



Climate Change Vulnerability of Drinking Water Supply Infrastructure in Coastal Areas of Bangladesh



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Abbreviations

ADB	Asian Development Bank
APEC	Asia-Pacific Economic Cooperation
ASR	Aquifer Storage and Recovery
BBS	Bangladesh Bureau of Statistics
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BHWDB	Bangladesh Haor and Wetland Development Board
BMD	Bangladesh Meteorological Department
BMPs	Best Management Practices
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CANSA	Climate Action Network South Asia
CEGIS	Center for Environmental and Geographic Information Services
CL	Cluster Latrine
COP	Conference of the Parties
CSD	The United Nations Commission on Sustainable Development
CZ	Coastal Zone
DPHE	Department of Public Health Engineering
ESCAP	Economic and Social Commission for Asia and the Pacific
GCM	General Circulation Model
GFS	Gravity Feed System
GHG	Greenhouse Gas
GoB	Government of Bangladesh
HTW	Hand Tube Well
HYSAWA	Hygiene Sanitation and Water Supply
IPCC	Intergovernmental Panel on Climate Change
IMF	International Monetary Fund
IUCN	International Union for Conservation of Nature and Natural Resources
IWA	International Water Association
IWFM	Institute of Water and Flood Management
JICA	Japan International Cooperation Agency
JMP	Joint Monitoring Programme
MDG	Millennium Development Goal
MICS	Multiple Indicator Cluster Survey
MOEF	Ministry of Environment and Forest
NAPA	National Adaptation Programme of Action
NGO	Non-Governmental Organization
NPSWSS	National Policy for Safe Water Supply and Sanitation
NWMP	National Water Management Plan
NWP	National Water Policy
OPP	Outline Perspective Plan
PPT	Parts Per Trillion
PSF	Pond Sand Filter
RCC	Reinforced Concrete
RCM	Regional Climate Model
RHS	Rainwater Harvesting Scheme
RO	Reverse Osmosis
RW	Ring Well
RWHS	Rain Water Harvesting
SAARC	South Asian Association for Regional Cooperation

SLR	Sea Level Rise
SMA	Statistical Metropolitan Area
SST	Sea Surface Temperature
STW	Shallow Tube Well
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
VIP	Ventilated Improved Pit
VSST	Very Shrouded Shallow Tubewell
WASA	Water Supply and Sewerage Authority
WATSAN	Water Supply and Sanitation
WB	World Bank
WTO	World Trade Organization
WHO	World Health Organization
WSSD	World Summit on Sustainable Development
WSUD	Water Sensitive Urban Design



Chapter 1

Introduction

1.1. Background

Bangladesh is regarded as the most vulnerable country in the world in terms of climate change impact. As such negotiations under UNFCCC process is of utmost importance for the country. Since negotiations at global level is based on facts, projections, economics, arguments, delicate politics, and emotions; so, it is important to produce facts and figures, forecasts, economic implication that would be helpful to support the negotiators of the country to present her case and obtain maximum benefit for the country.

IUCN, Bangladesh Country Office has received a grant from DFID (Department for International Development) to support the Ministry of Environment of Forests in climate change negotiation under project titled “Support to Bangladesh on Climate Change Negotiation and Knowledge management on various stream of UNFCCC process”. One of the objectives of the project is to generate information and support knowledge management in various tracks on climate change negotiation under UNFCCC. The project identified infrastructure as one of the knowledge management issues. The present study is focused only on safe drinking water supply infrastructure considering the importance of the issue and is limited to the coastal zone, one of the hotspots of Bangladesh. The study assessed the current status of drinking water availability, its vulnerability to natural and socio-economic hazards and future threats due to climate change. It also identified the possible adaptation measures and proposed possible investment programs and an institutional framework to make the adaptation part of development process.

1.1.1 Water Usage in Bangladesh

Rivers cover 8% and waterbodies including beels, haors and ponds cover 7% of the total area of Bangladesh. The estimated landuse coverage by 2025 in agriculture, forest, mangrove, urban and rural areas are 47%, 17%, 4%, 9% and 6% area (WARPO, 2004a). Water is used in different sectors where 50% demand is met from ground water and 50% from surface water (WARPO, 2004a). Domestic water demand is the basic human need. The per capita consumption varies from 100 to 350 l/c per day depending on the economic status (WARPO, 2004a). The projected gross domestic demand of water supply by 2025 for SMAs, other towns and rural areas are 167 l/c per day, 136 l/c per day and 112 l/c per day respectively (WARPO, 2004b). The gross commercial and industrial demand by the year 2025 is 35 l/c per day for SMAs and 30 l/c per day for towns (WARPO, 2004b).

Mostly river water is used for irrigation in certain regions as well as for processing. Groundwater is used where surface water is not accessible. The estimated evaporative demand of agriculture is 28,483 Mm³ for the year of 2025 (WARPO, 2004b). Rivers act as a piscine environment. Through regular flooding, standing waters

are restocked and gene pools kept adequately diversified. Rivers, ponds and lakes are potential sources for capture fisheries. The evaporative demand for the fisheries is 2,804 Mm³ (WARPO, 2004b). Environmental components include physical environment, wetlands and the brackish margins. Physical environment refers to several threatened and/or important species, as well as every living thing that lives in or drinks freshwater. Apart from the rivers and ponds, Bangladesh has other special type of wetlands such as Haors, Baors and Beels. For maintaining the wetlands both water quantity and quality like depths and drainage rates are vital. Tropical brackish margins support biomes that are essential to extensive marine food chains, such as that represented by the Bay of Bengal's rich fisheries. Environmental demands are taken to be those from rivers, urban, rural and other land types. The evaporative demand for the environment is 356 Mm³ (WARPO, 2004b).

1.1.2 Safe Coverage of Drinking Water Supply

The importance of safe drinking water has been reflected in the outcomes of a series of international policy forums, as well as the Millennium Development Goals adopted by the General Assembly of the United Nations (UN) in 2000 and the outcome of the Johannesburg World Summit for Sustainable Development in 2002. The UN General Assembly declared the period from 2005 to 2015 as the International Decade for Action, "Water for Life". Most recently, the UN General Assembly declared safe and clean drinking-water and sanitation a human right essential to the full enjoyment of life and all other human rights.

Safe or improved drinking water source is defined as one that, by nature of its construction or through active intervention, is protected from outside contamination, in particular from contamination with fecal matter. The WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) uses the following classification to differentiate between "improved" and "unimproved" drinking-water sources¹.

Improved Drinking Water	Unimproved Drinking Water
Use of <ul style="list-style-type: none"> • Piped water into dwelling, plot or yard • Piped water into neighbor's plot • Public tap/standpipe • Tubewell/borehole • Protected dug well • Protected spring • Rainwater 	<ul style="list-style-type: none"> • Unprotected dug well • Unprotected spring • Small cart with tank/drum • Tanker truck • Surface water (river, dam, lake, pond, stream, channel, irrigation channel) • Bottled water²

The MDG target (under MDG goal 7) set for drinking water and sanitation for Bangladesh, aims to halve by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation. Bangladesh has achieved some progress in MDG targets. The percentage of population using improved sources of water is 97.8% which is similar to the 97.6% found in 2006. In urban areas, the rate is 99.5%, which is marginally higher than the 97.4% found in rural areas. However, these figures are not reflective of arsenic contamination. The picture reverses if arsenic contamination is considered. Considering arsenic contamination, the proportion of the population using an improved drinking water source is 85.5% (93.3% in urban and 83.8% in rural areas) following the Bangladesh national standard of less than 50 micrograms of arsenic per litre. Using the WHO guideline for arsenic, of less than 10 micrograms per litre, 75.2% of the population uses improved drinking water source where 85.3% is in urban and 73% is in rural areas. (BBS, 2009)

The UN Coverage estimates on Access to Drinking Water and Sanitation Data Sheet on Bangladesh, has projected that by 2015 about 89% population will be using improved drinking water sources. However, the attainment of the MDG target in Bangladesh will be seriously challenged by climate change. Shortage of safe drinking water is likely to become more pronounced, especially in the coastal belt and in drought-prone areas in the

1 Data sheet, Bangladesh: UN Coverage estimates on Access to drinking water and sanitation

2 Bottled water is considered to be improved only when the household uses water from another improved source for cooking and personal hygiene; where this information is not available, bottled water is classified on a case-by- case basis

north-west of the country. This will impose hardship on women and children, who are responsible for collecting drinking water for their families. Increasingly saline drinking water may also result in health hazards. Climate change is likely to adversely affect women more than men. Access to drinking water, which is already a huge problem in parts of the country, is likely to get worse due to climate change in areas with saline surface and groundwater, drought-prone areas. In Bangladesh, the increasing prevalence of droughts will adversely affect availability of surface water and drinking water from hand tubewells and will require investment in deep set ground water technologies, conservation of water and rainfall harvesting, in some regions. Also, in the coastal zone, as sea level rises, salinity will move inland making safe drinking availability a big challenge. Urban areas are likely to be especially vulnerable to reduced surface and groundwater availability.

There is a need to monitor the availability of drinking water (both quantity and quality) and to develop strategies to increase supplies of drinking water and to provide improved sanitation services, as climate change becomes evident. In the meantime, every effort should be made to ensure that people currently living in drought-prone and saline affected areas are provided with adequate services (BCCSAP, 2009). Access to safe drinking-water is not only a basic human right but also important as a health and development issue at national, regional and local levels. Hence access to safe drinking-water is an essential component of effective policy for protection of health.

1.2 Importance of the Current Study

Several projects have been implemented with the support of development partners in the country to improve safe water supply, some projects are also under implementation. Most notables are DANIDA, ADB and World Bank funded projects. Water Supply and Sanitation Sector Programme Support (WSSPS-II) has developed a Climate Management Plan for Water Supply and Sanitation Sector of Bangladesh. Recently, the Asian Development Bank has conducted a study on water sector infrastructure of Khulna city. The World Bank in a study tried to estimate costs for adaptation in Bangladesh.

The past studies did not make any estimation of future adaptation costs related absolutely for drinking water supply infrastructure in particular. In this regard this study has important implication for strategic adaptation to climate change in the water supply and sanitation sector by fulfilling the following objectives:

- I. Generate an updated information of drinking water supply infrastructures in rural and urban coastal areas of Bangladesh with a projection of future domestic demand;
- II. Generate information on current state of damage to drinking water supply infrastructure due to climatic or salinity issues in coastal districts;
- III. Assess existing and suitable technologies for adaptation to climate change impacts;
- IV. Assess the economic costs associated with adaptation for safe drinking water infrastructure; and
- V. Identify possible funding mechanisms for safe drinking water infrastructure development.



