2018

Climate Vulnerability and Resilience (CVR) Assessment for the WASH SDG Programme in Bangladesh

Final Report

Sub-Programme Areas: Jashore Municipality, Benapole Municipality, Kushtia Municipality and Khulna City Corporation

SNV Netherlands
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Climate Vulnerability and Resilience (CVR) Assessment for the WASH SDG Programme in Bangladesh

Final Report

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Executive Summary

To tackle climate change, we need to increase equitable access to sustainable water sources and improved sanitation, so that in times of crisis, everyone is given a chance to survive and grow. The WASH SDG programme aims to gather evidence in sub-programme areas to identify WASH hazards, perform risk assessments and develop adaptive interventions. The programme works towards an improved WASH situation for all, using an integrated approach and ensuring that facilities and services are sustainable, climate resilient, gender sensitive and socially inclusive. Under this programme, an assessment titled "Climate Vulnerability and Resilience (CVR) Assessment" has been undertaken with the aim to creating climate proof WASH interventions strategies that will be integrated into the intervention strategy. With the objective to identify strategies for increased resilience to be integrated into interventions, this Climate Vulnerability and Resilience (CVR) Assessment will deepen understanding of the possible climate vulnerabilities of WASH services in the sub-programme areaa. To carry out this CVR assessment, a local consultant was hired by SNV.

The selected areas for the CVR assessment were Jashore and Benapole Municipalities under Jashore district where SNV will work under the WASH SDG programme, and Kuhstia Municipality and Khulna City Corporation where SNV has been implementing projects. As current knowledge is insufficient to identify the vulnerabilities of WASH facilities to different climatic hazards in a specific locality, the study focused on research on how the WASH service gets affected by these hazards and also on building resilience of local management structures as well as responsiveness of surrounding support structures in sub-programme areas.

Climate change impact will enhance current problems in water and sanitation, however, the impact of climate change is not uniform everywhere in the country, and some areas are more vulnerable than others. In addition, some of the areas have high resilience to climatic hazards than others. In this regard, the study areas were found being less vulnerable to most of the identified climatic hazards and having good resilience, especially against flood. Flooding due to sea level rise or melting of glaciers and increase in cyclone frequency/intensity have not been considered as threat. Among the other climatic hazards, increase in drought period and change in precipitation pattern was reported to be the major threats in the study areas. In Khulna City Corporation Salinity intrusion due to sea level rise is considered as another major climatic hazard. However, detailed local data on climate change indicators is difficult to be gathered and rather uncertain.

Among the study areas, only the water supply system of Khulna City Corporation is considered as vulnerable to the issue of salinity. Although in Jashore, Kushtia and Benapole Municipalities, this is not currently posing any significant threat. With the current trend of salinity intrusion, groundwater resources might get affected in future. Moreover, depletion of groundwater table during drought period increases vulnerability of the water supply systems. Because of the rate of rapid urbanization in all the cities, this has been taken into consideration by the authorities.

The sanitation system in urban areas of Bangladesh is mostly septic tank and pit latrine based, with people showing more willingness towards septic tanks. These technologies are becoming more climate

resilient with time as people have started to adapt to the changes observed in the past. But in areas of flooding/water logging and groundwater level rise, these technologies are vulnerable to floatation and causing widespread contamination. Water logging at household premises poses a significant risk when flooding of septic tanks/pits occurs, resulting in significant public health risks to the inhabitants. This problem has been found notable in Khulna City Corporation.

This untreated fecal waste has been found affecting quality of surface water in all the study areas. Due to the fact that rivers/water bodies in Jashore, Benapole and Kushtia have very low discharge except for the months in full monsoon (June-September), the effect of this pollution remains within the area. In Khulna City Corporation, due to tidal effect and inadequate drainage facility, the city areas often get flooded which helps spreading contamination in areas near the drains. It was found during the study that increased and intense precipitation will cause further damage to overall environment due to lack of safe fecal sludge management in all areas, which is the major climatic threat identified with regards to sanitation systems.

In the study areas selected for CVR assessment, the reliability of source of water supply need to be assessed. Based on the reliability analysis, further predictions on future impact of current climatic trend can be made. For sanitation system, it is more focused on resilience of technology and its management in the given conditions.

Although the study areas show good resilience to some of the climatic hazards in these areas, there are existing problems which are mostly due to lack of understanding and support, especially in sanitation systems. To overcome these problems, some recommendations have been made that the programme needs to incorporate in their strategies.

1. Scope and Purpose of the CVR Assessment

1.1 Background

The WASH SDG programme aims to gather evidence at the country and sub-programme area to identify WASH hazards, perform risk assessments and develop adaptive interventions. The programme is being implemented by a consortium consisting of the WASH Alliance International (WAI), Plan Netherlands and SNV, and runs in seven countries: Bangladesh, Ethiopia, Indonesia, Nepal, Tanzania, Uganda and Zambia. The programme will sustainably improve access to and use of sanitation and their hygiene behaviour for at least 2 million people. The programme will also deliver access to and use of safe drinking water for at least 450,000 people.

Water and climate change are inextricably linked, as the effects of climate change are first felt through water: through droughts, floods and storms. These disasters can destroy water supplies and sanitation facilities, or leave behind contaminated water putting the lives of local people at risk. The people living in low lying areas are at risk of floods and already have very low levels of access to water and sanitation and are extremely vulnerable. To tackle climate change, we need to increase equitable access to sustainable water sources and improved sanitation, so that in times of crisis, everyone is given a chance to survive and grow.

The WASH SDG programme works towards an improved WASH situation for all, using an integrated approach and ensuring that facilities and services are sustainable, climate resilient, gender sensitive and socially inclusive. The programme is built on three core strategic objectives:

- Increasing demand for improved WASH facilities and practices
- Improving the quality of service provision
- Improving governance of the sector

With the objective to identify strategies for increased resilience to be integrated into interventions, this Climate Vulnerability and Resilience (CVR) Assessment will deepen understanding of the possible climate vulnerabilities of WASH services in the sub-programme area. To carry out this CVR assessment, a local consultant was hired by SNV. As current knowledge is insufficient to identify the vulnerabilities of WASH facilities to different climatic hazards in a specific locality, the study focused on research on how the WASH service gets affected by these hazards and also on building resilience of local management structures as well as responsiveness of surrounding support structures in sub-programme areas.

1.2 Goals and Objectives

The overarching goal of the assessment is to create climate proof WASH interventions strategies to be implemented once the inception report is approved, so outcomes of the analysis will be integrated into the intervention strategy.

The CVR Assessment will deepen understanding of the possible climate vulnerabilities of WASH services in the sub-programme area, with the objective to identify strategies for increased resilience to be integrated into interventions. Whereas the potential scope of a climate vulnerability and resilience assessment is very large, the assessment prioritizes issues considering risk for sustained service delivery

(probability/impact). The assessment will also take into account the potential upstream and downstream impacts of changes in services, with the aim to define and negotiate socially and environmentally sustainable agreements between users regarding such impacts. In summary, the inputs from the CVR Assessment should generate a practical way forward for:

- Reduced vulnerability of WASH services, by well negotiated and designed infrastructure interventions
- Increased resilience of WASH services, by strengthening financial, social and technical capacity and safe guards
- Contribute to sustainability of water resources

1.3 Study Areas

The selected areas for the CVR assessment are Jashore and Benapole Municipalities where SNV will work under the WASH SDG programme, and Kuhstia Municipality and Khulna City Corporation where SNV has been implementing projects. Both Jashore and Benapole Municipalities are located under Jashore district but in different Upazilas (sub-district); Benapole Municipality is located in Sharsha Upazila. A brief background of the study areas are provided in this section. Figure 1 shows the locations of the study areas on a google map.

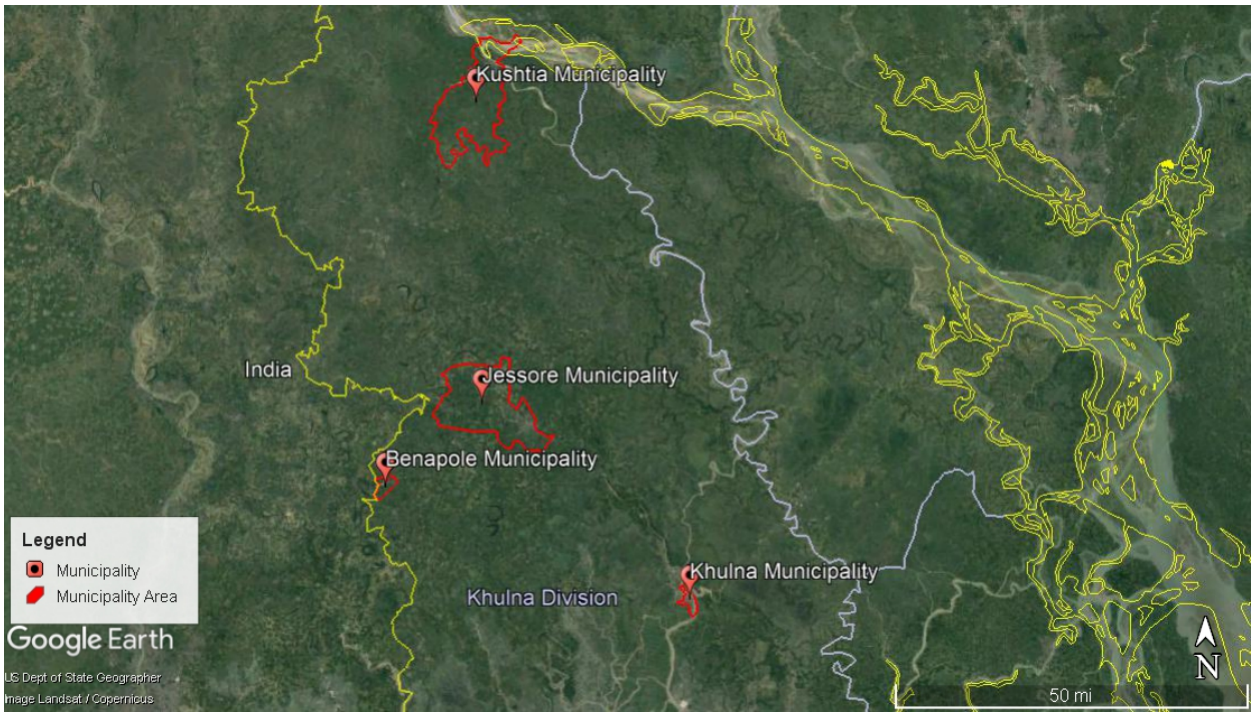


Figure 1: Location of study areas for the CVR assessment

Jashore Municipality:

Jashore is a district in the south-western region of Bangladesh. It is bordered by India to the west, Khulna and Satkhira Districts to the south, Magura and Narail to the east, and Jhenaidah District to the north. Jashore Municipality contains 9 words and 73 Mohallas. The area of the town is 25.72 sq. km. It's

population was 201,796 according to the 2011 Census (Wikipedia). There are some prominent rivers in the surrounding areas of Jashore Municipality namley Kabodak, Bhairab, Chitra, Ichamoti , Harihor , Dadra , Betraboti and Kodla.

Benapole Municipality:

Benapole is a township in Sharsha Upazila under the Jashore District of Bangladesh. The Petrapole Customs station of India is situated across the border. Benapole is the most important check post of Bangladesh and is operated by the Bangladesh Land Port Authority (BLPA) (Wikipedia). Once the Ichamoti river from India was connected to the Hakor river in Benapole, but due to man-made obstructions, that has turned into Hakor beel.

Kushtia Municipality:

Kushtia is a district in Khulna division. As of the 2011 Bangladesh population census data, Kushtia Municipality has a population of 375,149. The total area is 42.79 sq. km. and 21 wards consist the Municipality. The main rivers in Kushtia district are Padma, Gorai, Mathabhanga and Kumar.

Khulna City Corporation:

Khulna City Corporation has an area of 40.79 km^2. It is bounded by Dighalia Upazila and Khan Jahan Ali Upazila on the north, Batiaghata' Upazila on the south, Rupsa and Dighalia Upazila on the east and Dumuria Upazila on the west. The population of the city corporation was 663,342, according to 2011 population census (Banglapedia). It lies south of Jashore and Narail, East of Satkhira, West of Bagerhat and North of the Bay of Bengal. The main rivers in and around Khulna City Corporation are Rupsa, Bhairab and Mayur rivers.

