Better urban planning
Communication and coordination with concerned agricultural/fisheries/livestock departments to protect existing variety of crops, animals, birds etc. or promote new species.	Medium	Medium	Long term	Medium	Low	Improved governance
Awareness building programs on Biodiversity loss, land use planning and sustainable urban development.	High	Medium	Long term	Short	Low	Can be used for different urban systems awareness

Prioritised 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
						together
Economy						
Infrastructural Measures						
To increase climate adaptive trade and tourism based activities, eg. Eco-tourism, green procurement practices.	High	Medium-Low	Long term			
Policy/Non-Infrastructural Measures						
Coordination with the fisheries/agriculture sector departments to develop climate resilient varieties.	High	Medium	Long term			
Alternative income streams for affected low income earners and daily labourers. RCC can provide trainings with the help of NGOs on production of home-made foods like pickles, papad, toys, vegetable vending, handloom production, and driving auto rickshaw etc.	High	Medium	Long term			

7.1 Integration into City Plans

WASA is currently implementing four projects related to road improvement and drainage system improvement in the city. RCC has submitted a proposal submitted to the Government which aims at conferring protection on 17 water bodies in the city.

In the city's central park, a tree plantation drive is ongoing and RCC is planning on developing a biodiversity park on land identified along the Padma River.

Under the Urban Public Environmental Health Sector Development Programme, five secondary waste collection points are being improved.

To boost the economy in the city, tourism is being promoted. The river bank and other recreational places are being developed for this purpose, greening of the city is being done, and establishment of hotels is being encouraged.

In terms of health care, under the Urban Primary Health Care Program which is being funded by GIZ, primary health care issues are being researched. There are regular immunisation and family planning programmes conducted by the health department especially for the urban poor.

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

Water Supply

Issues:	The water resource in the city is reducing because of extraction of ground water and drying up of ponds.	
Some Existing / Planned Measures:	<ul style="list-style-type: none"> • RCC has submitted a proposal submitted to the Government which aims as conferring protection on 17 water bodies in the city 	
Potential Climate Impacts:	With increasing temperature and decreasing or irregular rainfall in the region, the water resource in the city will be under greater stress, leading to health impacts and impacts on economy dependent on water such as agriculture.	
Potentially Impacted Areas:	All wards in the city	
Risk Status:	Extreme	
Actors:	Vulnerable - Children - Elderly - Women - Farmers - Slum dwellers	Supporting - WASA - RCC - CDC

Prioritized Actions

Type of Measures	Cost per unit and description	Cost estimate
Policy and Institutional Measures		
Awareness building program for residents and community groups which may be in the form of arranging workshops, seminars, school programs, ward level visits and campaigns for preservation of water, publication and dissemination of leaflets and posters, exhibition etc. These programs could be implemented by NGOs and sectoral representatives with initiatives and leads taken by the ULBs like RCC, WASA, etc.	Cost of materials, trainings, meetings, publications, logistics, staff costs	USD 2500 per training
Infrastructural Measures		
Rainwater harvesting – Implementation of a rainwater harvesting program with the collaboration of the city water supply department i.e. Rajshahi WASA, for storing rainwater on surface (public) ponds/tanks and recharging ground water where appropriate. RCC can also encourage citizens to apply this rainwater harvesting program in their building rooftops for both potable and non-potable usage.	Civil and construction costs, materials, labour, landscaping, staff costs, meeting, training	USD 10000 per unit

Health

Issues:	Health care facilities in the region cater to the city and its surrounding regions, and are therefore under stress due to lack of space of housing patients. However, modern facilities are available in the city for health care.
Some Existing / Planned Measures:	<ul style="list-style-type: none"> Under the Urban Primary Health Care Program which is being funded by GIZ, primary health care issues are being researched. Regular immunisation and family planning programmes conducted by the health department especially for the urban poor.
Potential Climate Impacts:	In case of health risks due to sudden climatic impacts of increasing temperature and decreasing rainfall, the health

	system may fail in the city if there are suddenly more patients.	
Potentially Impacted Areas:	Slums and low income communities, ward 1, 4, 7, 9, 17, 19, 22, 23, 24, 25, 28, 29, 30	
Risk Status:	Extreme	
Actors:	Vulnerable - Children - Elderly - Women - Daily labours - Slum dwellers - Rickshaw pullers - Vendors	Supporting - Health staff - NGOs/CBOs - CDC

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 RCC 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, training, development of plan, staff costs	USD 15000
Infrastructural Measures		
Improvement of RCC Hospital and Urban Primary Health Care Centres (UPHCC) in terms of increasing beds, specialists, number of nurses and other staff, availability of medicines, diagnostic and operational equipment.	Construction costs, medical practitioners, equipments, staff	USD 150000 to 300000. A detailed DPR will have to be developed and implemented in a phased manner.