Chapter 2

Situation Analysis of Safe Drinking Water Infrastructure

2.1 Coastal Areas of Bangladesh

The study covers the coastal zone situated in the southern part of Bangladesh which is one of the hotspots of the country due to climate change. Coastal zone refers to the area where the land and sea meets. Bangladesh has a 710 km long coastline. About 62% of land has an elevation less than 3m and 86% less than 5m. Under the Integrated Coastal Zone Management Project (ICZMP), 19 districts have been identified as the coastal districts. These districts have been further divided into exposed (7 districts) and interior (12 districts) zones regarding distance from the coast or the estuaries. Delineation of the coastal zone was done based on three distinctive features which are: tidal fluctuations; salinity condition in both surface and ground water; and risks of cyclone and storm surge.

The coastal zone extends over 47150 sq km area and has a population of 3,85,17,698 (BBS 2011). The zone is characterised by vast network of rivers and channels, enormous discharge of water with huge amount of sediments, many islands, the Swatch of No Ground, shallow northern Bay of Bengal, strong tidal influence and wind actions, tropical cyclones and storm surges. The coastal zone is comprised of 10 agro-ecological zones. The distribution of land type in the zone are highland (15%), medium highland (67%), medium low land (14%) and low land (4%). (Islam, 2004)

2.2 Drinking Water Supply Infrastructures of Coastal Areas

2.2.1 Availability of improved water sources

Overall, the rate of population using improved drinking water source currently is 97.8% which is similar to the 97.6% found in 2006. In urban areas, the rate is 99.5%, which is marginally higher than the 97.4% found in rural areas. However, these figures are not reflective of arsenic contamination. At the division level, the percentage of improved water source ranges from 91.6 in Sylhet to 99.6% in Dhaka. At the district level, it ranged from 66.5 in Rangamati to 100% in Gazipur. (BBS, 2009)

Most of the households have tubewell connections. On an average 87% households have connection to tap water and 4% households use tubewell as main source of drinking water. The rest of the households use other sources of water such as bottled water, pond sand filter, rainwater, spring or well.

People are highly dependent on tube well water with more than 75% households using this source. Tap water is used in 25% of the households. Use of other sources of water is mainly observed in Lakshmpur, Noakhali, Chittagong and Cox's Bazar districts of the coastal zone. In the Sundarbans 25-50% households have tubewell water, 5-25% households have tap water and 25-75% households use other sources.

2.2.2 Arsenic contaminated water sources

Arsenic contamination in groundwater is a part of environmental degradation and has important implication for the water supply sector in Bangladesh. Considering arsenic contamination, the proportion of the population using an improved drinking water source is 85.5% (93.3% in urban and 83.8% in rural areas) following the Bangladesh national standard of less than 50 micrograms of arsenic per litre. Using the WHO guideline for arsenic of less than 10 micrograms per litre, 75.2% of the population uses improved drinking water source where 85.3 % is in urban and 73 % is in rural areas. (BBS, 2009)

The acceptable level of arsenic content according to the Bangladesh standard is less than 50 micrograms per litre, while the World Health Organization (WHO) set the acceptable limit of less than 10 micrograms per litre. Overall, arsenic content in drinking water of 12.6% (6.2% in urban and 14% in rural areas) households exceeded the Bangladesh standard. However, considering the WHO's guideline, arsenic content in drinking water of 23.1% (14.3% in urban and 25.1% in rural areas) households exceeded the standard value of 10 micrograms. Most contaminated with arsenic is 3.3% (1.4% in urban and 3.5% in rural areas) of households with arsenic content higher than 200 ppb. (BBS, 2009; JICA 2010)

The south west part of the coastal region is the most affected due to arsenic contamination. By GoB standard, the Gopalganj district has very high (>45%) and Jessore, Satkhira, Narail, Chandpur, Noakhali and Feni have high (25-45%) contamination. The situation seems much worse if WHO standard is applied, where most of the south west and south east region is highly affected.

Awareness about contamination can make people use alternative safe water thereby preventing them from diseases like arsenicosis. Knowledge of arsenic awareness has decreased indicating that lower number of tubewells has been tested for checking of arsenic content till 2006. The MICS found that only 40 % of household members were aware about the testing of their tube-wells and the results. However, 7.1 % of household members although knew of the testing but did not have the results. 44 % of household members were aware that no testing has been done of their water sources. Some 9.2 % of household members had no idea whether there have been any testing done or not on their water sources. (BBS, 2009)

2.3 Vulnerabilities from Natural Hazards

Bangladesh is affected with hazards of different types such as flood (river flood and flash flood), drought, cyclone, storm surge, erosion, salinity intrusion, earthquake etc. The occurrence, extent and intensity of these hazards vary from region to region of the country. The following map shows the multiple hazards map for the entire country. Also the multiple hazard map of the coastal region has been shown. For the assessment of vulnerabilities the hazards that have been considered are: flood, riverbank erosion, salinity intrusion, drought, cyclone and storm surge.

The coastal morphology influences the propagation of storm surges. Inundation due to flooding and storm surge differs based on the land elevation and surface form. In the last 200 years more than 70 cyclones have hit the coast damaging life and properties. Erosion is visible only in the estuaries where new land is also formed due to the accretion process. Regarding rainfall availability, there are some areas that have very little rainfall termed as 'Rainfall stressed areas'. This low amount of rainfall along with salinity intrusion will reduce the freshwater flow endangering the sustenance of ecosystem. Salinity ingress is another major problem for the coastal zone which leads to change in biodiversity, agricultural practices, forest species change etc and most importantly contaminating the drinking water.

Floods:

Bangladesh is one of the most flood prone countries in the world. Due to its location in the deltaic floodplains of Himalayan rivers, heavy monsoon rainfall associated with a low floodplain gradient, congested drainage channels and tidal flow and storm surges in coastal area causes severe floods in Bangladesh. Flood is a

concurrent phenomenon in Bangladesh. Normally catastrophic flood occurs after a certain period. Bangladesh has experienced severe floods in 1954, 1955, 1961, 1962, 1968, 1969, 1970, 1971, 1974, 1984, 1987, 1988, 1998, 2004 and 2007. During the last 50 years, at least 6 serious floods occurred, affecting 35-75% of the land area. The devastating floods in 1987, 1988 and 1998 inundated more than 60% of the country. The 1998 floods alone caused 1,100 deaths, flooded nearly 100,000 sq km, and rendered 30 million people homeless. Any severe flood cause immense human suffering as well as a serious adverse impact on the national economy. In the coastal zone 9 out of the 19 districts are under flood risk coverage of more than 50% in which the most vulnerable are Barisal, Chandpur, Gopalganj, Jhalokati, Narail, Pirojpur and Shariatpur districts.

Table 2.1: District wise Flooding Coverage in the Coastal Zone

Districts	F3 area (in sq.km)	F4 area (in sq.km)	F3 area (in %)	F4 area (in %)	F3 and F4 area (in %)
Bagerhat	279.72	1680.91	7.08	42.57	50
Barguna	188.40	79.35	12.41	5.23	18
Barisal	111.53	1916.84	4.48	76.99	81
Bhola	188.90	638.29	5.95	20.10	26
Chandpur	4.67	1386.00	0.28	81.63	82
Gopalganj	10.25	1433.94	0.69	97.23	98
Jessore	58.53	1407.72	2.27	54.50	57
Jhalokati	153.10	502.61	20.75	68.13	89
Khulna	85.17	1125.94	2.03	26.78	29
Lakshmipur	114.21	245.16	7.33	15.74	23
Narail	2.34	951.93	0.24	95.67	96
Patuakhali	268.62	891.33	8.50	28.21	37
Pirojpur	67.85	1038.77	5.34	81.68	87
Shariatpur	0.37	1001.39	0.03	80.05	80

Riverbank Erosion:

Riverbank erosion is one of the major natural disasters of Bangladesh. The total land eroded along both banks of the Jamuna was 1,800 ha in 2008. The erosion rate along Jamuna is 2000 ha per year where more than 20,000 people are permanently displaced every year. The hazard vulnerability assessment of erosion in the ECZ has taken into consideration both riverbank erosion and shoreline erosion affected areas. The erosion process in the right bank of Padma River, Ganges River and the lower Meghna River and also the erosion along the coastline specially the Chars (small islands) has been considered. Currently, there are 9 districts that are erosion prone with Bhola, Chandpur and Shariatpur districts having more than 10% of erosion prone areas.

Table 2.2: Districtwise Erosion Prone Area in the Coastal Zone

Districts	Erosion prone area (in sq.km)	% of erosion
Barisal	164.56	6.61
Bhola	353.30	11.13
Chandpur	182.70	10.76
Chittagong	69.14	1.39
Feni	10.52	1.13

Districts	Erosion prone area (in sq.km)	% of erosion
Lakshmipur	115.11	7.39
Noakhali	163.56	5.19
Patuakhali	122.41	3.87
Shariatpur	130.10	10.40

Cyclone and Storm Surge:

Among the countries affected by tropical cyclones, Bangladesh is one of the worst sufferers because of the huge number of deaths. For example during the cyclone of 1970 and 1991, the number of people who died is 5 lakh and 1 lakh 39 thousand respectively. Cyclone Sidr one of the strongest cyclones in the Bay of Bengal made landfall in Bangladesh on November 15, 2007. The storm caused large-scale evacuations and 3,200 deaths. The total estimated amount of damage and loss is BDT 115,600 million (US\$ 1,675 million). The fourth named storm of the 2007 North Indian Ocean cyclone season, Sidr formed in the central Bay of Bengal, and quickly strengthened to reach peak 1-minute sustained winds of 260 km/h (160 m/h).

In the coastal zone, half of the area is threatened with cyclonic storm surge. Around 45% area and 4% area are threatened by storm surge of more than 1 metre and less than 1 metre height respectively. The table below shows the risk areas of possible inundation due to storm surge. There are 13 districts which are vulnerable to storm surge of more than 1 metre namely Bagerhat, Barguna, Barisal, Bhola, Chittagong, Cox's Bazar, Feni, Jhalokhati, Khulna, Lakshmipur, Noakhali, Patuakhali, and Pirojpur districts. Again, for a storm surge of less than 1 metre, the districts at risk are Bagerhat, Barisal, Khulna, Lakshmipur and Pirojpur.