1.4 Organization of the Report

This report presents the findings of the CVR assessment with relevant background, methodology used in the study and some recommendations made based on the findings. Chapter 1 presents the background of this CVR assessment. The methodology that has been followed to carry out the study is presented in Chapter 2. In chapter 3, the findings from the study is described. Finally, Chapter 4 discusses the conclusion and recommendation.

2. Assessment Methodology

A two-step process was followed during the CVR assessment; first a review of existing information in order to narrow down the issues to be assessed in the specific sub-programme areas and secondly field assessment in the form of focus group discussion (FGD) and key informant interviews (KII). In the figure below the process is described in more detail.

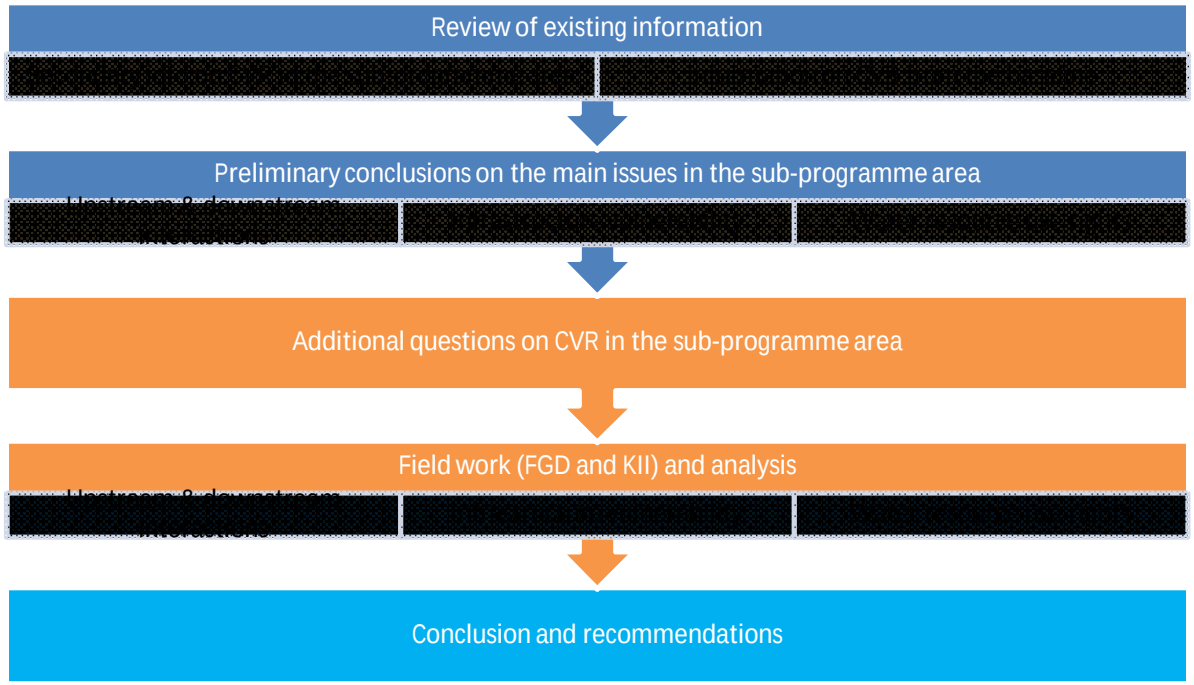


Figure 2: Steps included in the CVR assessment for Bangladesh.

2.1 Review of Existing Information

First a quick risk assessment of the proposed area was done to ascertain that climate change effects and water security issues will not go beyond the capacity/scope of the program to address. For secondary information, the national and local level information on climate change assessments was used (research papers, websites, reports, locally available information, country context analysis)[1].

The secondary information analysis in the CVR Assessment mainly considered 3 angles of analysis:

- Upstream and downstream interactions
- WASH infrastructure vulnerability

[1] Relevant secondary information to use are: Nationally Determined Contributions (NDCs) of countries which are meant to cover mitigation and adaptation. NAPA and NAP which are more focused on Adaptation. For Bangladesh, there is also the Climate Change Profile done by the Dutch Sustainability Unit of DGIS: http://dsu.eia.nl/publications/advisory-reports/7196

- Water resource and pollution rights

Based on the findings from secondary information review, a detailed assessment was undertaken, including field work and analysis.

2.2 Primary Information Collection and Analysis

The field assessment included focus group discussion and key informant interviews to collect primary information in study areas. Each of the four study areas was visited and representatives from key stakeholder organizations in WASH sector were met The list of people who were either participants of FGD or key informant are provided in Table 1 below:

Table 1: List of participants in the FGD and KII sessions

Respondent	Discussion format
• Executive Engineer, Municipality • Water Super or Assistant Engineer, Municipality water supply section • Conservancy Inspector, Municipality • Others (slum development officer, ward councillors, conservancy staff, etc.)	Focus group discussion
• Executive Engineer, Department of Public Health Engineering	Key informant interview
• Executive Engineer, Bangladesh Water Development Board	Key informant interview
• Agriculture Extension Officer	Key informant interview
• Local NGO representatives • Local WASH users • Local farmers	Focus group discussion

In the FGD or KIIs, the discussion was primarily focused on three sections, which are:

Section 1: Assessing current vulnerability
Section 2: Assessing future climate risks and vulnerability
Section 3: Identifying adaptation measures

The list of assessment questions are provided below in Annex-II. However, for representatives from different stakeholders, different questions were given priority. For example, regarding the upstream and downstream interactions, the representative from Bangladesh Water Development Board was requested to provide more insights than others on this particular topic. Similarly, to learn about the current sanitation practice in the Municipality, the Municipality staff and user groups were given more attention during the field assessment.

3. CVR Assessment Findings

3.1 Findings from Secondary Information

Bangladesh is often cited as one of the most vulnerable countries to climate change in the world, and was ranked sixth on German Watch's Global Climate Risk Index 2016 (Sönke Kreft, 2015). This vulnerability is caused by a combination of biophysical factors (being a flat, low, delta country, exposed to flooding and cyclones) and socio-economic factors such as high dependence on agriculture, population density and poverty levels (Ayers, et al., 2014).

Bangladesh has a unique geography, situated on the Bay of Bengal and forming one of the largest deltas in the world with a dense network of tributaries of the Ganges, Brahmaputra and Meghna (GBM) rivers. Due to its topography and climate, Bangladesh is subject to devastating cyclones, mostly in April-May and September-November (Karmalkar, et al., 2012). UNDP has ranked Bangladesh first of all countries in the world in terms of vulnerability to tropical cyclones. The country is hit by a severe cyclone on average every three years (Ministry of Environment and Forests, 2009). The cyclones are usually accompanied by high speed winds, sometimes reaching 250 km/hr or more and 3-10 m high waves, causing extensive damage to life, property and livestock. Most of the damage occurs in the coastal regions.

Bangladesh has a monsoon-type climate. This climate has three seasons:

- hot, humid summers (March-June) with average maximum temperatures of 37 °C;
- slightly cooler monsoon seasons (June-September);
- dry, cooler winters (October-March) with average maximum temperatures of 28 °C.

Bangladesh is vulnerable to flooding, with 80% of its surface forming a giant floodplain (Ayers, et al., 2014). In an average year, about 25% of the country is inundated. During severe floods, occurring every 4-5 years, over 60% of the country gets under water (Sharmin and Islam, 2013). These floods have devastating effects. Riverbank erosion results in the loss of thousands of hectares of agricultural lands (Ministry of Environment and Forests, 2009) and affects the population for decades (Sharmin and Islam, 2013). In addition, floods contribute to further salinization of coastal lands, causing not only loss of harvests but also of productive agricultural land (Thomas, et al., 2013). Out of 2.85 million hectares of coastal and offshore areas, about 1.2 million hectares of arable land are already affected by varying degrees of soil salinity (World Bank, 2011).

Bangladesh experiences different types of floods every year (river floods, storm surges initiated by cyclones, tidal flooding, and extreme rainfall conditions resulting in water-logging). The storm surges that accompany the cyclones of the Bay of Bengal cause more destruction in the coastal areas and offshore islands of Bangladesh than the very strong winds that are associated with the cyclones. Besides cyclone induced flooding, water-logging is another type of flooding presented in the coastal region, which effects WASH infrastructure as well as hygiene practises.

While many parts of Bangladesh suffer from widespread and common floods, other parts experience seasonal droughts (Xenarios, et al., 2014). These occur especially in the northwest of the country, and

mostly in the months leading up to the November-December rice harvest. In **Error! Reference source not found.**3, an overview of the different types of extreme climatic events and their distribution over the country, including the selected 3 WASH SDG programme districts, is provided.

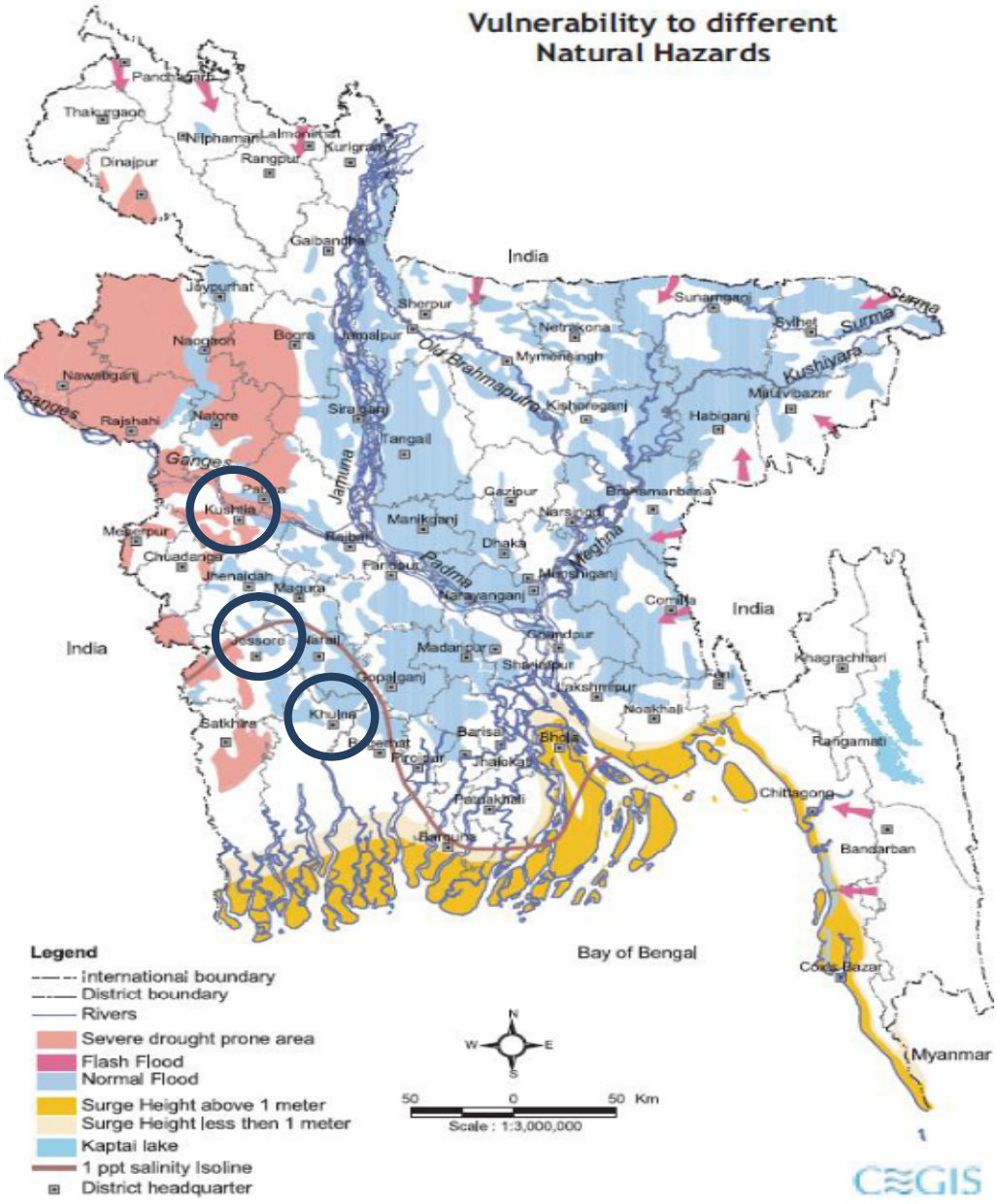


Figure 3: Vulnerability to natural hazards (Ministry of Environment and Forests, 2009)

During floods or water logging caused by heavy rainfall and poor drainage facility, water sources like tube wells and freshwater ponds get damaged, and availability of and accessibility to fresh water is reduced significantly. In flood-affected areas access to WASH services becomes more problematic, and competition will increase between different uses and users. A study (JNA, 2013) showed that during

water logging events people have to travel further to get clean water. Water-logging has caused significant displacement in many areas in the South-Western part of Bangladesh (UNDP, 2011). Latrines often become non-functional during floods. For female headed households the situation is more severe given the mix of responsibilities and reduced capacities to cope with the floods (McNelly, 2011). Furthermore, in flood conditions women and girls are struggling with issues related to health care and feminine hygiene (McNelly, 2011).