Biodiversity

Issues:	Biodiversity loss is seen throughout the city with reduction in species of birds, animals, and fish due to loss of habitat.
Some Existing / Planned	<ul style="list-style-type: none"> In the city's central park, a tree plantation drive is

Measures:	ongoing <ul style="list-style-type: none">RCC is planning on developing a biodiversity park on land identified along the Padma River.	
Potential Climate Impacts:	Increasing temperatures and decreasing or irregular rainfall can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	
Potentially Impacted Areas:	All wards, particularly Rajshahi University area, Central Park and Zoo and river bank	
Risk Status:	Extreme	
Actors:	Vulnerable - Fishermen - Residents	Supporting - RCC

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 promote new species.	Cost of meetings, trainings, staff costs	USD 2000 per year
Infrastructural Measures		
Afforestation along roads and riversides wherever appropriate	Cost of plants, materials, labour, staff, equipments	USD 30000 per drive

Solid Waste Management

Issues:	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	
Some Existing / Planned Measures:	<ul style="list-style-type: none"> Under the Urban Public Environmental Health Sector Development Programme, five secondary waste collection points are being improved. 	
Potential Climate Impacts:	Increasing temperatures and decreasing 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.	
Potentially Impacted Areas:	Ward 1, 4, 7, 9, market areas of ward 12, 17, 22, 23, 24, water logged area of ward 25, 28 29	

Risk Status:	High	
Actors:	Vulnerable - SWM Workers - Children - Elderly	Supporting - RCC

Prioritized Actions

Type of Measures	Cost per unit and description	Cost estimate
Policy and Institutional Measures		
Development of an Integrated Solid Waste Management Plan for the city	Cost of consultant, meetings, trainings, designing and printing	USD 20000
Infrastructural Measures		
Establish a sustainable waste collection system. Segregation of waste at source should be enforced and RCC could take initiatives to collect both residential and commercial waste against a service charge by engaging NGOs or any other private organizations. Covered vans with closed detachable containers to easily transport the waste could be used. Moreover, the vans should be modified with a number of bins into which the separated waste is collected and transported. A composting facility should be created along with the aforementioned infrastructure.	Cost of IEC, renovation of vans for collection, sorting facility, labour, staff, training	A detailed DPR needs to be developed to assess actual costs. Decentralised systems can be set up for about USD 25000 for each ward, including small pit composting system, simple sorting facility and IEC.

Economy

Issues:	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.
Some Existing / Planned Measures:	<ul style="list-style-type: none"> To boost the economy in the city, tourism is being promoted. The river bank and other recreational places are being developed for this purpose, greening of the city is being done, and establishment of hotels is being

	encouraged.	
Potential Climate Impacts:	Increasing temperature and decreasing rainfall will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. It can also increase immigration to the city from surrounding areas. Daily labour and vendors will be impacted since they will be unable to work in harsh climate.	
Potentially Impacted Areas:	Peri-urban areas of ward 1, and ward 2, 17, 30, 26, 27 & 29	
Risk Status:	Extreme	
Actors:	Vulnerable - Farmers - Farm labourers - Women - Entrepreneurs - Slum dwellers - Daily labours - Vendors - Rickshaw pullers	Supporting - Entrepreneurs

Prioritized Actions

Type of Measures	Cost per unit and description	Cost estimate
Policy and Institutional Measures		
Alternative income streams for affected low income earners and daily labourers. RCC can provide trainings with the help of NGOs on production of home-made various street foods like pickle, papad etc, toys, vegetable vending, handloom production, and driving auto rickshaw etc.	Trainings, investment on infrastructure for home based industries	A detailed DPR needs to be developed to assess actual costs.
Infrastructural Measures		
To increase climate adaptive trade and tourism based activities, eg. eco tourism, green procurement practices.	Cost of training, cost of investment on infrastructure.	A detailed DPR needs to be developed to assess actual costs. Phased implementation is necessary

8. CONCLUSION

The implementation of the IAP toolkit in the city of Rajshahi revealed that the city is vulnerable to climate change impacts and needs to adapt to possible impacts of the same. Rajshahi is located in the drought prone North West part of the country, the frequency of

which is increasing, and therefore there is a greater need for the town to build resilience through appropriate and feasible adaptation interventions. The ICLEI ACCCRN Process helped identify two climate risk scenarios of decreased or irregular precipitation and increased temperature. Five urban systems were identified as fragile - water supply, health, biodiversity, solid waste management, and economy - and climate fragility statements were formulated for all of them corresponding to the two climate scenarios.