Table 2.3: Districtwise Storm Surge Risk Area in the Coastal Zone

Districts	Area (in sq . km) with Storm Surge >1m	Area (in sq . km) with Storm Surge <1m	Area (in %) with Storm Surge >1m	Area (in %) with Storm Surge <1m
Bagerhat	2271.58	399.17	57.52	10.11
Barguna	1287.30	0.00	84.82	0.00
Barisal	1512.30	259.65	60.74	10.43
Bhola	1819.84	0.00	57.31	0.00
Chandpur	86.60	7.55	5.10	0.44
Chittagong	1723.62	0.00	34.58	0.00
Cox's Bazar	742.29	0.00	32.78	0.00
Feni	685.63	0.00	73.44	0.00
Jhalokati	693.57	11.43	94.02	1.55
Khulna	1340.51	522.33	31.89	12.42
Lakshmipur	905.78	108.55	58.15	6.97
Noakhali	2480.69	72.87	78.76	2.31
Patuakhali	2418.29	0.00	76.54	0.00
Pirojpur	984.39	130.08	77.41	10.23
Satkhira	1153.98	110.64	29.52	2.83
Shariatpur	323.62	7.42	25.87	0.59

Rainfall stress areas:

Areas with less or equal to 380mm throughout the dry season (Nov-May, NWMP) has been termed as the

rainfall stressed area in this study. Inadequate rainfall means that there is insufficient water for the ground water and surface water to recharge which consequently has negative effect on the provision of water supply. Water is used for multiple purposes such as drinking, domestic, industrial use, environmental use etc. So lack of water may lead to health problems. The rainfall stressed areas have been identified by analyzing the rainfall data of 34 BMD stations with a time range of 1948 to 2008. The districts identified as rainfall stressed are Jessore (99.64%), Satkhira (63.29%), Khulna (57.33%), Narail (55.96%) and Bagerhat (16.34%).

Salinity intrusion:

The intrusion of saline water from the sea into the inland is hazardous for the environment in many water. Most importantly, saline water contaminates sweet water resources rendering it unusable for drinking. Moreover, salinity damages the fisheries, crops and the Sundarbans. The biodiversity of the Sundarbans is changing due to increased level of salinity. In the base year 14698 sq. km area is exposed to high salinity of 1 ppt under zero sea level rise. Severely affected districts are Bagerhat, Bhola, Chittagong, Cox’s Bazar, Jessore, Khulna, Lakshmipur, Narail, Noakhali and Satkhira having more than 15% area under 1 ppt saline zone.

Table 2.4: Districtwise salinity coverage in the Coastal Zone

Districts	Saline area (in sq.km)	Salinity area (in %)
Bagerhat	886.78	22.46
Barguna	16.53	1.09
Bhola	1259.46	39.66
Chittagong	3090.63	62.01
Cox's Bazar	531.26	23.46
Feni	54.48	5.84
Jessore	1567.51	60.68
Khulna	1168.04	27.78
Lakshmipur	267.83	17.20
Narail	657.02	66.03
Noakhali	1344.96	42.70
Patuakhali	117.24	3.71
Satkhira	3736.35	95.59



Chapter 3

Climate Change Projections and Risks

3.1 Climate Change Projections

According to the Intergovernmental Panel on Climate Change's (IPCC) latest assessment of "climate change and water", the warming observed over the past several decades is consistently associated with changes in a number of components of the hydrological cycle. Subsequently, climate change has the potential to alter river flow regimes and water resources considerably. The consequences of climate change will be added onto the weather variations that occur from year to year and onto inter-decadal climatic variations. Hence, the traditional approach of the past being the key to the future in water resource planning and management will no longer be applicable, as historical stream flows and groundwater recharge rates are likely to be altered (Bates et.al 2008). The impacts of climate change on water supply directly affect sustainable development of the country and put at risk poverty reduction, mother and child care, overall public health as well as existing ecosystems. Water supply will be crucially affected by climate change in many ways in Bangladesh.

Rainfall:

Since the variation of rainfall will be sensitive in terms of geographic locations, many areas will endure water logging, turbidity as well as sedimentation problems in the country. Availability of fresh water will decrease due to salt water intrusion and regional rainfall patterns. Occurrence of water-borne diseases will increase while water treatment and water supply infrastructure will face challenge. Rainfall is one of the most major components for recharging groundwater. Thus, water options could be experienced on seasonal water depth variations in terms of layer status.

Meanwhile, there is acute water stress in some parts of the region, where surface water and groundwater have shown an alarming situation vis-a-vis irrigation and safe drinking water. Increased rainfall brings water borne infectious diseases from one place to another through runoff whereas scanty rainfall often leads to desertification in an area. A number of people will lose year-round access to safe drinking water due to irregular rainfall. Thus, recurrent costs for water supply and public health will increase. Bangladesh will be at high risk from climate change induced moisture stress and resulting phonological drought impacts. Given reductions in mean dry season rainfall it is likely that dry spells may increase/lengthen with negative consequences for water availability/soil moisture.

An overall increase is observed in all the seasons in the mean seasonal rainfall and found to be maximum during the pre-monsoon (MAM) and monsoon (JJA) season by around 100 mm increase in the mean seasonal rainfall. Increase in the mean seasonal rainfall is seen particularly in the coastal regional stations of Sitakunda, Patuakhali, Kutubdia and in Khulna in the range of 1.2 to 2.1 mm/year. Decrease in the pre-monsoon (MAM) seasonal rainfall is evident in the coastal regional stations of Bhola and Madaripur in the range of 3-19 mm/year decrease in the mean seasonal rainfall. Increase in the monsoon (JJA) rainfall is observed in the coastal district

stations of Kutubdia, Mongla, Sitakunda and in Teknaf stations in the range of 21-42 mm/year increase in the mean seasonal rainfall. (CEGIS, 2011)

For this study, the water stressed areas in terms of critical rainfall of 380 mm in the year 2050 has been identified. The analysis was done based on the B1 scenario of climate change. In the coastal zone, the change is insignificant with only slight increase from the base condition.

Temperature:

In several studies, GCMs and RCMs have been used to generate climate scenarios for Bangladesh (Ahmed and Alam, 1998; Agrawala et al, 2003; Islam et al., 2008; Rahman et al., 2009a; Rahman et al., 2009b; Tanner et al., 2007). These studies are mostly based on GCM results where only a few includes RCM results. The studies predicted drier dry season, wetter wet season and overall increase in temperature. In general, change in annual temperature might be around 1°C by 2030 and 2°C by 2050 (CEGIS, 2011).

An increasing trend has been observed in the mean annual temperature, mean maximum temperature and mean minimum temperature by 0.016°C/year, 0.02°C/year and 0.012°C/year respectively during the past 32-year period (1977-2008) of Bangladesh (Mukherjee et al., 2010). Statistically significant correlation (both parametric and non-parametric) in terms of rise in mean temperature is found valid in 8 out of 13 observatories in the coastal zone. Significant rise in minimum temperature and mean maximum temperature is also found in 8 out of 13 observatories (Mukherjee et al. 2010).

Winter has become warmer with a significant rise in the minimum temperature by 0.45°C and 0.52°C during the winter (DJF) and monsoon (JJA) seasons. Also, summer has become hotter which is experienced during the pre-monsoon and monsoon seasonal months with rise in the maximum temperature by 0.87 °C and 0.42°C during the pre-monsoon (MAM) and post-monsoon (JJA) seasons. Statistically significant rise in the minimum temperature during the winter season (DJF) is observed Chuadanga (0.05°C/year) and Madaripur (0.06°C/year) stations. Rise in the maximum temperature during the hot summer months is prominently observed in the range of 0.03°C/year to 0.05°C/year in Sitakunda (Mukherjee et al. 2010).

If the temperature increases according to the predicted scale, temperature of surface water will be increased and then evaporation will bring increased demand for irrigation. Meanwhile, a number of places are not getting adequate irrigation and drinking water during summer in Bangladesh. Due to these decreasing parameters, public health will be in danger. Increased temperature can be one of the most important reasons for decrease in soil humidity, top soil degradation, constraint for seed germination as well as overall agriculture that would aggravate livelihood and public health.

Sea level rise:

Global sea level rise due to ice melting induced by global warming is aggravating the uniform cycle of climate of Bangladesh. It is predicted that, the sea level may rise by 27cm, 62 cm and 88 cm by 2030, 2050 and 2100, respectively. Such impact will lead to displacement and resettlement of millions of people residing in the vulnerable areas of the coastal region.

Flood:

Flood would be one of the most adverse impacts of climate change in the context of Bangladesh since about 80% of its total area is virtual floodplain. The flood frequency will lead to reduced water quality and increased scarcity of safe water. Risks will be higher for water treatment and supply infrastructure. Symptom of skin diseases, cholera and diarrhea as well as water borne infectious diseases will be exposed and increased. Sources of water points can become extinct, since flood destroys them, and recurrent costs will be higher in this regard. The total flooded area will increase by 6%, 10%, and 20% for a sea level rise of 15 cm, 27 cm, and 62 cm respectively (WB, 2010).

In this study, an increase of 13% has been considered for the year 2050 for flood risk assessment under climate change condition (WB, 2010).

Cyclone and storm surge:

Countries in temperate and tropical Asia will have increased exposure to typhoons, tropical storms due to Climate Change. According to IPCC (2001) there is evidence of the change in the regional frequencies of tropical cyclones but not their locations. There is also evidence that the peak intensity may increase by 5% and 10% thereby, resulting into more storm surges and coastal flooding. The cyclone high risk area will increase with the penetration of the cyclone more towards the inlands, exposing more population. (CEGIS, 2011)

The cyclone High Risk Areas (HRAs) of 8,900 sq km will increase by 35% and 40% in the 2020s and 2050s, respectively due to the increase in the storm surge height and wind velocity. The total coastal area is 39,400 km² and population density is about 930 person/ km². Currently about 8.3 million people live in cyclone HRAs and, based on projections of future population density, this will increase to 14.6 million in the 2020s and 20.3 million in the 2050s. (Tanner et al., 2007)

Salinity intrusion:

Sea level rise and salinity intrusion will reduce fresh water options where already 53% of the area has been affected by salinity. This could increase expenses for water treatment mechanism. Saline water intrusion into groundwater will be increased due to low elevation as well as hydraulic structures. In turn, access to safe drinking water options can be dramatically reduced. This changed physical environment will affect public health issues and coastal livelihoods.

The salinity front will move towards inland from the south of Bangladesh with SLR and it will be further aggravated if the fresh water flows from upstream declines. Low saline areas (0-1ppt) will decrease from 11% to 9% and 4% by 2050 and 2100 respectively, whereas high saline area (20ppt-25ppt) will increase from 13% to 16% and 18% by 2050 and 2100 respectively. Based on model predictions, the population exposed to high salinity (>5 ppt) is expected to increase to 13.6 million in 2050 and to 14.8 million in 2080. (CEGIS, 2006) Again, according to another estimate, the area under 1 ppt salinity line will increase to 17.5% (1 ppt) and area under 5 ppt salinity will increase to 24% by 2050. So, there will be around 7% increase in area under 5 ppt salinity levels. (CEGIS, 2011)

A study by the World Bank (2010) predicted that with a sea level rise of 62 cm, the cyclone-induced storm surges will inundate an additional 15 % of the coastal area by the year 2050. This prediction has been used in the current study.