Besides forming a threat to the existing physical infrastructure of Bangladesh, climate change is likely to have several impacts on public health in Bangladesh, such as: increased likelihood of diseases (e.g. cholera, dysentery, malaria etc.) due to degraded water quality, especially if combined with standing water, (fresh) water shortages and pollution of sources of water (Ministry of Environment and Forests, 2009).

3.1.1 Climate Variability

Under the current climatic trends, the incidence of extreme events is changing. A significant increase in cyclone frequency has been observed during the 'cyclone seasons' in November and May (World Bank, 2011). Extreme events in Bangladesh, such as cyclones and floods, will be both heavier and more frequent (Thomas, et al., 2013).

A significant sea level rise has been measured in Bangladesh, with 4 mm per year at Hiron Point in the West, 6 mm per year at Char Changa in the centre of the country, and even 8 mm per year at Cox's Bazar in the South East (Sharmin and Islam, 2013). The sea level is expected to rise further, with the IPCC projecting increases of 14 cm by 2030, 32 cm by 2050, and 88 cm by 2100 (compared to 2000) (Khatun and Islam, 2010). A 1-meter sea level rise would inundate 18% of the country's land (Yu and Yu, 2010).

Sea level rise and cyclones have combined effects: cyclone-induced storm surges are projected to inundate an additional 15% of the coastal area (World Bank, 2010). Sea level rise has been one of the factors that led to an increase in soil salinity in Bangladesh, from 1.5 million hectares under mild salinity in 1973 to 3 million in 2007 (Khatun and Islam, 2010).

The average temperature shows an increasing trend, especially during the monsoon season (June-August). Annual rainfall for the country as a whole has not changed significantly over the last decades, however there has been a significant increase in certain seasons, including a 3.4% increase in country-wide rainfall during the pre-monsoon summer season and a 1.7% decrease in monsoon rainfall (Karmalkar, et al., 2012).

Climate change is likely to increase river salinity, leading to shortages of drinking water and significant changes in the aquatic ecosystems in the South-Western coastal areas of Bangladesh during the dry season (The World Bank, 2015). An overlay of isohalines on administrative areas of the coastal districts indicates that Khulna District will be affected severely by the increase in river salinity with climate change by 2050 (Dasgupta, et al., 2014). The estimates indicate that even in the best case future scenario, freshwater (0–1ppt) zones will be lost entirely in Khulna District (Dasgupta, et al., 2014). In addition, a serious shortage of water for dry season agriculture (water with salinity <2ppt) is envisioned with climate change (Dasgupta, et al., 2014). River water will no longer be utilizable for agriculture in

Khulna District in the worst case future scenario. Figure 4 presents the spatial variation of the maximum river salinity level during 2011–2012 in the southwest zone.

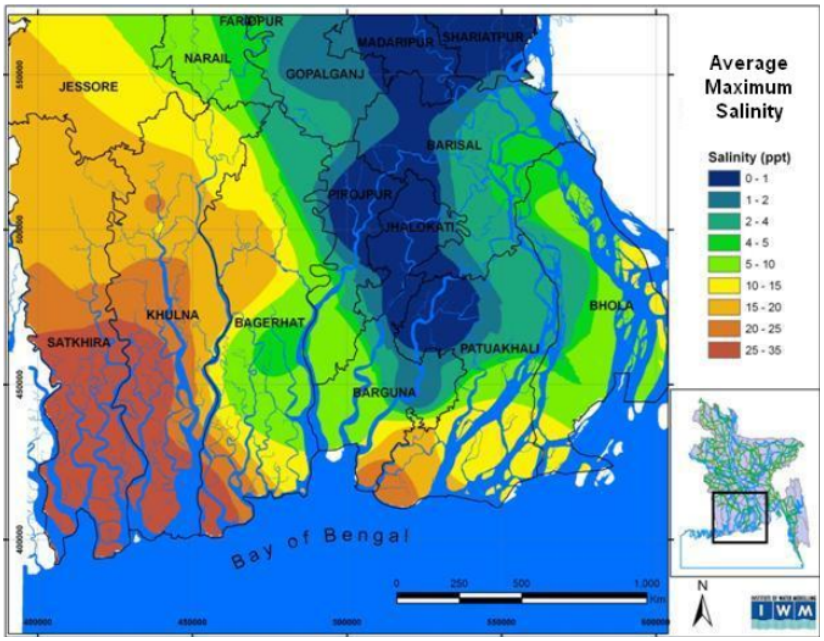


Figure 4: Map of Average Maximum River Salinity in the South-West Region of Bangladesh (Dasgupta, Kamal, Khan, Choudhury, & Nishat, River Salinity and Climate Change: Evidence from Coastal Bangladesh, 2014)

The areas of coastal districts of Bangladesh belong to high risk zones (HRZ). The people who live in the exposed coast are considered as vulnerable partly or fully to surge flooding. The administrative districts Satkhira, Khulna, Bagerhat, Barguna, Patuakhali, Jhalkhati, Pirojpur, Barisal and Bhola are located in the exposed coast (refer to Figure 5). (Karim and Mimura, 2018)

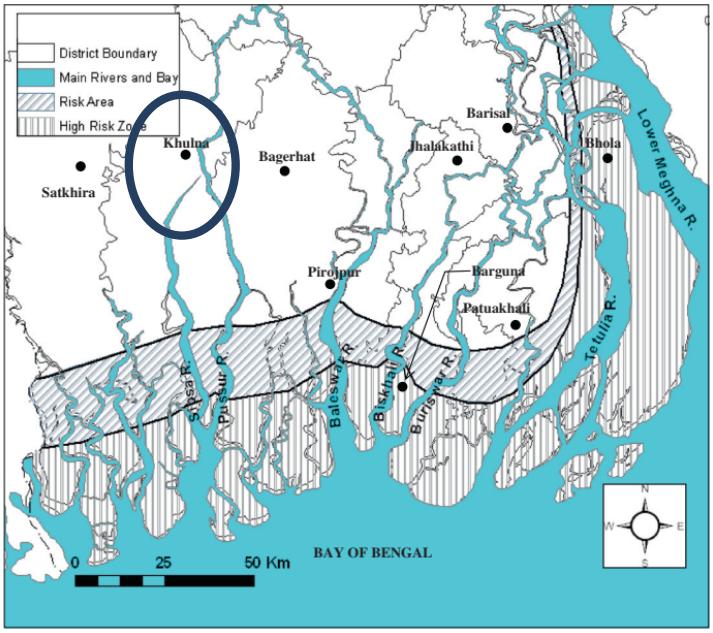
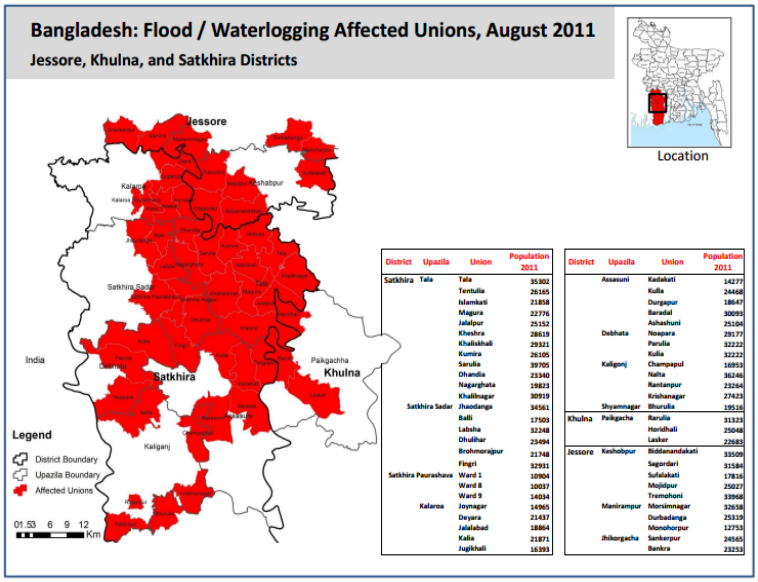


Figure 5: Flood risk map corresponds to a typical projected climate (Scenario V: 2 1C temperature rise and 0.3 m SLR)

The south-west coastal region of Bangladesh has been very fertile and rich in biodiversity, and people had their own indigenous sediment management system. However, construction of polders, which started in early 60's, led to the present water logging crisis. The compartmentalized polder system delinked flood plains from rivers (Tareq, 2016). Sedimentation took place only in river channel, raising river beds; water remains trapped in beels, turning these into water logged area. Water logging hazard is a burning issue for Jashore, Khulna and Satkhira, the three coastal districts of the southwest region of Bangladesh (Tareq, 2016). In the greater Khulna area, the coastal rivers or estuaries are mainly saline because freshwater discharges are very low, especially in dry season. The flow regimes are driven by high, variable sediment laden flows. The rivers of this region show a continuous process of siltation gradually from the NW towards the SE direction (Tareq, 2016). Rahman (2011) founded that Mani Rampur, Keshabpur, and Abhaynagar Thana's of Jashore District, Dumuria Thana of Khulna District, and Tala Thana of Satkhira District face water logging problem almost every year (Rahman, 2011). The severity of water logging problem prevails in 274 villages of 17 unions under Khulna, Jashore and Satkhira districts (Tareq, 2016). Figure 6 shows the areas that suffered from water logging in the recent past.

Khulna area is much lower (even less than a meter) than that the other coastal parts, a significant proportion of which again falls below high tide level. Being a coastal and a low lying area, it is affected by floods regularly. River induced floods in Khulna are also related to floods in India, forming the Western border of the district (ICCAD, 2017). Mondal et al. (2013) analyzed tidal water levels of the Rupsa-Pasur River at Khulna and at Hiron Point that located near to the Bay of Bengal for a period of 74 years (1937–2010) and found that the annual maximum tidal high water level is increasing and the annual minimum low water level is decreasing at a rate of 7–18 mm and 4–8 mm/yr. depending on the locations, respectively (Tareq, 2016). The possible reasons for the decreasing trends in annual minimum water levels could be the reduction in the sweet water flow from upstream areas or the reduction in storage areas of saline tidal water or both. The increasing trends in annual maximum water levels could result either from silting up of the rivers, reduction in flood tide propagation areas, or a rise in the sea level, or a combination of these factors (Tareq, 2016). Sea level rise will aggravate the drainage congestion, water logging and flooding problems that are already severe in the urban and peri-urban areas of Khulna.