The vulnerability map of the city shows ward 1, 17 and 29 as the vulnerable hotspots in the city. A majority of the population is dependent on primary sectors like agriculture and fisheries for their livelihoods. These are the most vulnerable to the climate risks. The RCC has high adaptive capacity since they have access to resources, information and ability to respond to stress. This is also true for government agencies like WASA or the non-government organisations. However, common citizens including farmers, daily labourers, fishermen, vendors, women, children, elderly, and others due to either a lack of information and education, or a lack of financial resources lack the capacity to adequately respond to stress and therefore have low adaptive capacity. Most of them are also dependent heavily on ecosystem based employment, and therefore are easily impacted by climatic changes.

The list of interventions identified in this CRS includes both hard and soft measures. These measures either directly or indirectly contribute to climate change adaptation while making the city more resilient. The Policy/Non-Infrastructural Measures include awareness generation activities for water conservation, waste segregation, training and capacity building for alternate livelihoods, research on resilient species for agriculture or fishery among others. Also important are intergovernmental coordination and cooperation as well as formulation of long term and holistic city level plans for development. The hard measures include infrastructural development to improve water supply and waste management, maintenance and conservation of natural resources, and investment in improvement and diversification of livelihood.

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. RCC 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 city is also important in order to avoid duplicity of efforts and enhance coordination among different government agencies.

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	<p><i>Flexibility & Diversity: Water supply is dependent on ground water only and does not function in dry season</i></p> <p><i>Redundancy: Dependent only on ground water, no other source available</i></p> <p><i>Safe failure:</i></p>	<p>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.</p>	<p>The water resource in the city is reducing because of extraction of ground water and drying up of ponds.</p>	<p>With increasing temperature and decreasing rainfall in the region, the water resource in the city will be under greater stress, leading to health impacts and impacts on economy dependent on water such as agriculture</p>

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
Health	<p><i>Flexibility & Diversity: Enough facilities in the region for health care to meet climatic health challenges</i></p> <p><i>Redundancy: Public facilities are under stress since they cater to surrounding regions as well.</i></p> <p><i>Safe failure: Sudden stress cannot be met if the number of patients increase drastically due to climatic events.</i></p>	Health system includes public and private facilities, primary health centres are also available. Enough facilities to take care of residents of Rajshahi, but since it caters to surrounding regions, the facilities are under stress.	Health care facilities in the region caters to the city and its surrounding regions, and is therefore under stress due to lack of space of housing patients. However, modern facilities are available in the city for health care.	In case of health risks due to sudden climatic impacts of increasing temperature and decreasing rainfall, the health system may fail in the city if there are suddenly more patients.
Biodiversity	<p><i>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.</i></p> <p><i>Redundancy:</i></p> <p><i>Safe failure:</i></p>	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 can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.

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
Solid Waste Management	<i>Flexibility & Diversity:</i>	Lack of resources hinder complete collection of waste. Lack of public awareness make waste disposal in sustainable manner difficult.	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 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
	<i>Redundancy:</i> <i>Safe failure: Solid waste is collected from 60% of the households, but remaining dump the waste near lampposts in roads, in ponds, in drains, etc.</i>			
Economy	<i>Flexibility & Diversity: Economy is dependent on agriculture, fishery and fruit orchards, that are dependent on climate.</i>	Urban poor and landless are dependent on agriculture, fishery, fruit cultivation as agricultural labour. Women are very dependent on agriculture. 5-10 % of	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	Increasing temperature and decreasing rainfall will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. It can also increase in migration to the city from
	<i>Redundancy:</i>			

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
	<p><i>Safe failure: Failure in case of climatic changes, can cause severe impacts on income of urban poor.</i></p>	<p>the population is dependent on agriculture</p>	<p>land.</p>	<p>surrounding areas. Daily labour and vendors will be impacted since they will be unable to work in harsh climate.</p>

Annexure 2

Risk Prioritisation

Urban Systems	Climate fragility statement	Likelihood	Consequence	Risk Score	Risk Status
Water Supply	With increasing temperature and decreasing rainfall in the region, the water resource in the city will be under greater stress, leading to health impacts and impacts on economy dependent on water such as agriculture	5	4	20	Extreme
Health	In case of health risks due to sudden climatic impacts of increasing temperature and decreasing rainfall, the health system may fail in the city if there are suddenly more patients.	5	4	20	Extreme
Biodiversity	Increasing temperatures and decreasing rainfall can exacerbate habitat loss caused by urbanisation that will further reduce urban biodiversity.	4	5	20	Extreme
Solid Waste Management	Increasing temperatures and decreasing 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	3	4	12	High

Urban Systems	Climate fragility statement	Likelihood	Consequence	Risk Score	Risk Status
Economy	Increasing temperature and decreasing rainfall will impact agriculture, fishery, fruit cultivation, and thereby economy of the city. It can also increase in migration to the city from surrounding areas. Daily labour and vendors will be impacted since they will be unable to work in harsh climate.	5	5	25	Extreme