Erosion:

Analysis of remote sensing images from 1973 to 1996 of the 240 km long Brahmaputra-Jamuna River between the Indian border, and the confluence with the Ganges revealed that the river has been widening at an average rate of about 130 m per year EGIS (1997). This resulted into erosion of about 70,000 ha in 23 years and accretion of only 11,000 ha of land. It was also mentioned in the report that the observed erosion during the flood years 1987 and 1988 was 8,000 ha per year against an average of 3,000 ha per year during the mentioned 23 year period. Climate change is expected to influence the river dynamics through changes in the river flow and sediment transport. As long term prediction value for the year 2050 is not available therefore, the assessment of future risks under climate change has been done assuming that the current erosion rate will prevail.

3.2 Potential Risks Due To Natural Hazards

3.2.1 Potential risks in base scenario

Risks under the base condition of hazards have been analyzed for all the districts. The factors that have been considered for assessment of the risks are magnitude and extent of physical hazard. Upazilawise risk assessment values have been summarized to derive the integrated risk results for the districts. Extent wise the hazards have been ranked also. The impact of a hazard depends on its characteristics and level of damage.

The magnitude of hazard for a particular area has been done through analysis of historical data of hazards. In this regard each of the hazards has been given a weightage value based on its impact on that particular area. For example- in terms of water supply, storm surge has the worst impact followed by flood. Consequently, salinity intrusion is also disastrous for this region. Erosion causes mainly structural damage. So, while assigning the weightage value, focus was mainly on water supply. The districts have been ranked from high to low based on the level of risk.

Table 3.1: Area coverage weightage for each hazard

Coverage of Each Hazard (%)	Ranking
0-25	1
25-50	2
50-75	3
75-100	4

Table 3.2: Ranking based on magnitude of each hazard

Hazards	Hazard Magnitude Weightage *
River Bank Erosion	1
Flood	4
Water Stress	2
Salinity Intrusion	4
Storm Surge	5

*Here, higher weightage means higher magnitude or hazard impact in the region and scored on a scale of 5.0

In the coastal zone, 56%, 26% and 17% area are under high, medium and low risk respectively due to the vulnerability of natural hazard. Bhola and Jhalokathi districts are under 100% high risk whereas Gopalganj and Narail are also under 100% risk but low. 59 upazilas in the districts of Bagerhat, Bhola, Chittagong, Feni, Jhalokati, Khulna, Lakshmipur, Noakhali, Patuakhali, Pirojpur, Satkhira have more than 50% of the area under high risk. 46 upazilas under the districts of Bagerhat, Barguna, Barisal, Chandpur, Chittagong, Cox's Bazar, Feni, Jessore, Khulna, Lakshmipur, Patuakhali, Satkhira and Shariatpur falls under medium risk. Comparatively, the 36 upazilas that are less vulnerable are under the districts of Bagerhat, Chandpur, Chittagong, Cox's Bazar, Feni, Gopalganj, Jessore, Khulna, Narail, Shariatpur.

Table 3.3: Districtwise area under High, Medium and Low Risk in the Coastal Zone

District	Level of Risk	Area under Risk (%)	Risk Area (sq km)	Number of Upazila
Bagerhat	High	75	2975	4
	Low	4	177	1
	Medium	20	797	4
Barguna	High	39	597	3
	Medium	61	921	2
Barisal	High	44	1104	4
	Medium	56	1385	6
Bhola	High	100	3176	7

District	Level of Risk	Area under Risk (%)	Risk Area (sq km)	Number of Upazila
Chandpur	High	10	167	1
	Low	72	1223	6
	Medium	18	309	1
Chittagong	High	57	2843	14
	Low	6	287	4
	Medium	37	1855	7
Cox's Bazar	High	25	559	3
	Low	28	629	2
	Medium	48	1076	3
Feni	High	53	494	3
	Low	11	102	1
	Medium	36	338	2
Gopalganj Jessore	Low	100	1475	5
	Low	83	2147	7
	Medium	17	436	1
Jhalokati	High	100	738	4
Khulna	High	68	2875	5
	Low	9	358	5
	Medium	23	970	4
Lakshmipur	High	71	1109	3
	Medium	29	449	2
Narail	Low	100	995	3
Noakhali	High	91	2852	7
	Medium	9	298	2
Patuakhali	High	85	2700	5
	Medium	15	460	2
Pirojpur	High	94	1192	6
	Medium	6	80	1
Satkhira	High	53	2059	1
	Medium	47	1850	6
Shariatpur	High	8	96	1
	Low	40	500	2
	Medium	52	655	3

3.2.2 Potential risks in climate change scenario

The methodology as followed for the base scenario has been used for the risk assessment of the climate change scenarios. The hazards have been ranked based on the area coverage and magnitude as shown below.

Table 3.4: Ranking of vulnerable upazilas under risk of different hazards in the Coastal Zone

Hazard	Hazard Magnitude Weightage*	Area Weightage and Magnitude Weightage (Out of 20)	Risk (%)
Water Stress	2	8	40
		2	10
		4	20
		6	30
Flood	4	16	80
		12	60
		8	40
		4	20
Erosion	1	1	5
Storm Surge	5	20	100
		15	75
		10	50
		5	25
Salinity Intrusion	4	16	80
		12	60
		8	40
		4	20

3.3 Potential risks due to social vulnerability

Socio-economic condition also has an influence on the water supply facilities. Therefore, the social risks was assessed using indicators like the distribution of vulnerable groups such as the elderly, the pregnant women, the children, the female population and the poor people. In socio cultural context the female population is considered more vulnerable than their male counterparts. The dependent group (children, pregnant women, elderly) of people are physically vulnerable. During a hazardous condition, they have difficulty moving and their access to water supply facilities is reduced. So, the higher the proportion of vulnerable population, the higher is the risk. Impoverishment also enhances social vulnerability as poor people have less access to safe water supply options. Considering all these factors social risk parameters has been ranked based on the risk level.

Table 3.4: Weightage for Social Risk Parameters

Social Risk Parameters	Range for Weightage (%)	Weightage Score (higher score means higher weightage)
<i>Female Ratio*</i> (upazilawise minimum female percentage is 30% and maximum is 55%)	30-35	1
	36-40	2
	41-45	3
	46-50	4
	51-55	5

Social Risk Parameters	Range for Weightage (%)	Weightage Score (higher score means higher weightage)
<i>Dependant Group*</i> (children 0-9 yrs and elderly > 60 yrs) (upazilawise minimum percentage of children and elderly population is 10% and maximum is 40%)	10-15	1
	16-20	2
	21-25	3
	26-30	4
	31-35	5
	36-40	6
<i>Poor/Underprivileged(population affected)**</i>	0 - 24	1
	25-49	2
	50 - 74	3
	75 - 100	4

*percentage as of total population

** percentage as of population below total poverty line

The entire coastal zone is not only vulnerable due to natural hazards but also socially vulnerable with 42% and 46% population under high and medium risk respectively. The districts that are under high social risk of more than 50% are Cox's Bazar, Gopalganj, Jhalokati, Lakshmipur, Narail, Pirojpur, Satkhira and Shariatpur. More than 50% of the population in the districts of Barguna, Bhola, Chandpur, Feni, Jessore, and Patuakhali are under medium risk. Districts that have 10-30% population with low social risk are Bagerhat, Barisal, Chittagong, Jessore, Khulna and Satkhira.

Table 3.5: Districtwise area under High, Medium and Low Risk in the Coastal Zone

District	Level of Risk	Population at Risk (%)	Population at Risk (Number)	Number of Upazila
Bagerhat	High	47	699503	4
	Low	18	266389	1
	Medium	35	510198	4
Barguna	High	18	163927	1
	Medium	82	728854	4
Barisal	High	31	710780	3
	Low	29	676473	2
	Medium	40	937057	5
Bhola	High	27	487411	3
	Medium	73	1289384	4
Chandpur	High	30	731225	3
	Medium	70	1684793	5
Chittagong	High	45	3462282	11
	Low	12	938729	4
	Medium	42	3215341	10

District	Level of Risk	Population at Risk (%)	Population at Risk (Number)	Number of Upazila
Cox's Bazar	High	52	1184905	5
	Medium	41	933547	2
	NA	7	171538	1
Feni	High	25	363609	2
	Medium	66	954204	3
	NA	8	119558	1
Gopalganj	High	71	828407	4
	Medium	29	344008	1
Jessore	High	12	341328	1
	Low	26	710701	3
	Medium	62	1712518	4
Jhalokati	High	68	466321	3
	Medium	32	216348	1
Khulna	High	43	989762	6
	Low	14	324007	2
	Medium	43	1004758	6
Lakshmipur	High	87	1506273	4
	NA	13	222915	1
Narail	High	69	501466	2
	Medium	31	220202	1
Noakhali	High	26	808828	2
	Medium	48	1485603	4
	NA	26	813652	3
Patuakhali	High	29	438178	2
	Medium	71	1097676	5
Pirojpur	High	73	817751	4
	Medium	20	218289	2
	NA	7	77217	1
Satkhira	High	54	1078966	3
	Low	20	394112	2
	Medium	26	512881	2
Shariatpur	High	55	635922	3
	Medium	45	519902	3

3.4 Integrated risk due to natural hazard and social vulnerability

The cumulative effects of hazard with social vulnerability enhance the risks on the provision and access to safe water. Therefore, the integrated risk has been assessed by merging both the hazard risk and social risk assessments done in the previous sections. Weightage has been given based on the level of individual risks

with more focus on the hazard vulnerability than the social. The integrated risks have been classified into five classes as given below:

Table 3.6: Category of Risks

Physical	Social	Risk Category
High	High	Very High
High	Medium	High
Medium	High	High
Medium	Medium	Medium
Medium	Low	Medium
Low	High	Medium
High	Low	Medium
No Risk	High	Low
Low	Medium	Low
No Risk	Medium	Very Low
No Risk	Low	Very Low
Low	Low	Very Low

It can be seen that 33 upazila, 46 upazila, 58 upazila, 13 upazila and 3 upazila are under Very High, High, Medium, Low and Very Low risk. In the coastal zone, areas under very high, high and medium risk are 28%, 33% and 31% respectively. So 61% area of the CZ (19% of Bangladesh) with a population of 20 million is highly vulnerable to natural and social hazards.