District	Upazila	Union	Population 2011
Satkhira	Tala	Tala	35302
		Tentulia	26165
		Islamkati	21858
		Magura	22776
		Jalalpur	25152
		Kheshra	28619
		Khalishkali	29321
		Kumira	26105
		Serulia	39705
		Dhandia	23340
		Nagarghata	19823
		Khalilnagar	30919
	Satkhira Sadar	Jhaodanga	34561
		Balli	17503
		Labsha	32248
		Dhulihar	23494
		Brohmorajpur	21748
		Fingri	32931
	Satkhira Paurashava	Ward 1	10904
		Ward 8	10037
		Ward 9	14034
	Kalaroa	Joynagar	14965
		Deyara	21437
		Jalalabad	18864
		Kalia	21871
		Jugikhali	16393

District	Upazila	Union	Population 2011
	Assasuni	Kadakati	14277
		Kulia	24468
		Durgapur	18647
		Baradal	30093
		Ashashuni	25104
	Debhata	Noapara	29177
		Parulia	32222
		Kulia	32222
	Kaligonj	Champapul	16953
		Nalta	36246
		Rantanpur	23264
		Krishanagar	27425
	Shyamnagar	Bhurulia	19516
Khulna	Paikgacha	Rarulia	31323
		Horidhali	25048
		Lasker	22683
Jessore	Keshobpur	Biddanandakati	33509
		Sagordari	31584
		Sufalakati	17816
		Mojidpur	25027
		Tremohoni	33968
	Manirampur	Morsimnagar	32658
		Durbadanga	25319
		Monohorpur	12753
	Jhikorgacha	Sankerpur	24565
		Bankra	23253

Figure 6: Identification of Water Logged Areas after monsoon rains in 2011 in some coastal districts (FAO, 2015)

The rainfall of Khulna division (the study area located within this region) during the peak monsoon period was remarkably lower as compared to that at national average. It is evident from future projection (by linear regression) that although summer rainfall is found almost static but autumn rainfall is in increasing trend in Khulna Division as well as throughout the country i.e., national average (Figure 7). Recently, Mondal et al. (2013) have also analyzed the rainfall data for a period of 63 years (1948–2010) at Khulna region (Figure 8) and found that the number of rainy days in a year and the maximum number of consecutive rainy days are found to be increasing in the southwest coastal region of Bangladesh. They also found that the rainfalls have increasing trends where most increment will be occurred during monsoon. (Tareq, 2016) The increasing trend of pre-monsoon rainfall in Satkhira region could solve the water scarcity problem, whereas, in Jashore, it could increase water logging problem (Hossain, et al., 2014).

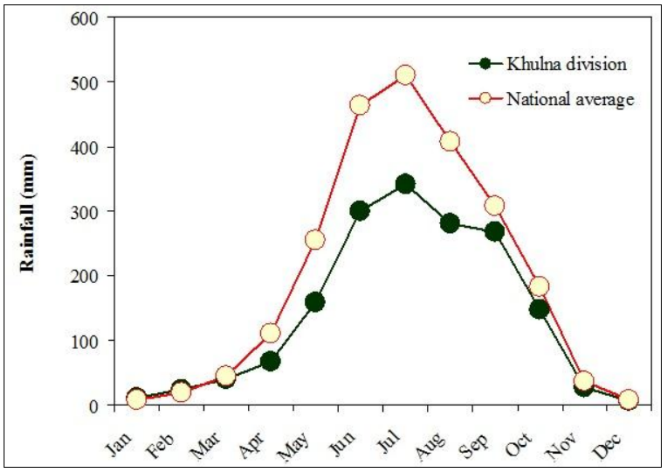


Figure 7 Monthly rainfall distribution in Khulna Division as well as national average

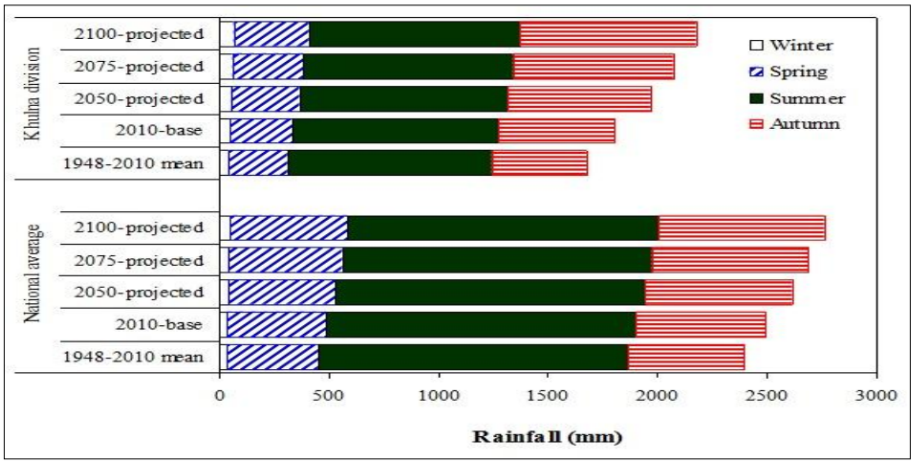


Figure 8 Future projection of seasonal rainfall in Khulna Division as well as national average (Data represent the mean from 1948 to 2010)

A summary of current trends and expected change in main climatic parameters such as sea level rise, temperature and rainfall for Khulna, Jashore and Kushtia are provided in **Error! Reference source not found.**, Table 2 and Table 3 respectively.

Jashore:

In Jashore, the wet season is hot, oppressive, and overcast and the dry season is warm and mostly clear. Over the course of the year, the temperature typically varies from 55°F to 96°F and is rarely below 50°F or above 101°F. The rainy period of the year lasts for 9.3 months, from February 17 to November 26, with a sliding 31-day rainfall of at least 0.5 inches. The most rain falls during the 31 days centred around July 5, with an average total accumulation of 9.1 inches. Figure 9 and Table 3 summarizes the climate change trend in Jashore district.

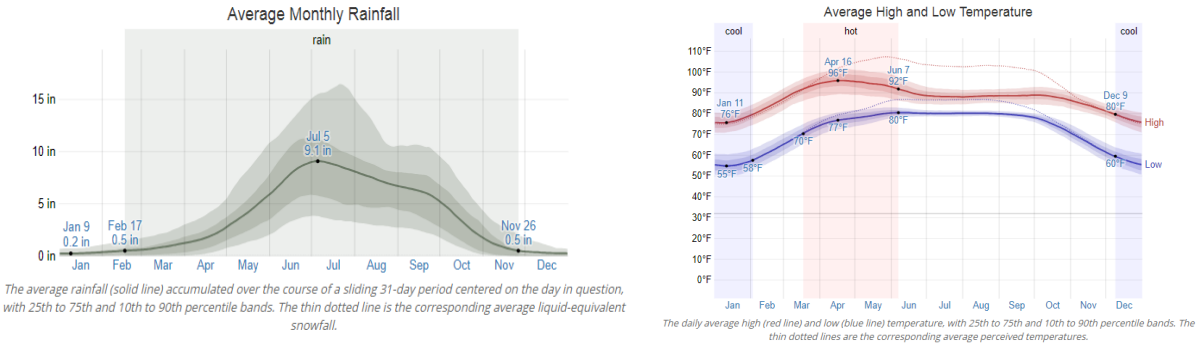


Figure 9 Historical observed monthly rainfall and temperature for Jashore, Bangladesh (Weather Spark)

Table 2: Climate Change trends and prediction for Jashore District

Jashore			Source
Climate trends (1991-2015)	Sea level	Rise of 4 mm per year, based on observations at Hiron Point (Sundarban)	(Sharmin & Islam, 2013)
	Mean annual temperature	Max 30.08°C, Min 17.87°C (1991-2015)	(The World Bank Group, 2018)
	Annual rainfall trends	Small increase (1950-2006).	(Rimi, 2008)
	% rain in heavy events	Not significant. Rainfall in pre-monsoon and winter season had a decreasing trend whereas it had an increasing trend during monsoon and post- monsoon seasons (1950-2006).	(Rimi, 2008)
Climate projections (by 2060s)	Sea level	Increases of 14 cm by 2030, 32 cm by 2050, and 88 cm by 2100 (compared to 2000)	(Khatun & Nazrul Islam, 2010)
	Mean annual temperature rise	1.53°C by 2030 compared to 1986-2005.	(The World Bank Group, 2018)
	Mean rainfall	Positive trend.	(Worldbank, 2018)
	Seasonal rainfall trends	Decrease in April, October and November and increase in June and September	
	Trends in % of rain falling in heavy events	Slight decrease in July, October and November and increase in August and September	
	Increases 1- and 5-day rainfall maxima	Decrease in April and November and increase in June	

Kushtia:

In Kushtia, the wet season is hot, oppressive, and mostly cloudy and the dry season is warm and mostly clear. Over the course of the year, the temperature typically varies from 53°F to 96°F and is rarely below 48°F or above 102°F. The rainy period of the year lasts for 8.5 months, from March 3 to November 18, with a sliding 31-day rainfall of at least 0.5 inches. Figure 10 and Table 4 summarizes the climate change trend in Kushtia district.

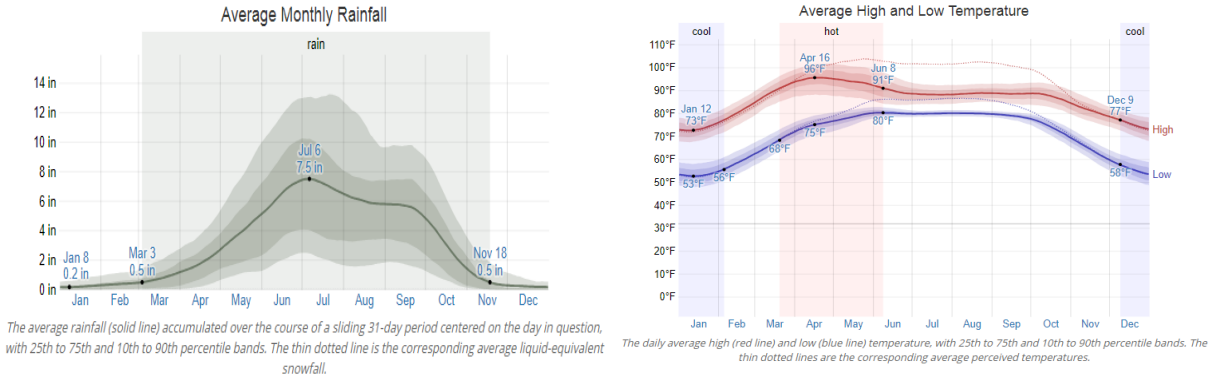


Figure 10 Historical observed monthly rainfall and temperature for Kushtia, Bangladesh (Weather Spark)

Table 3: Climate Change trends and prediction in Kushtia District

Kushtia			Source
Climate trends (1960-2006)	Sea level	Rise of 4 mm per year, based on observations at Hiron Point (Sundarban)	(Sharmin & Islam, 2013)
	Mean annual temperature	Max 29.76°C, Min 17.96°C (1991-2015)	(The World Bank Group, 2018)
	Annual rainfall trends	Small increase (1950-2006).	(Rimi, 2008)
	% rain in heavy events	Not significant. Rainfall in pre-monsoon and winter season had a decreasing trend whereas it had an increasing trend during monsoon and post- monsoon seasons (1950-2006).	(Rimi, 2008)
Climate projections (by 2060s)	Sea level	Increases of 14 cm by 2030, 32 cm by 2050, and 88 cm by 2100 (compared to 2000)	(Khatun & Nazrul Islam, 2010)
	Mean annual temperature rise	1.74°C by 2090 compared to 1986-2005.	(The World Bank Group, 2018)
	Mean rainfall	Positive trend in next 20 years.	(Hossain, Roy, & Datta, 2014)
	Seasonal rainfall trends	Decrease in April, October and November and increase in June and September	
	Trends in % of rain falling in heavy events	Slight decrease in July, October and November and increase in August and September	
	Increases 1- and 5-day rainfall maxima	Decrease in April and November and increase in June	

Khulna:

In Khulna, the wet season is oppressive and overcast, the dry season is humid and mostly clear, and it is hot year round. Over the course of the year, the temperature typically varies from 57°F to 94°F and is rarely below 52°F or above 100°F. The hot season lasts for 3.0 months, from March 12 to June 12, with an average daily high temperature above 91°F. The hottest day of the year is April 18, with an average high of 94°F and low of 78°F. The cool season lasts for 1.5 months, from December 12 to January 30, with an average daily high temperature below 81°F. The rainy period of the year lasts for 9.6 months,

from February 14 to December 1, with a sliding 31-day rainfall of at least 0.5 inches. The rainless period of the year lasts for 2.4 months, from December 1 to February 14. Figure 11 and Table 5 summarizes the climate change trend in Khulna.

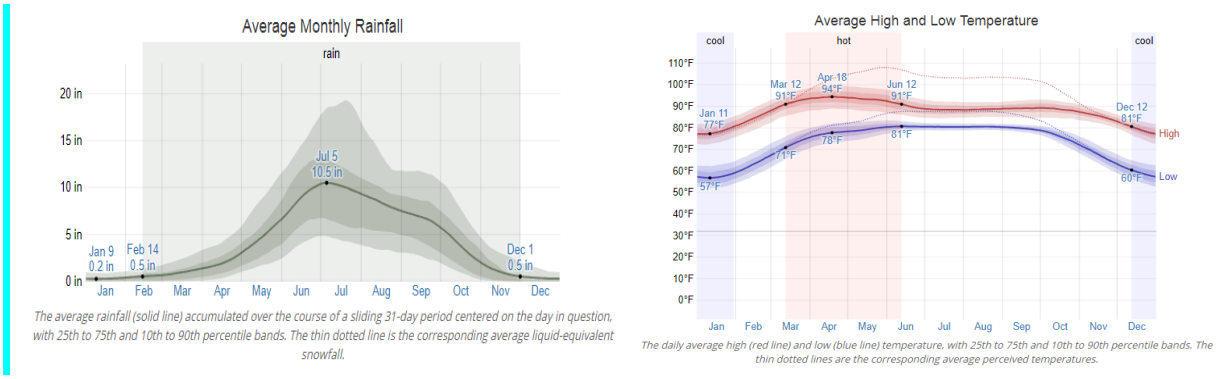


Figure 11 Historical observed monthly rainfall and temperature for Khulna, Bangladesh (Weather Spark)

Table 4: Climate Change trends and prediction in Khulna District

		Khulna	Source
Climate trends (1991-2015)	Sea level	Rise of 4 mm per year, based on observations at Hiron Point (Sundarban)	(Sharmin & Islam, 2013)
	Mean annual temperature	Max 29.6°C, Min 18.8°C (1991-2015)	(The World Bank Group, 2018)
	Annual rainfall trends	The analysis of rainfall data for a period of 63 years (1948-2010) at Khulna indicates that the rainfalls have increasing trends	(Mondal, et al., 2012)
	% rain in heavy events	Not significant. Rainfall in pre-monsoon and winter season had a decreasing trend whereas it had an increasing trend during monsoon and post- monsoon seasons (1950-2006).	(Rimi, 2008)
Climate projections (by 2060s)	Sea level	Increases of 14 cm by 2030, 32 cm by 2050, and 88 cm by 2100 (compared to 2000)	(Khatun & Nazrul Islam, 2010)
	Mean annual temperature rise	value of monthly temperature change varies between 0 and 4 degrees. (2020-2039).	(The World Bank Group, 2018)
	Mean rainfall	the value of monthly precipitation change varies between -100 and +200 mm in 2020-2039 compared to the reference period (1986-2005).	(The World Bank Group, 2018)
	Seasonal rainfall trends	Decrease in April, October and November and increase in June and September	
	Trends in % of rain falling in heavy events	Slight decrease in July, October and November and increase in August and September	
	Increases 1- and 5-day rainfall	Decrease in April and November and increase in June	

3.1.2 Upstream and Downstream Interactions

3.1.2.1 Geographical Introduction

Bangladesh is part of the world's largest delta as the Meghna, Brahmaputra and Ganges (MBG) rivers, three of the largest rivers in the world, end up in the Bay of Bengal after joining in Bangladesh (Figure 12). Vast amounts of sediment are transported by the Ganges, Brahmaputra and Meghna rivers and settle down on flood plains or are transported to the Bay of Bengal. This sediment has two sources: 1) directly from the Himalayas (when rivers receive upstream flow) or 2) from the Bay of Bengal (in the case of tidal rivers).

Figure 12: The catchments of the Ganges (green), Brahmaputra (blue) and Meghna (pink) (Hossain, et al., 2015)

The rivers entering Bangladesh and the Bay of Bengal contain large amounts of sediment. As the Ganges moves East ward, sediment deposition from the Ganges to the South-West delta increases causing these rivers to receive less upstream flow and, consequently, come under increasing tidal influence. Without upstream flow that flushes out the dry-season sediment during the monsoon season, rivers quickly fill up with sediment. In these tidal rivers, floodplains developed get inundated twice daily by the high tide.

Freshwater flow from upstream river and tidal effects jointly determine the extent of salinity. As the tides in the Bay of Bengal are semi-diurnal, peak daily salinity generally coincides with the arrival of high water at the coast. The daily range of salinity concentrations at the river entrances varies with the spring or neap tide as well as with the season. Tidal amplitudes during spring tides are around 2.5 to three

times higher than the neap tides (Dasgupta, et al., 2014). The higher water levels at the coastal boundaries during spring tides result in greater volume of saline water entering inland. The dilution effect of any freshwater flows in the inland rivers is consequently weaker during spring tides in the dry season. As a result, salinity in coastal inland surface water during spring tides are generally higher (Dasgupta, et al., 2014).

Salinity generally increases almost linearly from October (post-monsoon) to late May (pre-monsoon), with the gradual reduction in the freshwater flow. At the end of May, the salinity level drops sharply because of rainfall and increased upstream flow of freshwater through the river system. The salinity levels are at the minimum in the wet season, usually during September or early October (Dasgupta, et al., 2014). However, effect of salinity was found low in Jashore and Kushtia (Figure 13). But salinity in Khulna is increasing alarmingly.

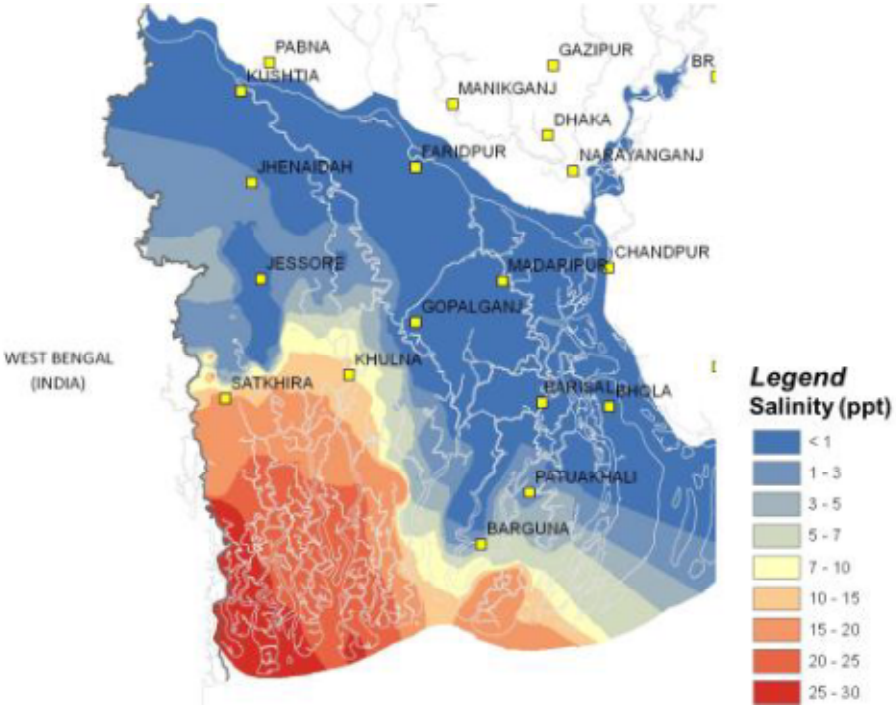


Figure 13: Average maximum salinity - surface water during 2011-2012 in the South-West zone. (BanDuDeltAS, 2015)

3.1.2.2 River Systems in Project Areas: Changes and Impacts

The project areas are located in the South-Western zone of Bangladesh where hardly any upstream and downstream linkages exist. However, during full monsoon, some upstream linkages are visible from the Ganges-Padma route. The rivers in Jashore district are in a moribund state as their flows have fallen drastically for widespread encroachment by land grabbers and unplanned government development projects. Sources concerned said though official records put the number of rivers in the district at 36, existence of two dozen could not be found. Many rivers have disappeared from the map of the district. Among the live rivers are Kobadak, Bhairab, Mathabhanga, Kumar,

Naboganga, Ichhamoti, Betrabatri, Harihor, Mukteshwari and Chitra. But the rivers have shrunk to either narrow canals or large drains due to encroachment on their areas.

Jashore and Kushtia are located in South-West region of Bangladesh. The area is mainly drained by a number of North-South flowing rivers. From East to West, important rivers are the Gorai-Madhumati-Baleswar rivers, the Bhairab-Pusur rivers, the Bhadra-Gengrail rivers, and the Hari-Teka-Mukteswari rivers, Sibsa Rivers, the Kabadak-Betna rivers and the Jamuna-Ichamati-Kalindi rivers. These North-South rivers are interconnected by East-West Rivers. In this region, flows of these East-West rivers are very important for the complete circulation of tide all over the tidal flat. The main rivers in Khulna are Rupsa, Bhairab and Mayur rivers. Water in rivers of Khulna are more saline than rivers in Jashore and Kushtia districts. In the rainy season, water becomes fresh to slightly salty and in the dry season, it becomes salty.

Due to flow diversion and water withdrawal by upper riparian countries, it is found that water flow of 975 rivers decrease below the critical level in the country, especially in the dry season (Rahman M. , 2005). Depth of 98% of river has decreased and submerged sand bars are found in 87% river (Rahman, 2005). Mouth of 12% rivers has silted up due to continuous siltation. Number of Dead River is increasing gradually due to siltation. Siltation also accelerated the emergence of sand bars and decreased depth in many rivers (Rahman, 2005).

The polders of coastal reaches through the implementation of the Coastal Embankment Project also had a backlash that has been demonstrated by enhanced sedimentation within the riverbeds, which eventually choked up the rivers (Sarker, 2004). Not only the morphological processes have been altered severely with adverse effect in terms of narrowing down of width of rivers and estuary, it also reduced the height difference between the crest height of embankment and the peak water level (mostly during neap tides in peak monsoon). Following a few iterations of such cascading effects, the drainage capacity of the affected rivers has been shrunk significantly (Ahmed, et al., 2007).

However, the most dramatic hydrological effect has been observed in the river ever since the Ganges flows have been withdrawn by building and commissioning of the Farakka barrage in 1975 ((Mirza, 2004); (Hal crow-WARPO, 2001). The adverse impacts reached their height during the period between 1990 and 1996, when the Gorai river has been found completely disconnected from its tributary the Ganges River (DHV-WARPO, 2000).

Accordingly, the mixing zone between freshwater and brackish water has been shifted towards North. During the dry season, a combination of extreme low flow and increased salinity accelerates the processes of siltation in the riverbed, which eventually choke the river and drastically reduce its drainage capacity (Rahman, Hassab, et al., 2000).

Upstream withdrawal of water from the Ganges added significantly to the magnitude of siltation process. Withdrawal of the Ganges water reduced the amount as well as velocity of upstream flow, thus reducing the flushing capacity of Ganges and its distributaries. The weak flushing power in the Ganges favoured the formation siltation in the river over the years which change the overall river morphology (NFPCSP, 2009).

The Kabodak is the tributary of the Bhairab. The Bhairab River has already dried due to siltation as an outcome of flow reduction in the Ganges as a result of water withdrawal. Since upstream part of the Bhairab River has died, the Kabodak also now is a nearly dead river with no flushing action as well water pressure from the upstream. But siltation has been continuing for years during high tides. As a consequence, the Kabodak River has been causing flooding in the entire region every year causing suffering of millions of peoples (Anonymous, 2009). Adel stated that not only the Kabodak river, majority of the channels in the South-West coastal areas are almost dead due to siltation. Eventually, siltation problem of tidal rivers has been spreading progressively Southwards i.e. seawards gradually affecting the downstream areas of the coastal region.

From (NFPCSP, 2009) it is found that embankments caused deposition of silts in the riverbeds of the tidal rivers. The Kabodak River is one of the burning examples of river siltation and subsequent flooding. This river has become symbol of sufferings of five Upazilas of Jashore and Satkhira districts. From (NFPCSP, 2009), it is also found that another reason behind flow reduction in the Kabodak was the construction of several bridges on the river in many places. Dredging up to 40 km to revive its navigability was done in 2004-05. However, the result did not last for long. Dredging could not solve the problem of siltation since upstream pressure was nil and siltation was a continuous process from downstream during tidal actions.

Most of the rivers carry appreciable amount of suspended sediment load. The inland rivers represent the remaining channels of the old spill or regional rivers, which have lost their connection to the main river Ganges. The Kumar, Nabaganga, Kabadak, Bhairab are good examples of such inland rivers in Khulna division. The inland and regional rivers run into tidal rivers or estuaries. The coastal rivers or estuaries are mainly saline because freshwater discharges are very low, especially in dry season, which is evident is Rupsa river. The flow regimes are driven by high, variable sediment laden flows.