Chapter 4

Adaptation to Future Climate Change Risks

4.1 Probable Adaptation Options and Measures

Climate change and its impacts can be dealt with in two main approaches. Mitigation measures are concerned with the reduction of GHG emission for preventing changes in climate. Adaptation refers to the efforts to deal (or cope) with the impacts of climate change (due to the failure of mitigation efforts) that can neither be prevented nor can be avoided. (UNDP, 2007)

Adaptation has gained importance as an important response measure for the short to long term. Proactive measures for adaptation are the sole requirement to ensure sustainable water supply options in the face of water unavailability and hazard vulnerability due to climate change. The adaptation options can be technology focused, management oriented, community based etc.

4.1.1 Adaptive technologies for hazards

As the impacts of climate change are evident, therefore improved or modified technologies are needed. The level of modification and improvement will depend upon the type of hazard and the area that it will be used in. Piped system, tubewells, protected dug well and RWHS are considered as the safest options. But all of these run into the risk of contamination through inundation with flooding or storm surge. Technologies that can adapt with the climatic hazards of the coastal zone are listed in the following table:

Table 4.1: Technical options according to the type of hazard

	Location/district	Hazards	Cost	Coverage (No of families)
Piped system	Bagerhat, Satkhira, Barisal, Bhola, Jessore, Narail, Meherpur, Khulna, Kushtia	Flood, Storm surge, Salinity intrusion, Water scarce areas	18,50,000	5,000
Raised Deep Tubewells	Bagerhat, Barisal, Bhola, Chandpur, Feni, Gopalganj, Jessore, Jhalokati, Khulna, Lakshmipur, Noakhali, Satkhira, Shariatpur	Flood, Storm surge	45,000	50-60
Very Shrouded Shallow Tubewell	Bagerhat, Chittagong, Cox's Bazar, Feni, Gopalganj, Jessore, Khulna, Narail, Noakhali, Pirojpur, Satkhira, Shariatpur	Salinity	25,000	5-10

	Location/district	Hazards	Cost	Coverage (No of families)
Tara pump no 6	Chandpur, Comilla	Flood, Water scarce areas	50,000	10-20
Rainwater Harvesting Scheme (RHS)	Barisal, Patuakhali, Bhola, Feni, Chittagong, Cox's Bazar	Flood, Storm surge, Salinity intrusion	10,000	1
Pond Sand Filter (PSF)	Bagerhat, Barguna, Khulna, Patuakhali	Salinity, Water scarce areas	35,000	80
Protected Dug well	Barguna, Patuakhali, Pirojpur, Satkhira,	Flood, Storm surge	35,000	20-30

Source: Ahmed, 2002; WaterAid, 2009a

1. Flood

Flood is a common hazard in all regions of Bangladesh and it affects the water supply facilities. Flood mainly affects quality of water. So contamination of the water sources is an issue of vital concern. To deal with flood, specific measures can be taken, some of which are adaptation options for water supply and some are directly related with managing flood itself. Adaptation measures for water supply are:

Raised Deep Tube wells

During severe flood tube wells go under water and become inaccessible. So setting up tube wells on a high ground or on raised platform can make them usable during flood. In flood prone areas two types of raised tubewells can be used: Tara Dev Head Deep Tube well and Deep Tubewell Number 6. Usually, deep tube wells are installed at a depth of 150-200m depending upon the availability of the shallow and deeper aquifer at different geographical region.

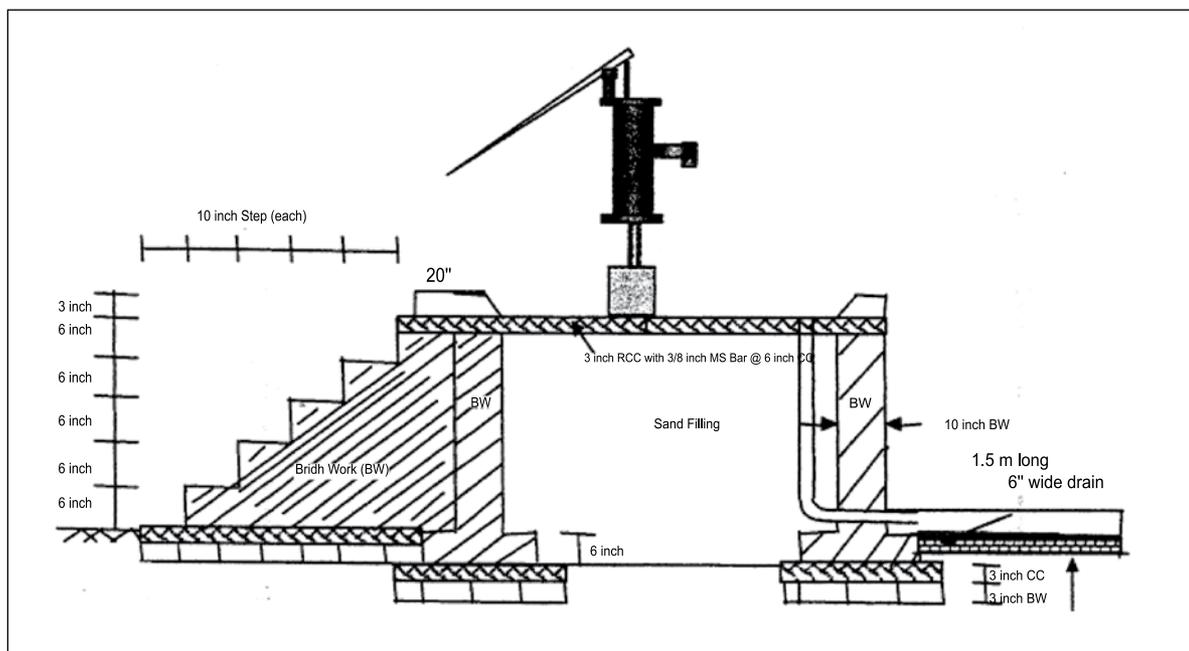


Figure 4.1: Raised tubewells 6 No. Pump

Rainwater Harvesting (RWH)

Rainwater harvesting is already a source to obtain drinking in some areas of the country. This technique is expected to become more prominent for the purpose of supplementing other sources. Rain water can be kept safe during flood and can be managed if it is stored in a container or reservoir high from the ground. Apart from drinking purpose, RWH can be used for domestic use also. It is a simple, affordable, technically feasible and socially acceptable safe drinking water supply option for the difficult geo-hydrological areas. The physical, chemical and bacteriological characteristics of harvested rainwater usually represent a suitable and acceptable standard of potable water. Due to ease of collection and storage, acceptable drinking water standards, this option is very useful in the coastal zone especially in the flood prone areas, saline areas, areas prone to declining water table and having rocky/ stony layer in soil formation etc. RWH is suitable for arsenic affected areas as rainwater is free from arsenic contamination. This technique is suitable for flood prone areas as ground water sources become unusable during flood. Some of the key features of this system are given below (WaterAid, 2009a):

- The major components of RWHS are catchments (used for holding rain water), gutters (water conveyance system from catchments to storage reservoir), flushing systems, water tank and water collection points.
- Water reservoir tanks can be made of concrete, ferro-cement, brick, plastic sheet, fiberglass, earthen Motka etc. The design and construction of storage tank is technically the most difficult aspect of this system.

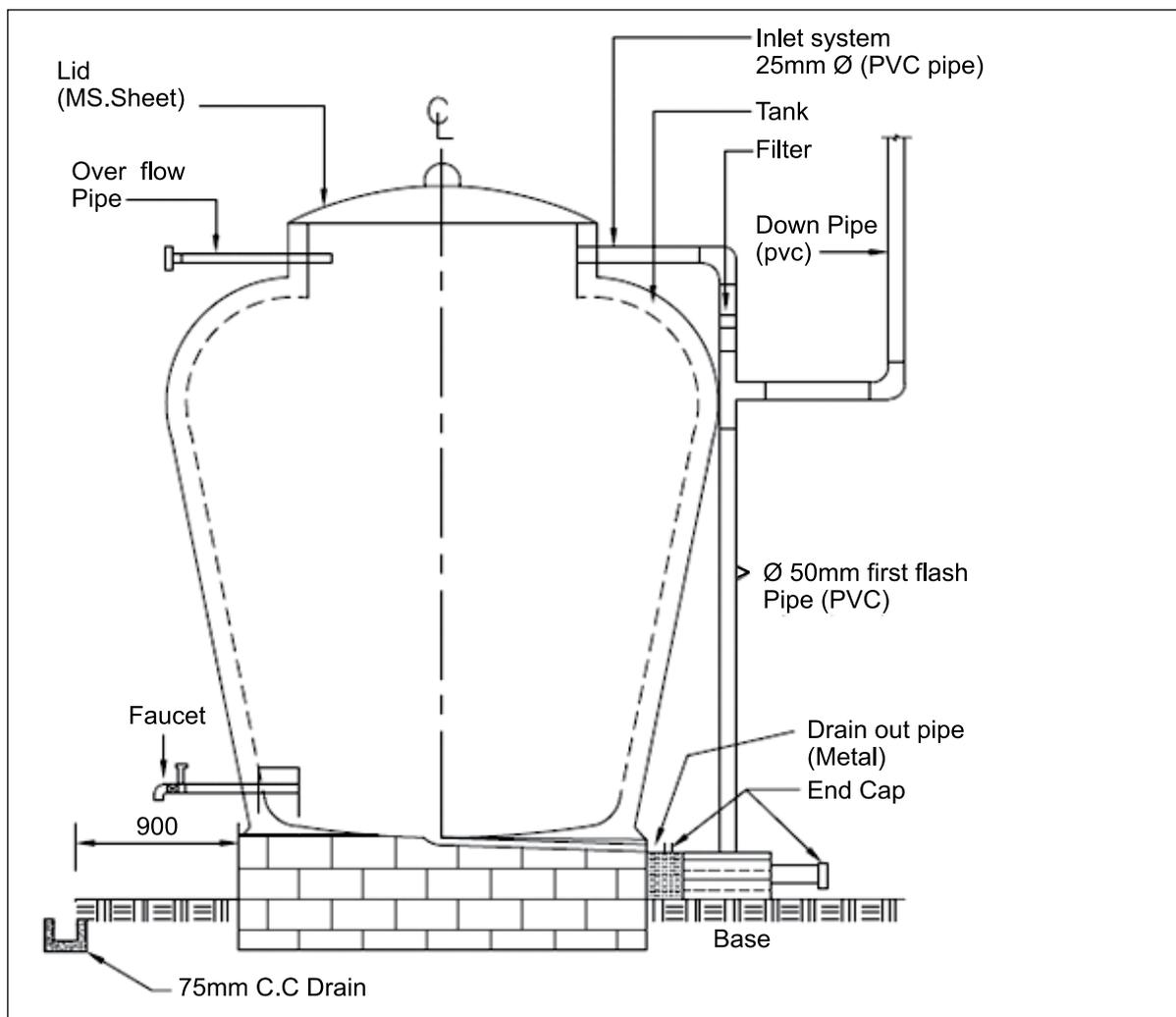


Figure 4.2: Schematic diagram of RWHS (WaterAid 2009a)