The rivers of this region show a continuous process of siltation gradually from the North-West towards the South-East direction (Tareq, 2016). From (NFPCSP, 2009) it is found that embankments caused deposition of silts in the riverbeds of the tidal rivers. The Kabodak/Betna River (see **Error! Reference source not found.**) is one of the examples of river siltation and subsequent flooding. This river has become symbol of sufferings of five Upazilas of Jashore and Satkhira districts (NFPCSP, 2009). The Kabodak is the tributary of the Bhairab. The Bhairab River already dried due to siltation as an outcome of flow reduction in the Ganges as a result of water withdrawal. Since upstream part of the Bhairab River has died, the Kabodak also now is a nearly dead river with no flushing action as well water pressure from the upstream. But siltation has been continuing for years during high tides. As a consequence, the Kabodak River has been causing flooding in the entire region every year causing suffering of millions of peoples (The Daily, 2009). However, the project areas are not affected by flooding.

3.1.3 Water Use and Pollution Rights

Over the years, the Government of Bangladesh has passed down several legislatives, policies, strategies, national plans on safe drinking water and sanitation. National Policy for Safe Water and Sanitation 1998, the National Water Policy 1999, the National Water Management Plan 2004, National Policy for Arsenic

Mitigation & Implementation Plan, 2004, Pro-Poor Strategy for Water and Sanitation Sector (PPSWSS), 2005, National Sector Development Programme (SDP) for Water Supply and Sanitation (2010), Water Act (2013), Pourashava Act (2009) are such examples of policies and strategies taken by the Government of Bangladesh. The summary of main national policies for safe water and sanitation are presented in Annex-I. The issues of climate change, such as salinity intrusion, extended dry period etc., are also addressed in some of these national policies.

3.2 Findings from Field Assessment

Findings from field assessment (FGD and KII) are summarized in this section. For each Municipality/City Corporation, the key findings in order to assess the climate vulnerability and resilience in WASH are presented. First the identified climate vulnerability in the study areas are presented. Then the current WASH condition in all areas with regard to climate vulnerability are described. Finally, the impact of climatic hazards on water and sanitation is discussed.

3.2.1 Identified Climate Vulnerability

During the field assessment through FGD and KIIs, the respondents were asked about the vulnerability of different climatic hazards in their respective cities. The findings are presented in Table 6 below.

Table 5: Identified effects of different climate effects in study areas

Climate Change Effect	Hazard	Vulnerability (Very Low, Low, Medium, High, Very High)			
		Jashore Municipality	Benapole Municipality	Kushtia Municipality	Khulna City Corporation
Increased cyclone frequency and intensity.	Floods, storm surges and strong winds	Low	Low	Low	Low
Increase of erratic rainfall events (e.g. intense rainfall) during rainy season	Flooding	Very Low	Very Low	Very Low	Very Low
	Water logging	Medium	Low	Low	High
Decrease in seasonal precipitation, April/November precipitation will be limited.	Droughts	Medium	Medium	Medium	Medium
Increase in temperature, especially in March-April, and October	Heat waves	Medium	Medium	Medium	Medium
	Melting and thawing of glaciers & snow in the upstream Ganges-Brahmaputra-Meghna (GBM) Basin resulting in flooding	Low	Low	Low	Low
Seal level rise	Coastal flooding and saline intrusion into freshwater aquifers/rivers	Low	Low	Low	Medium

3.2.2 Water Supply

Water supply system in Jashore Municipality, which is groundwater based, covers 73% of its population in 9 wards. There are 27 Production Tube Wells that is supplying water from 350-450 ft depth to this population without any water treatment plant. Although availability of water remains good throughout the year except in few tube wells in some areas during the extreme drought period, water quality is a concern as concentration of Iron (Fe) and Manganese (Mn) is high in groundwaterin Jashore. Salinity is increasing slightly in few Production Tube Wells, although the concentration is very much within the acceptable limit. Rest of the households (27%) of the Municipality are getting water from private tube wells from 60-70 ft depth.

In Benapole Municipality, water supply is also groundwater based where 2 Production Tube Wells extract water from 750-800 ft depth to supply water to 20-25% people in the city area. Since aquifers within Benapole city area are not suitable for using as drinking water source, the Production Tube Wells are installed at 6-7 km distance from the centre of the Municipality. Rest of the people which is approximately 75-80% of total population of Benapole Municipality get their water from private tube wells which are mainly installed at a depth of 100-200 ft form ground level. Some people also use surface water from Hakor beel for cooking and bathing purposes. It was reported during the field assessment that Iron concentration in groundwater is very high is this area.

Out of 21 wards in Kushtia Municipality, 14 wards are covered by piped water supply system which is groundwater based. 22 Production Tube Wells are functional that extract water from a depth of 350-400 ft in this area. There are Iron Removal Plants which can treat Iron but due to low capacity, large amount of water cannot be treated before supplying to consumers. Presence of Arsenic in water was also reported in groundwater in this area. People who do not get water supply from pipe network use private tube wells.

In Khulna City Corporation, piped water supply coverage is approximately 30%. At present, number of functional Production Tube Well is approximately 85. The depth of screen of these tube wells vary within a range of 800 to 950 ft. Households that are not covered by piped water supply network get water from private tube wells. Shallow tube wells get water from approximately 150-250 ft depth. Leakages in pipe lines are a major problem of the water supply system in Khulna, which increases during rainy season as pressure of water from surroundings is high. Salinity has been found slightly increasing in some Production Tube Wells, especially in ward 1, 2 and 3. The Khulna WASA (KWASA) is implementing a surface water treatment project to increase its water supply coverage which is expected to be in operation in 3 years.

The overall effect of climatic hazards on water supply and the technologies used in the study areas has not been found alarming. Table 7 below presents the current vulnerability of water supply to climate change in study areas.

Table 6: Effect of climate change on water supply

Climate change effect	Hazard relevant to water supply	Vulnerability (Very Low, Low, Medium, High, Very High)			
		Jashore Municipality	Benapole Municipality	Kushtia Municipality	Khulna City Corporation
Increased cyclone frequency and intensity.	Infrastructure affected (e.g., power failure)	Low	Low	Low	Low
Increase of erratic rainfall events (e.g. intense rainfall) during rainy season	Water sources getting inundated due to flooding or water logging	Very Low	Very Low	Very Low	Very Low
Decrease in seasonal precipitation, April/November precipitation will be limited.	Droughts causing groundwater table depletion and water scarcity	Medium	Medium	Medium	Medium
Increase in temperature, especially in March-April, and October	Rise in temperature affecting water quality	Low	Low	Low	Low
	Melting and thawing of glaciers & snow in the upstream Ganges-Brahmaputra-Meghna (GBM) Basin resulting in flooding	Low	Low	Low	Low
Seal level rise	Coastal flooding and saline intrusion into freshwater aquifers	Low	Low	Low	Medium

From Table 7, it can be said that the resilience of current water supply systems to climate change effects in all four cities is very high. Among the identified hazards, groundwater depletion during dry season needs to be given attention as water supply in all four cities is groundwater based. Therefore, the problem might increase in future if the drought period keeps lengthening.

3.2.3 Sanitation

Bangladesh has made significant progress in increasing access to sanitation during the last decade mainly because of dynamic leadership of local government division and coordinated effort of all

stakeholders. However, on site sanitation is the only option irrespective of wealth quintile wherein pit latrines are being used by low income communities. On the other hand, increasing use of on-site sanitation facilities has generated a large demand for faecal sludge management (FSM) to keep the toilets operational. In the absence of effective FSM services, the huge quantities of faecal sludge generated in septic tanks and pits are inaptly managed, disposing the sludge directly in local environment including water bodies, leading to serious environmental degradation.The major concern for sanitation in all four study areas is poor management of fecal sludge in absence of total service chain (safe containment system, proper collection/emptying, transportation, treatment and end use) facilities.

At present, Jashore Municipality has very limited capacity to manage their fecal waste. There is one vacutug of 1,000 L capacity that collects sludge from few households. They are planning to start a city-wide waste management project, which would reduce unsafe disposal of faecal sludge in environment. There are also Vacutugs operating in Khulna City Corporation and Kushtia Municipality in limited capacity which covers a very small percentage of total population. Both of these cities have piloted fecal sludge treatment plant, but due to its limited capacity, fecal sludge from most of the households remain untreated.

Currently around 55% households use pit latrines out of which only 26% are twin pit latrines. Out of 18% of double alternating pits, Y-junction in 80% are not functioning. Presence of soak well is negligible and 7% of the septic tanks are found directly discharging into water bodies. Most of these septic tanks were constructed without following the standard design and hence, are not functioning properly as a septic tank which is supposed to pre-treat the fecal waste up to a level.

Once the septic tanks or pits are full, the common practice is mainly dumping fecal waste in drains/water bodies by manual emptying. There are no waste water treatment hence these drains are connected to surrounding rivers, canals, water bodies or low lying lands. In Jashore, the drains are connected to Bhairab river and Mukteshwari canal, hence fecal waste ends up into these water bodies. It was reported by the informants that this untreated fecal waste has been affecting quality of river water. It also pollutes environment of Jashore Municipality and also of surrounding areas. Both aquaculture and agriculture is affected as quality of water in rivers and canals has deteriorated gradually due to unsafe dumping of fecal waste. During rainy season, the fecal waste causes less pollution in water bodies as it gets diluted with storm water. But during dry period, this pollution is significant and felt by people living around these water bodies.

The wastewater from the drainage systems in Jashore Municpality areas, which contains large amount of fecal waste, drains out mainly to Bhairab river in the east and Mukteshwari canal in the west. Bhairab river that flows through the city has been suffering from siltation and has never been excavated. The river is not getting the flow from Ganges through Padma (upland flow), so sedimentation is happening in the river every year. The Mukteshwari canal also needs dredging. Tidal effect in these rivers/canals is only visible in monsoon, although it does not have any significant effect on the city area. Therefore, fecal waste from Jashore Municipality that ends up in these rivers hardly reaches other surrounding Upazilas due to lack of flow. During monsoon the upstream flow from Padma increases and dilutes fecal waste contamination and hence the effect is not significant on downstream areas.

In Benapole, the Hakor Beel and other low lying areas receives wastewater from drains which contain fecal waste. In Kushtia, the Gorai and Kali rivers and in Khulna, the Bhairab, Mayur and Rupsa rivers receive all wastewater coming through the drains. Since tidal effects are very low in the water bodies in Benapole and Kushtia during dry season, the effect of pollution caused by fecal waste remains within the city area. This concentrated effect poses significant threat to human health during dry season. In rainy season when flow in water bodies increases, this effect of pollution is comparatively less.

In Khulna City Corporation, where all rivers are tidal rivers, the dynamics is different than other areas. During high tides, some parts of the city get inundated due to poor drainage facility. Hence the wastewater in drains spread over roads and lands when river water enters into the city through these drains. Therefore, the untreated fecal waste in drains is not only polluting the rivers/canals when it reaches there, the river water entering into the city through drains also causes pollution as it gets mixed with wastewater in drains. Moreover, when it rains during the high tides, the storm water cannot drain out and causes water logging. As a result, the wastewater spreads over the surrounding areas of the drains and causes inconvenient to city dwellers.

It was reported by local people during the study that another practice is digging holes near in open lands and dumping fecal waste from septic tanks/pits, which is done by local pit emptiers. But this becomes difficult during rainy season as water table rises and digging holes becomes inconvenient for the workers. Moreover, the rate of filling up the septic tanks/pits increases during rainy period. Therefore, the contamination rate during wet seasons increases. It also poses threat to quality of water in shallow aquifers from which still a significant percentage of people gets water from. As static water level during rainy season can be found within 30-40 ft of ground level, the fecal contamination might reach into the shallow aquifers through percolation.

Although flooding is not a problem in the studies areas, water logging causes inconvenience as the drainage systems are not working properly in city areas. Land in some areas have become lower than surrounding areas and also number of ponds/water bodies reduced, therefore water cannot drain out rapidly and takes time to drain out to the outlet Poor solid waste management also clogs the drains and reduces storm water flow through the drains. Water logging becomes severe after sudden intense rainfall, which was reported as a common incident in Khulna City Corporation, and Kushtia and Jashore Municipalities.

Impact on sanitation infrastructures due to climate change events was reported as very low in the study areas. Some latrines get affected during cyclones which are mainly poorly built and in slum areas only.

The overall effect of climatic hazards on sanitation used in the study areas has been found alarming. Table 8 below presents the current vulnerability of sanitation to climate change in study areas.

Table 7: Effect of climate change on sanitation

Climate change effect	Hazard relevant to sanitation	Vulnerability (Very Low, Low, Medium, High, Very High)			
		Jashore Municipality	Benapole Municipality	Kushtia Municipality	Khulna City Corporation

Climate change effect	Hazard relevant to sanitation	Vulnerability (Very Low, Low, Medium, High, Very High)			
		Jashore Municipality	Benapole Municipality	Kushtia Municipality	Khulna City Corporation
Increased cyclone frequency and intensity, rainfall, floods.	Physical damage to sanitation Infrastructure	Low	Low	Low	Low
Flooding due to sea level rise, and heavy rainfall	Septic tanks/pits getting inundated due to flooding or water logging	Low	Very Low	Low	Medium
Decrease in seasonal precipitation, April/November precipitation will be limited.	Shortage of water for sanitation	Very Low	Very Low	Very Low	Very Low

From Table 8 it can be said that the resilience of current sanitation system to climate change effects in all four cities is high, except for the scenario of water logging after intense rainfall which is resulting in spreading of fecal waste from septic tanks/pits into the surrounding areas. Although the climatic effect is not high on sanitation in the study areas, the lack of fecal sludge management in each city is polluting the environment significantly.

4. Conclusion and Recommendation

4.1 Climate Variability

The existing major problems in the WASH sector in Bangladesh arises from population growth, urbanisation, increasing water demand, unsustainable faecal sludge and waste management and a degrading environment in general. This already has a high impact on hydrological processes as well the quality of water in the environment. It is understood from secondary information that the climate change impact will enhance current problems, which is confirmed when talking with people on the ground. However, the impact of this climate change is not uniform everywhere in the country and some areas are more vulnerable than others. In addition, some of the areas have high resilience to climatic hazards than others. In this regard, the study areas were found being less vulnerable to most of the identified climatic hazards and having good resilience, especially against flood. Among the climatic hazards, increase in drought period and change in precipitation pattern was reported to be the major threats in the study areas. Flooding due to sea level rise or melting of glaciers and increase in cyclone frequency/intensity have not been considered as threat. Salinity intrusion due to sea level rise is considered as another major climatic hazard, but only in Khulna City Corporation. However, detailed local data on climate change indicators is difficult to be gathered and rather uncertain.

4.2 Impacts on Water Supply and Sanitation

The water supply system in all four areas is groundwater based (KWASA's surface water treatment plant in Khulna will be commissioned soon) , which is supplied to people by either pipe network or private tube wells. Tube wells (boreholes) were found to be highly resilient to most impacts of climate change on freshwater systems, but were less resilient to issues of saline intrusion resulting from sea-level rise. Saline intrusion from rising sea levels may represent a more long-term problem and drying environments may make shallow tube wells less viable. However, only the water supply system of Khulna City Corporation is considered as vulnerable to the issue of salinity. Although in Jashore, Kushtia and Benapole Municipalities this is not posing any significant threat currently, with the current trend of salinity intrusion, groundwater resources might get affected in future. Sinking deeper tube wells, particularly where these are separated from shallower aquifers by aquicludes in the case of saline intrusion, offers a potential solution but will change the cost-effectiveness of tube wells. Moreover, depletion of groundwater table during drought period increases vulnerability of the water supply system. Because of the rate of rapid urbanization in all the cities, this has been taken into consideration by the authorities.

The sanitation system in urban areas of Bangladesh is mostly septic tank and pit latrine based, with people showing more willingness towards septic tanks. These technologies are becoming more climate resilient with time as people have started to adapt to the changes observed in the past. But in areas of flooding/water logging and groundwater level rise, these technologies are vulnerable to floatation and causing widespread contamination. Flooding/water logging of household premises is also a significant risk when flooding of septic tanks/pits occurs, resulting in significant public health risks to the inhabitants. This problem has been found notable in Khulna City Corporation.

Once the septic tanks or pits are full, the common practice in all study areas found was mainly dumping fecal waste in drains/water bodies or connecting septic tanks to open drains. These drains are connected to surrounding rivers, canals, water bodies or low lying lands. This untreated fecal waste has been affecting quality of river water. Due to the fact that rivers/water bodies in Jashore, Benapole and Kushtia have very low discharge except for the months in full monsoon (June-September), the effect of this pollution remains within the area. In Khulna City Corporation, due to tidal effect, the city areas often get flooded which helps spreading contamination in areas near the drains. It was found during the study that increased and intense precipitation will cause further damage to overall environment due to lack of safe fecal sludge management in all areas, which is the major climatic threat identified with regards to sanitation systems.

4.3 Recommendation

Whether at local, national or international level, an effective response to increase climate change resilience in the drinking water and sanitation sector will include promoting resilient technologies, adapting or updating technical norms and regulations and enhancing management of services. Where reliable safe water and sanitation are not universal it will also imply reviewing policy and management on progressive upgrading of services and reflection on policy targets and their monitoring (Guy Howard, 2010).In the study areas selected for CVR assessment, the reliability of source of water supply need to be assessed. Based on the reliability analysis, further predictions on future impact of current climatic trend can be made. For sanitation system, it is more focused on resilience of technology and its management in the given conditions.

Although the study areas show good resilience to some of the climatic hazards in these areas, there are existing problems which are mostly due to lack of understanding and support, especially in sanitation systems. To overcome these problems, some recommendations can be made.

- Advocacy for using surface water instead of groundwater considering future population growth in the city areas that will increase demand. Suitable sources of surface water need to be identified.
- Introduce climate resilient water safety plan from catchment to consumers to address existing climatic hazards in the water supply systems.
- Advocacy for promoting city-wide fecal sludge management that will stop environmental pollution.
- Public awareness on safe management of fecal waste is needed. In addition, people should be made aware of septic tank guidelines.
- The drainage system should be developed/restored to facilitate rapid drain out of storm water during rainy season and to prevent water logging.
- Lobby and advocacy towards relevant national / regional authorities (departments and ministries) on climate resilience of the WASH SDG programme.

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Annex-I: Water Use and Pollution Rights

National Water Policy, 1999

Bangladesh Government has already formulated a National Water Policy. It has been proclaimed in the introduction of the National Water Policy "...as water is an essential item for human lives, socio-economic development of the country and environmental protection, Government has formulated a policy to adopt necessary strategy and programmes with the aim of management of the water resources of the country on the basis of extensive coordination and equal distribution. The Government has formulated the policy for a continuous march forward in the accomplishments of the overall objectives of economic development, poverty reduction, self-sufficiency in food, public health and security, improvement in the standard of living style of the people and environmental protection."

In a review of the water policy the observation is that the issue of climate change has not been included in the policy. At present it is globally accepted that the temperature is gradually increasing and the seal level is also rising comparatively. Bangladesh would be one of the most vulnerable countries. Especially the South-West region of the country would meet the severest catastrophes. It is feared that the whole region will go under water. This will not only cause scarcity of safe drinking water but also make the environment unfit for human habitation.

It is necessary to look into the relevant sections of The Policy, which are - Sections 4.1 River estuary management, 4.2 Water resources planning and management, 4.3 Water rights and distribution, 4.6 Water supply and health facilities, 4.8 Water and industry, 4.12 Water for environment are related to safe drinking water. Moreover, it is necessary to judge how far the said policy made in the national perspective, how is able to solve the water problem especially in the South-West region.

- **Section 4.1. River Estuary Management:** Special emphasis has been given in this section for solving different problems in the river estuaries of the country. It has also been mentioned that the joint efforts would be taken with the neighboring countries like Myanmar, India, Nepal and China to solve the problems of the river estuaries originating from these countries and flowing through Bangladesh i.e. the Ganges, the Brahmaputra and the Meghna, so that Bangladesh can exercise its due water rights in the dry season and can undertake coordinated efforts for flood control and management. It has been mentioned in section 4.1 (e) that the Government would take necessary steps to control chemical and organic pollution of water in the rivers through joint venture projects with the neighboring countries but there is no hints about the salinity issue. It is clear that increase in the flow of water in the rivers would be substantially decrease salinity in the river water but such actions are only limited to policy books. While the government is saying that construction of Ganges Barrage would reduce salinity in the surface waters of the South West Bangladesh, but that is only limited to the Eastern side of Khulna and Bagherhat district. Moreover, the inter river linking of project of India has already started, but no significant actions has been taken from the government yet

- **Section 4.2. Water resource planning and management:** This is the most important section which contains hopes and aspirations for a solution of all the problems (drought, flood, drainage, river siltation, river erosion, land reclamation from the seas and rivers, damage to lives, properties and infrastructure, preservation of land and water bodies). It mentioned that development efforts would be undertaken through identification of the different hydrological zones in course of the rivers. But still such study to find zones is not yet proceeding in the coastal belt.

- **Section 4.3. Water rights and distribution:** This section proclaims that the ownership of water lies with the state. The state reserves the right to ensure equal distribution of water for skillful development and water use as well as poverty reduction. It has been mentioned in section 4.3 (b) that the Government would take necessary steps for distributing water in the deficit zone on priority basis for domestic and municipal use. The section mentioned about reducing salinity from the river water and salinity management, but nothing mentioned about the salinity problem of drinking water in village areas of South-West part of the country. Additionally, while government is providing almost free water all over the country but in the South West coastal Bangladesh, people are buying water from the technologies provided by the government (RO-Plant). So such inequality in the distribution of water persists.

- **Section 4.6. Water Supply and Health System:** In this section it has been mentioned that there is salinity intrusion into ground water in the coastal zone. The section also contains measures for addressing the problem. Such as sub-section 4.6 (a) includes —provide necessary assistance to ensure supply of safe drinking water through rain water harvesting and 4.6(b) has provision for preservation of natural sources of surface water in major urban areas to maintain the water level and management of rain water. Here rainwater is identified as the only source of fresh water. But other technologies are now available which are much more efficient than rain water harvesting. Besides, the section only talks about managing and preserving natural resources to ensure potable water only for urban areas whereas the majority of the population lives in the rural areas. This again contradicts with other sections of the policy and even with other policies where it says that Water is a basic human need and state should supply water to everyone without any discrimination.

- **Section 4.8. Water and Industry:** In this section we could observe that the excessive salinity in the water is a main obstacle to industrial growth in the South-West region. But it is surprising to note that the section includes various steps to control water contamination but the salinity issue has not got the same importance respectively.

- **Section 4.12. Water for Environment:** From this section we can quote —it is very important to protect the environment and its bio-diversity and the regenerative process under the national water resource development and management. The problems of salinity increased in agricultural land and the environmental problem for salinity intrusion have been duly mentioned in this section. But the sub-section 4.12 Includes measures for water flow from the upper stream to maintain environmental balance in the coastal rivers and sub-section 4.12 (d) includes measures for protection of the lakes, ponds, wetlands, canals, reservoirs etc from environmental degradation and revival of its effectiveness. But contradictory policies for example leasing out fresh water reservoirs for shrimp cultivation has resulted in improper implementation of policy. Besides, no such actions to control ground water salinity have been mentioned here.

In the backdrop of the above review, it may be concluded that, the National Water Policy has not appropriately included the effective measures to address the safe drinking water problem making situation much more challenging for the inhabitants of the South-West coastal region. The policy has clearly undermined the salinity problems and till to date no amendment has been done considering salinity. To add on, climate change is now also a much bigger factor which requires immediate attention. While the policy clearly states measures for urban areas but rural areas have been ignored completely showing that state promotes inequality for drinking water.

National Safe Water Supply and Sanitation Policy

The salinity issue was not properly incorporated in the National Water Policy. Just like the National Water Policy, the issue of salinity was also ignored here as well. In the Basic Needs section it has been mentioned —it is necessary to improve the water supply and sanitation services in order to meet the basic needs of the citizens. The basic need of the people of the South-West region is saline-free drinking water. Although the policy contains provisions for supply of safe drinking water it has not properly incorporated in any place of the policy the issue of saline-free drinking water supply.