Pond Sand Filter (PSF)

Water gets contaminated during flood and water become highly turbid. So Pond sand filter technique can be used for treatment of surface water of ponds. It is a type of slow sand filter that removes turbidity from water and yields bacteriologically safe water for domestic use. Pond sand filter is simple low-cost technology, effective in turbidity and bacterial removal and a popular option of potable water supply in the coastal belt and arsenic prone areas. Some basic characteristics of PSF are described below (WaterAid, 2009a):

- The PSF is installed near or on the bank of a pond, which does not dry up in the dry season. The banks of the pond should be raised so that surface run-off cannot enter the pond, if possible, it can be raised over flood level so that the pond water can be used during flood.
- PSF is constructed with locally available materials and trained masons.
- The water from the pond is pumped by a manually operated hand tube well to feed the filter bed, which is raised from the ground, and the treated water is collected through tap(s).
- On average, the operating period of a PSF between cleaning is usually two months, after which the top layer of the sand bed needs to be cleaned and replaced.
- Its operation and maintenance are also simple and cheap.

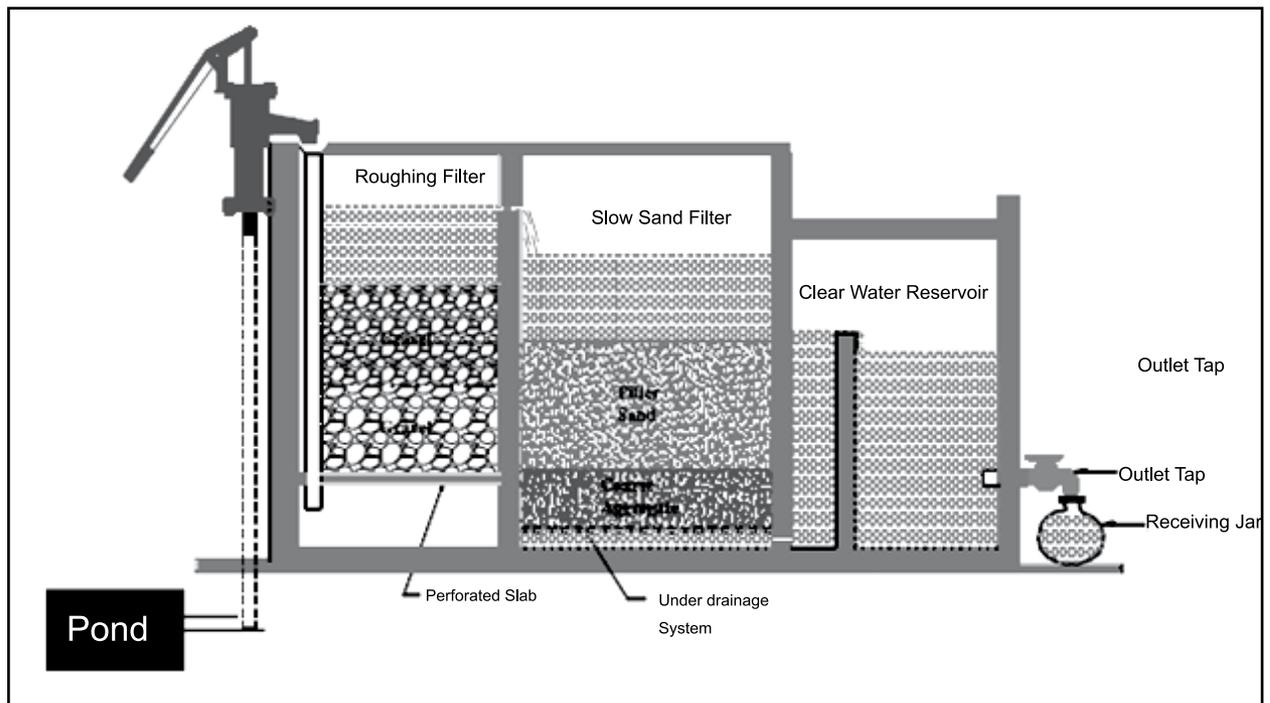


Figure 4.3: Diagram of PSF (DPHE, 2008)

Protected Ring Well or Dug Well

Ring well with cover can be used during flood. This type of well is appropriate for areas where water level is comparatively high. The wells are installed at a depth of 6-8 m and one pipe is connected with the available aquifer. Moreover, a tubewell is attached with the well and the main well is covered by net for protection.

Dug well is considered as safe water option as the water is free from dissolved arsenic and iron. So this well is suitable even in locations where tubewells particularly in shallow aquifer are contaminated. It is one of the oldest method of withdrawing groundwater for water supplies. The criteria for constructing this well include the following (DPHE, 2008):

- A stable soil layer at the top (a clay layer is preferable); and
- A sandy layer within 9 to 12 m.

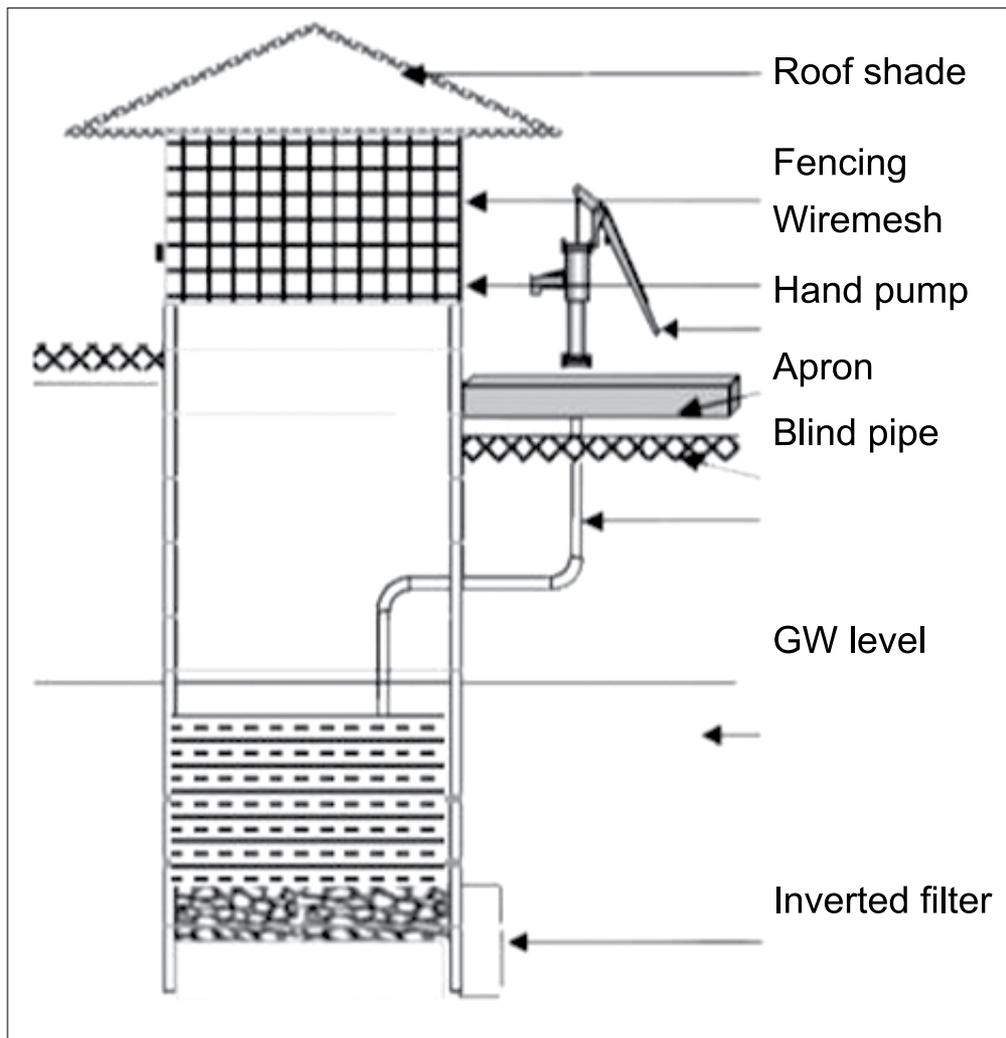


Figure 4.4: Dug well with sanitary protection (DPHE, 2008)

Gravity-Feed System (GFS) Technology

The GFS technology is suitable in a place where the source of supply is at a sufficient elevation with respect to the consumption point. This is a simple technology which is used for water transmission and distribution to the consumption point from source point. In recent times, this technology has been introduced in the EH area. The main source for the GFS is spring or harvested rainwater reservoir. (WaterAid, 2009a)

2. Cyclone and Storm Surge

Raised Deep Tube Wells

Cyclone and storm surge inundated tube wells are unusable. Therefore, in areas which are vulnerable to cyclonic storm surges should have raised tubewells to protect them from inundation. For cyclone and storm surge areas two types of raised tubewells can be used: Tara Dev Head Deep Tube well and Deep Tubewell Number 6.

Protected Ring Well

Ring well (RW) with head cover is provided specially in areas that are threatened with cyclone and storm surge. This type of well is suitable for areas where static water level is comparatively high and shallow or deeper aquifer is arsenic affected. The wells are installed at a depth of 6-8 m and one pipe is connected with the available aquifer.

Rainwater Harvest (RWH)

Rainwater harvesting is already being used as drinking water solution in some places and will become more salient, for the purpose of supplementing other sources. Rain water is safe and it can be managed and kept safe during storm surge if it is stored in a container or reservoir high from the ground.

3. Salinity Intrusion

Sea level rise due to global warming will cause salinity intrusion up into the rivers and salinity is the key problem of water supply in the coastal zone. Saline free water is a key consideration of water supply adaptation, as it is related to future health issue (Ahmed, A.U., 2004). Flushing of brackish water zones with increased volumes of freshwater will help adaptation to increasing salinity ingress under climate change. (Ahmed A., 2004). Investing on a barrage on the Ganges River would benefit the southwestern region of the country by pushing salinity front towards the bay (CEGIS, 2006). It is also found that the option of having a barrage with proposed link canals to maintain a good flow regime along Betna-Bhairab, Gorai, and Madhumati systems would provide high dividend in terms of salinity control under climate change.