Regarding technology options the policy states —the process of technological development will continue for water supply and sanitation according to the specific local needs‖. The policy does not specify any technological options for supply of saline-free drinking water and how the specific needs of the people of the South-West region would be met

Under the investment sections of the policy it is stated, —it is necessary to identify the weakness on emergency basis‖. Not efforts have been taken in the past to discover or develop sources of safe drinking water. So it can be said for sure that none of major objectives of the National Water Policy or the National Water Management Plan would succeed due to lack of proper guidelines in these documents.

Under the section 8.1.2 the policy states —Local government bodies in village, Union and Upazila level shall have a direct role in planning, implementation and maintenance of rural water supply. Through this section the policy gave the responsibility of maintenance of rural water supply to the local government but again in the section 8.1.4 it states —User communities shall be responsible for operation and maintenance of water supply facilities and shall bear its total costs‖ Here a contradiction is created about who is actually responsible for maintaining the water options. Field visits suggest that there is no involvement of local government in maintaining the water options. Local people are maintaining it even though sometimes it becomes a burden for them. The options that are not being maintained properly are becoming unusable within a few years. Countless water option can be found in the South West coastal areas which are currently dysfunctional due to lack of maintenance.

Under the section 8.1.11 the policy states —In each and every village of Bangladesh at least one pond will be excavated/re-excavated and preserved for drinking water. Necessary security measures will be undertaken to prevent water of the pond from contamination. But the government did not even care about such policies in the past. It leased out the reserve ponds for fresh water sources in almost all villages across the South West Bangladesh to shrimp farmers to boost up and promote shrimp farming. The results are catastrophic as now we can see find larges areas without any fresh water ponds.

National Strategy for Water and Sanitation for Hard to Reach Areas

The strategy for the first time developed a strategic framework for the coastal region of Bangladesh particularly the areas affected by high salinity and for which due credit should be given to government. The strategy discussed about the problems that the local people face regarding their access to safe

drinking water, provided immediate and sustainable solution and also discussed about who and how a project will be implemented. These specific detailing out of the overall situations and solutions for the coastal region in particular saline water affected regions were laid out which will remain as a bench mark in ensuring fresh drinking water supply to around 20 million people living in the region. The coastal people hopes that their long demand and struggle for drinking water will end through successful implementation of these strategies and they are very grateful to the government of Bangladesh.

When this strategy is critically analyzed in the context of South West coastal region, some gaps can be spotted which acts as hurdles in ensuring safe drinking water for the coastal people. In section 6.2.1 of the strategy under Strategies for Sustainable Solution it stated —Construction of reinforced houses in clusters on raised grounds along with individual or community type drinking water and sanitation infrastructures.‖ First of all, because of the land ownership pattern of the local area, People will not leave their own properties to live in cluster. Besides people who owns land in relatively raised ground will not accept others to reside on their land. Thus, this strategy will lead to unrest in the locality.

Under the same section the concerned strategy also stated "Constructing desalination plants and rainwater harvesting with underground reservoirs to be located on highlands e.g., cyclone shelters, schools, madrassas, office buildings, market places etc for community water supply." Both desalination plants and rainwater harvesting systems require high installation costs and involve regular high maintenance cost. The strategy paper under the same section in Design and Implementation states that "DPHE, LGED, Disaster Management Bureau and NGOs will provide technical assistance in design and installation of facilities while concerned LGI with effective participation of the community will implement." There are no clear guidelines about who will maintain or repair such expensive systems once they are installed. Over the years it has been found in the local area that, such expensive mechanisms stop working within a year or two of when the project ends. It is true that using rain water to recharge ground water is a new and innovative technology but it is very recent concept and yet to face any difficulties. Moreover, rain water harvesting systems for individuals is not highly accepted in places where other water options are available, even though those options are little far away from their households. Besides, families which are very poor cannot sustain rainwater harvesting system for long. So clearly, such expensive, untested and socially unacceptable systems will not certainly become sustainable solutions.

The sustainable solutions will only be installed in highlands. But most of the South West coastal regions are basically low land areas where tidal actions take place. A higher percentage of pro poor people live in these low lying tidal flood plains. Then clearly these people will be excluded from such sustainable solutions. Besides, people who reside far from the installation points will still have to travel a long way every day just to collect daily water. So the problems of the mass community will still remain with only few people getting the service.

The immediate solutions under the same sector stated that —tube wells with appropriate treatment units for arsenic, iron or salinity removal, desalination plants for treating saline surface water, rain water harvesting, PSFs with raised and lined ponds are 13 recommended drinking water technologies for application in coastal areas.‖ Understanding the local context, these options would be more sustainable, considering that their maintenance costs are very less and are socially acceptable among the people. Moreover, in the local area, it can be observed that collecting water from desalination plants and rainwater harvesting systems requires some money.

Water Act (2013)

The recently published Water Act 2013 is based on the National Water Policy, and designed for integrated development, management, extraction, distribution, usage, protection and conservation of water resources in Bangladesh.

As per this Act, all forms of water (e.g., surface water, ground water, sea water, rain water and atmospheric water) within the territory of Bangladesh belong to the government on behalf of the people. The private landowners will be able to use the surface water inside their property for all purposes in accordance with the Act. A worthwhile initiative is the requirement for permits/licenses for large scale water withdrawal by individuals and organizations beyond domestic use. Without prior permission issued by the Executive Committee, no individuals or organizations will be allowed to extract, distribute, use, develop, protect, and conserve water resources, nor they will be allowed to build any structure that impede the natural flow of rivers and creeks. However, the maximum amount of surface water or groundwater that can be withdrawn by individuals or organizations is not mentioned in the Act. Setting up a priority order for water usage in an area where the water resources is in critical condition is also a significant step. The priority order as depicted in the Act is as follows: drinking water>domestic usage>irrigation>fish culture> bio-diversity>wildlife>in-stream flow>industry>salinity control>power generation>recreation>miscellaneous. It should be noted that only drinking water and domestic usage are considered as basic rights.

In view of water resources protection and conservation, the Act adopted a timely decision to address the water needs in irrigation and urban areas in the context of available surface water, groundwater, and rainwater. The situation of drinking water supply in Dhaka City is a good example in this context. For instance, Dhaka City annually receives about 2000 mm of precipitation, of which about 80% occurs during the rainy season. If the rainwater is harvested and distributed after proper treatment then the water needs during this time period can easily be met

The need for water resources management in the context of natural drainage pattern has also been highlighted in the Act. Management of water resources within the territory of the country in rivers, creeks, reservoirs, flood flow zone, and wetlands has been assigned to the Executive Committee under the Ministry of Water Resources, which is another noteworthy decision. Draining of wetlands that support migratory birds has been prohibited by the Act. Consequently, without prior permission from the Executive Committee, building of any structure that can impede the natural flow of water has been prohibited; however a few activities, including dredging of rivers for maintaining navigability, land reclamation projects by filling wetlands, flood control and erosion control structures will be exempted pending prior permission. It is not clear as to how or if the government will address the issue of land grabbing and encroachment that are clear impediment to natural flow in the flood flow zone, wetlands, and foreshore of rivers.

The Act provides provisions for punishment and financial penalty for non-compliance with the Act, including negligence to abide by government policy, ordinance, non-cooperation with government officials, refusal to present necessary documents, providing false information, affiliation with perpetrators, and protection measures for water resources management. The maximum penalty for violations is set to five years of imprisonment and/or monetary penalty of Tk.10, 000. The amount of monetary penalty was set to be Tk. 500,000 in the draft proposal of the Act in 2012. This drastic

reduction in monetary penalty may encourage many people to pay the penalty instead of abiding by the law. Punishment related to water quality degradation caused by industrial discharge and other sources of pollution is not adequately addressed in the Act. Water pollution issues are deferred to the provisions of the Environmental Protection Act of 1995 without much clarification. The Act remains nebulous without a clear commitment by the government to ensure the quality of water for various beneficial uses as outlined in the Environmental Protection Act. The Act does not address the need for establishing effluent treatment plants or the maximum contaminant levels that will be allowed for discharge to receiving bodies of water by industries and other potential sources of pollution.

No court can accept any law suit under the provision of this Act without a written complaint from the Director General of Water Resources Planning Organization or his appointee, which is a severe drawback of this Act. Although the Act is formulated to protect the quality and quantity of the water resources that belong to the people, no individual or organization will be allowed to file a law suit against other individuals, organizations, or government authority if even they violate various provisions of the Act. The Act provides unlimited power to the Executive Committee to take any action that they deem necessary to implement various provisions of the Act. This Act also exempts the government authority of any violation, non-compliance, negligence, wrongfully causing financial damage to individuals or organizations, and/or avoidance to implement this Act in the name of good faith. Limitless power of the Executive Committee without any provision for check against such power may lead to wrong-doing and anarchy. Although an accused will be allowed to defend oneself in the court, there is no clear provision to appeal against any judgment given out by a court.

In summary, the Act recognizes the significance for managing all forms of water resources in the context of natural flow of surface water and recharge of groundwater. The Act provides the legal framework for development, management, extraction, distribution, usage, protection, and conservation of water resources. However, the Act falls short in making a commitment by the government to ensure the quality of water for various beneficial uses. The lack of clear directives that will facilitate recovery of the flood flow zone by evicting land grabbers and encroachers remains as a serious weakness of the Act. The unlimited power vested upon the Executive Committee without any liability has the potential for misuse of the Act.

Paurashava Act, 2009

According to Sub-clause (2) of Clause 50 of the Local Government (Paurashava) Act, 2009 (amended in 2010) (hereinafter referred to as "Paurashava Act 2009"), Paurashava shall be responsible for, among others, (a) Water supply for residential, industrial and commercial use; (b) Water and sanitation; and (c) Waste management, in areas within its jurisdiction.

According to Schedule 2 of Paurashava Act 2009, which describes the detail functions of the Paurashava, "A Paurashava shall make adequate arrangements for the removal of refuse from all public streets, public latrines, urinals, drains, and all buildings and land vested in the municipality and for the collection and proper disposal of such refuse". A Municipality is also responsible for public toilets and according to Schedule 2 of the Paurashava Act 2009, "A municipality shall provide and maintain, in sufficient number and in proper condition, public latrines and urinals for both male and female users, and shall make arrangements for proper maintenance of these facilities and keep them clean".

Thus, although the term "faecal sludge" is not specifically mentioned in the Paurashava Act 2009

(primarily because this term was not widely used at that time), it is clear that the responsibility of management of "faecal sludge" [referred to in the Paurashava Act as "refuse" accumulated in "public toilets, urinals, drains and all buildings and land"] lies with the Municipality.

It is also clear that the Municipality shall perform these responsibilities in accordance with the provisions of the Paurashava Act 2009. However, for proper management of faecal sludge, if the Municipality deems it necessary, it could formulate necessary "rules", "regulations" and "by-laws" according to the provisions described in Schedule 6, Schedule 7, and Schedule 8, respectively, of the Act 2009.

For example, according to Schedule 8 of the Paurashava Act 2009, sub-act could be formulated, among others, "For the purpose of health system management, inspection of lands and households; cleaning and disposal of waste by house owner; installation of public and private toilets and urinals, maintenance and visit; responsibility of the public regarding health system, and providing license to the sweeper".

Annex-II: Assessment Questions

Table 9: Assessment questions used in the FGD and KII sessions

Section 1: Assessing current vulnerability	
Q. No.	**Question**
Q. 1	What is the status of present water supply system (Technologies, Coverage, etc.)?
Q. 2	What is the status of present sanitation system (Technologies, Coverage, etc.)?
Q. 3	What are the major rivers and water bodies in the area and what kind of up/downstream interaction is present? How this interaction is affecting WASH?
Q. 4	What are the climate change impacts in the study areas and how it is linked to WASH?
Q. 5	What is current vulnerability of water supply and sanitation facilities in the study area to climate change?
Q. 6	What are the climate change impacts on existing water and sanitation facilities in different seasons and how climate change makes it vulnerable considering the climate variability?
Q. 7	What are the impacts of climate change on WASH infrastructure in study area?
Q. 8	Who are the most affected groups in terms of WASH in the study area?
Section 2: Assessing future climate risks and vulnerability	
Q. 9	How sanitation system and water availability will be affected by climate change in future in study area?
Q. 10	How WASH infrastructure will be affected in study area?
Q. 11	How river systems will be affected in study area and how this will affect the WASH services?
Section 3: Identifying adaptation measures	
Q. 12	What should be the adaptation measures to reduce impact of CC on WASH?