Rain Water Harvest (RWH)

Rain water harvesting is a good drinking water solution for both urban and rural areas, especially for coastal region where salinity is a problem and most of the surface water sources with high salinity concentration. The average annual rainfall in the coastal and hilly region is more than 3,000 mm, as against an average annual rainfall in Bangladesh is about 2,400 mm. (WaterAid, 2009). And climate change will not affect much the average rainfall in this region; rainwater option of water supply in the hilly and coastal areas will be effective for these regions.

Pond Sand Filter (PSF)

Pond sand filter is best suited for coastal region as salinity concentration is much in this region. Pond sand filter is effective to remove turbidity and give bacteriological safe water. But increased flooding will affect source water. So protection of source is important to save water source.

Desalination

Desalination technique is climate independent. It is used mainly in coastal region for safe water as salinity concentration is high in the surface and ground water in the coastal region. Membrane technology and reverse osmosis (RO) are new technologies for desalination of water.

Deep tube wells

Deep tube wells are suitable for all regions except eastern hilly region as it is difficult to set deep tube wells there.

Tara pump

Tara pump is used as an intermediate technology in areas where it is not possible to withdraw water in lower water table areas using shallow tubewells. Tara Tube well is needed when the water level in dry season goes below 7.5 meter and STW cannot function normally. A Tara tube well is called Tara-I or Tara-II depending on capacity of lifting water. Nowadays Tara pump no 6 and Tara Dev head pump are used.

Very Shrouded Shallow Tubewell (VSST)

Very shrouded shallow tubewell can be considered as a feasible option in areas where water is available in the saturated zone. The main feature of this technology includes e shrouded with coarse sand around the filter area. This is a low cost technology. This technology is also used in the saline problem areas.

4. Water Scarcity and Groundwater Depletion

Lower rainfall, resulting in increasing drought, especially in drier northern and western regions of the country

will lead to water scarcity. To reduce pressure on declining groundwater aquifers low-water-consuming crops instead of paddy should be cultivated (Ahmed A., 2005). Capacity building for advanced irrigation techniques could also be considered as an important adaptation option in order to conserve available water resources (Ahmed A., 2004). Sinking deep hand tubewells, subject to availability of groundwater sources, and building community/household based rainwater harvesting units in water scarce regions should be considered as adaptation measures (Schaerer & Ahmed, 2004).

Ground water depletion is a serious concern, and managed recharge of aquifers is needed in some regions. Adaptation measures related to groundwater depletion are:

- Technical options are available for groundwater recharge. A managed recharge strategy strongly implies a shift to conjunctive management of surface and groundwater; and
- Groundwater storage – creates an opportunity for adaptation to and mitigation of climate change effects.

Deep Tubewells

Ground water level is depleting in drought prone areas so shallow aquifers will not draw enough water. So deep tube wells have to be set up in those areas. For example, Tara (no-6) tube wells are suitable for drought prone areas. Usually, deep tube wells are installed at a depth of 150-200m depending upon the availability of the shallow and deeper aquifer at different geographical region.

Pond Sand Filter

Pond sand filter technique can be used for treatment of surface water of ponds and river. Water source should be the ponds or rivers which contain water all the year round. It is a type of slow sand filter and used to treat surface water of pond and river. Pond sand filter is effective to remove turbidity and give bacteriological safe water.

4.1.1 Management Options

Protection from Flood, Cyclone and Storm Surge

Flood management and water management during flood is very much important to cope with the impact of flood on water supply. Flood management will mitigate impact of flood on water supply. Flood management measures may include removal of obstructions of drainage by dredging of rivers/khals and construction of drainage structures i.e. culverts, bridges and regulators should be considered as adaptation measure in order to facilitate drainage and flood related vulnerability (Ahmed, Alam, & Rahman, 1998) (Ahmed A., 2005) (Faruque & Ali, 2005). Cyclone or storm surge cannot be prevented, but through proper management the loss and damage can be reduced.

Management activities include:

- Flood plain management is very important to reduce flood and intensity of flood. Unplanned structures and destruction of forest and vegetations cause more runoff and hence more floods;
- Regular dredging of river beds to increase the conveyance capacity of rivers;
- Improving drainage facility. Restoring khals and drainage systems that already filled up or encroached illegally;
- Construct protecting wall surrounding the water sources like pond, well and water pump station;
- Susceptibility of intake structures and susceptible points on the network e.g., build flood barriers, build infrastructure to tackle floods, re-route pipes, reconfigure network connections, relocate reservoirs to reduce vulnerability, install redundant pipes/network around vulnerable locations;
- Protection of water sources is very important to prevent water from being contaminated. Water source should be protected as water is getting scarce and treatment of water is very costly. Water from protected sources can be used during floods;
- Construction of new flood and cyclone shelters;
- Rehabilitation of old shelters and making them usable;
- Improve and modernize flood and cyclone warning system. Warning system is very important to make

- people aware and to reduce losses; and
- Preparedness in the pre disaster phase to deal with the crisis situation.

Reuse of water (Recycling)

Reuse of water (recycling) is necessary as quantity of usable water is getting scarce. We have to ensure efficient use of water as usable water source is limited. Water efficiency and demand management are very essential when water is inadequate. It enables peoples to use much less water. These are also generally the most gainful measures to tackle reduced supplies.

4.1.2 Institutional Strengthening

Strengthening governance and water management is a must to combat water crisis induced by climate related hazards. The institutions involved in water supply services should be more efficient and have knowledge of forthcoming challenges of water supply and develop strong water management strategies. For the purpose of institutional strengthening the following needs to be done:

- Improve coordination and integration among the agencies working on water sector;
- Make the institutions more people oriented to share knowledge with the people of the community;
- Build long-term resilience through stronger institutions; and
- Allocate additional funds in the national budgetary allocations and innovative funding mechanisms for adaptation in water management sector.

4.1.3 Community Involvement and Responsiveness

Community involvement is very important to deal with water resources and for operation and maintenance of water technologies. To make efficient use of water community involvement is mandatory. As hazards related to climate change will affect water supply, it is important to make people conscious of impacts on water supply. Peoples are not aware of climate consequences on water resources. Knowledge is very important for making people aware to use water efficiently. Again policies have to be implemented at community level. Community's involvement is inevitable along with the government and institutional efforts for long term solutions for adaptation. Local initiatives and knowledge are important part of adaptation and in many cases are the most cost effective, feasible and appropriate options to maintain the sustainability of the system. So improving and sharing knowledge and information on climate and adaptation measures is very important. Measures that can be taken for adaptation are:

- Training on managing and protecting the water sources in the pre-disaster and disaster phase;
- Capacity building on water use, collection, techniques of filtering during the disaster phase;
- Awareness generation to improve perceptions on efficient water use; and
- Formation of community based water management groups including local leaders:
 - mitigate conflict among water users;
 - help to implement water pricing to reduce wastage of water;
 - help in operation and maintenance of water supply technologies and water source protection;
 - help in operation and maintenance of community based treatment plants;
 - build partnership with water supply and sewerage authorities; and
 - distribute knowledge among water users about low cost water technologies and efficient use of water.

4.2 Adaptation Cost for Proposed Measures

Projects for adaptation will cover multiple sectors one of the main being the water supply sector. The projects may vary from short term to long term. The project may either be implementation based or research study. The projects that have been proposed in this study are taken from BCCSAP and NWMP. The detailed description of the individual projects has been given in the Annex.

Chapter 5

Policies and Institutional Arrangement for Adaptation

5.1 National Policies, Strategies and Plans Related to Drinking Water / Policy Reforms Needs

Several policies and strategies have been formulated by the Government of Bangladesh to meet people's demand of safe water supply such as:

- National policy for safe water supply and sanitation 1998 (WSS policy);
- National water policy 1998 (NWP);
- National water management plan 2004 (NWMP);
- National policy for arsenic mitigation & its implementation procedure 2004 (Arsenic policy);
- Sector development framework on water supply and sanitation 2004 (SDF);
- National sanitation strategy 2005;
- Pro-poor strategy for water and sanitation sector in Bangladesh 2005.

Alongside the WSS Policy 1998, the NWP and the NWMP gives broad guideline on water resources management which includes water supply. The NWP 1998 and the NWMP 2004 give broad direction for water resources management including a broad outline of water supply sector. The arsenic problem is addressed in the Arsenic Policy 2004. PRSP stressed the need for water and sanitation for achieving poverty reduction. A Sector Development Plan (SDP) for the Water and Sanitation sector is being prepared with the aim for planning, implementing, coordinating and monitoring all activities in the sector by the Ministry of LGRD&C. SDP is a framework plan for the period of 2010-2025 which is now pending the government's approval process.

National Policy for Safe Water Supply and Sanitation (NPoSWSS), 1998

The objectives of this important Policy are to improve the standard of public health and to ensure improved environment through the following steps:

- Bringing about behavioral changes regarding use of water and sanitation;
- Reducing the incidence of water-borne diseases;
- Building capacity in local governments and communities to deal more effectively with problems relating to water supply and sanitation;
- Promoting sustainable water and sanitation services;
- Ensuring proper storage, management and use of surface water and preventing its contamination;
- Taking necessary steps for storage and use of rain water; and
- Ensuring storm-water drainage in urban areas.

The policy specifies the following targets to be achieved within the near future:

- (i) Increasing present coverage of safe drinking water in rural areas by lowering the average number of users per tubewell from the present 105 to 50;
- (ii) Ensuring the installation of one sanitary latrine in each household in the rural areas and improving public health standard through inculcating the habit of proper use of sanitary latrines;
- (iii) Making safe drinking water available to each household in the urban areas;
- (iv) Ensuring a sanitary latrine within easy access of every urban household through technology options ranging from pit latrines to water-borne sewerage;
- (v) Installing public latrines in schools, bus stations and important public places and community latrines in densely-populated poor communities without sufficient space for individual household latrines;
- (vi) Ensuring supply of quality drinking water through observance of accepted quality standards;
- (vii) Removal of arsenic from drinking water and supply of arsenic-free water from alternate sources in arsenic-affected areas;
- (viii) Taking measures in urban areas for removal of solid and liquid waste and their use in various purposes; and
- (ix) Ensuring the use of waste for the production of organic fertiliser (compost) in rural areas.

National Policy for Arsenic Mitigation, 2004

In the National Policy the major problems are identified and the strategies taken for Arsenic Mitigation 2004 can be mentioned as follows:

In Bangladesh surface water is abundantly available during monsoon but it is scarce during the dry season. Ninety seven percent of the population relies on ground water for drinking purpose. Ground water used for drinking in many areas of Bangladesh has been reported to have contamination by arsenic above the Bangladesh National Standard of 50 parts per billion (ppb). The percentage of contaminated tubewells in villages varies from more than ninety percent to less than five percent. Geographically, the tube wells in the delta and the flood plains regions, which comprise 72% of the land area, are more or less affected by arsenic contamination.

- Arsenic contaminated aquifers have no regular pattern, varies both horizontally and vertically within short distances.
- Population exposed to arsenic in Bangladesh runs into millions, thousands of people are suffering from arsenicosis and many among them have developed cancer and other complications.
- Arsenic contamination is geological and there is no known control at source and also there is no proven treatment for arsenicosis. Hence the primary option is alternate supply of arsenic safe drinking water. Therefore, it is simultaneously a water supply and a health issue.
- Water supply brings with it the issue of appropriate and affordable technology options to the community. The shallow tube wells, cornerstone of the water supply miracle in Bangladesh, can no longer provide safe water for drinking and cooking in arsenic affected areas.
- Symptoms of arsenic poisoning bring in the social dimensions. People with arsenic induced symptoms face social sanctions with apparent but no real justification.
- Arsenic in ground water used for irrigation may also have affect on agriculture and food chain.
- The variety of ways arsenic affects life and people have attracted the attention of a diverse group of stakeholders. Different ministries and government agencies, academics, NGOs and bilateral/multi-national development partner agencies are pursuing separate programmes without any co-ordination. This is resulting in duplication of activities and conflicting strategies that inhibit synergy and optimal use of scarce resources.
- A policy guideline for arsenic mitigation programmes for arsenic affected areas to guide and co-ordinate all activities has therefore, become imperative.

National Water Policy (NWP), 1999

The NWP elaborated by the Ministry of Water Resources and approved in 1999 outlines the national policy for management of water resources. The NWP provides guidance to all agencies and institutions working directly or indirectly with the water sector.

The aim is to ensure availability of water to all elements of society including the poor and the underprivileged, and to take into account the particular needs of women and children.

The policy promotes institutional changes that will help decentralize the management of water resources and enhance the role of women in water management and develop a legal and regulatory environment that will help the process of decentralization, sound environmental management, and improve the investment climate for the private sector in water development and management.

The emphasis in the NWP on coordination within the sector signifies the current lack in this respect. Legal and regulatory difficulties in defining the water rights of different users result in disputes among users such as farmers, fishermen and domestic users.

There is no overall water law, formal system of water rights or regulatory instruments for water use and allocation. State intervention has largely favored development of agriculture often at the disadvantage of other users. The NWP seeks to redress this situation and emphasizes equitable use of all sources of water and accords great importance to household and municipal use of water. The policy directs for this purpose to enact a Water Resources Act (Draft Bangladesh Water Law, under process of finalization, last revised September, 2011), which will define water users' rights and set the framework for a comprehensive water regulation system to ensure fair, equitable and sustainable access to water resources.

The Government may confer water rights on private and community bodies to provide defensible and enforceable ownership to ground water and surface water for attracting private investment. Public water institutions will, to the extent feasible, use private providers of specific water resource services in carrying out their mandates, giving preferences to beneficiary groups and organizations.

In relation to the water supply and sanitation sector, the NWP aims to:

- Facilitate availability of safe and affordable drinking water supplies through various means, including rainwater harvesting and conservation;
- Preserve natural depressions and water bodies in major urban and rural areas for recharge of underground aquifers and rainwater management;
- Mandate relevant public water and sewerage institutions to provide necessary drainage and sanitation, including treatment of domestic wastewater and sewage and replacement of open drains and construction of sewers, in the interest of public health;
- Empower, and hold responsible, municipalities and urban water and sewerage institutions to regulate the use of water for preventing wastage and pollution by human action; and
- Mandate local governments to create awareness among the people in checking water pollution and wastage.

The objectives of the National Water Policy are mentioned here:

- a. To address issues related to the harnessing and development of all forms of surface water and ground water and management of these resources in an efficient and equitable manner;
- b. To ensure availability of water to all elements of the society including the poor and the underprivileged and to take into account the particular needs of women and children;
- c. To accelerate the development of sustainable public and private water delivery systems with appropriate legal and financial measures and incentives, including delineation of water rights and water pricing;
- d. To bring institutional changes that will help decentralize the management of water resources and enhance the role of women in water management;
- e. To develop a legal and regulatory environment that will help the process of decentralization, sound environmental management and improve the investment climate for the private sector in water development and management; and
- f. To develop a state of knowledge and capacity that will enable the country to design future water resources management plans by itself with economic efficiency, gender equity, social justice and environmental awareness to facilitate achievement of the water management objectives through broad public participation.

The following aspects are of particular importance for the Safe Water Supply and Sanitation Sector:

- Water will be considered an economic resource and priced to convey its scarcity value to all users;
- Relevant public water supply agencies will be gradually given authority to charge for their services;
- Water charges realized from beneficiaries for O&M in a project would be retained locally for the provision of services within that project; and
- Effective beneficiary participation and commitment to pay for O&M will be realized at the project identification and planning stage by respective public agencies

Sixth Five Year Plan (FY2011-FY2015), 2011

The specific objectives regarding access to water supply is to: mitigate arsenic problem in drinking water by providing alternative systems, expand water supply coverage to currently underserved Pourashava areas, provide improved water supply to underserved, un-served and inaccessible areas. The target set by the SFYP is given below:

Table 5.1: Water Supply- Target Coverage at the end of SFYP

Sl. No.	Service Area	Target Coverage at the end of SFYP		
		By Piped Water	By Water Points	Total
1	City Corporation	70%	30%	100%
2	District HQs Pourashava	70%	30%	100%
3	Upazila HQs Pourashava	30%	70%	100%
4	Growth Centre & Other Pourashava	20%	80%	100%
5	Rural Areas	1%	99%	100%

National Water Management Plan (NWMP), 2004

The aim of preparing the National Water Management Plan (NWMP) was to operationalise the directives given by the National Water Policy. The NWMP was prepared by WARPO in 2001 and approved in 2004. The NWMP has three main objectives in line with the Water Policy aims and national goals: These objectives are: i) Rational management and wise use of Bangladesh's water resources; ii) People's quality of life improved by the equitable, safe and reliable access to water for production, health and hygiene; and iii) Clean water in sufficient and timely quantities for multi-purpose use and preservation of the aquatic and water dependent ecosystems. NWMP is a framework plan under which the line agencies are expected to plan and implement their activities in a coordinated manner. The plan is presented in three phases: in the short term (2000-2005) it is considered a firm plan of ongoing activities; in the medium term (2006-2010) it is an indicative plan and in the long term (2011-2025) a perspective plan. Implementation of the plan is to be monitored regularly and updated every five years.

NWMP has delineated Bangladesh into eight hydrological regions namely Northwest (NW), North Central (NC), Northeast (NE), Southeast (SE), South Central (SC), Southwest (SW), Eastern Hills (EH), plus the active floodplains and charlands of the Main Rivers and Estuaries (RE) based on which regional plan and programmes have been formulated. NWMP chalked regional programmes for the south west, south central and southeast regions that are relevant with the coastal region. These programs have been included as part of the adaptation programmes in the previous chapter section 4.2.

Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009

The theme, programme and subsequent actions relevant to the haor area are:

Water and sanitation programme in climate vulnerable areas

Objective: Ensure adequate water supplies and improved sanitation

- Monitor changes in water quality and quantity available for drinking and forecast future changes due to climate change.

- Plan for and invest in additional water supply and sanitation facilities.

Outline Perspective Plan (OPP) of Bangladesh 2010-2021, 2010

A healthy population by improving the quality of life contributes in the country's economic growth. Therefore, strategies such as improvement of public health facilities like water supply will be improved with extended coverage in rural areas, towns and cities. As per the OPP, coverage of most of the services should be maintained at the level achieved by 2015. One of the main objectives of ensuring supply of safe water would be the removal of arsenic from drinking water and providing water from alternate sources in arsenic-affected areas.

The overall goal is to achieve a major breakthrough in environmentally sound and equitable socioeconomic development within this Perspective Plan period. Major environmental and climate change strategies include:

- In rural areas, the arsenic contamination of groundwater will continue to be addressed with determination. The urgent need at present is a comprehensive arsenic mitigation programme with a view to providing safe water to worst affected areas. Mitigation options include treatment of arsenic contaminated water, and increase the use of surface water sources. Deep aquifers appear to offer a long-term source of arsenic-free and safe drinking water. With rural electrification the scope of distribution of deep tube well water through pipes in the village may hold some promise.
- To improve navigability and water discharge, and to reduce flood risks, a strategy of dredging and training of rivers in a planned and phased manner will be pursued.
- Integrated coastal zone management will continue to be a policy thrust. The Coastal Zone Policy and the Coastal Zone Strategy will be put to use, and may be revised and modified if necessary as the implementation process progresses. A major emphasis will be placed on desalinization of water and land.
- In adaptation activities both structural and non-structural measures, as appropriate, will be undertaken to protect the people and equip them at the same time to respond better. The option of O&M and rehabilitation activities for embankments and polders to prevent flood waters and salinity intrusion will be examined and the best approaches identified for implementation.

5.2 Institutional Framework for Adaptation of Drinking Water Supply

Adaptation is process which for it to be effective needs to be adopted in every tier from the global, regional, national to local level. The adaptation approach should highlight location specific measures addressing the direct and indirect impacts of climate change on water supply. Adaptation should also consider the individual as well as collective interests of the community as well as the interest of the region and the country as a whole. Within the country, several agencies under different agencies are involved in water service delivery. Ministry of Local Government, Rural Development and Cooperatives (MoLGRD&C) is the lead authority in ensuring water supply for all. MoLGRD&C along with the Planning Commission under Ministry of Planning is responsible for policy decisions, sectoral allocation and funding, project appraisals, approval, evaluation and monitoring. MoLGRD&C sets the policy guidelines for water supply and sanitation related service delivery. The ministry also monitors the functioning of LGED, DPHE and WASAs. MoLGRD&C provides support to the municipalities and communities in building water supply infrastructure. Additionally, Ministry of Food and Disaster Management (MoF&DM) and Ministry of Health & Family Welfare (MoH&FW) are involved indirectly with WATSAN activities. Disaster Management Bureau under the MoF&DM oversees the disaster management activities. MoH&FW through its agencies imparts education and training on health and hygienic issues.

Department of Public Health Engineering is vested with the responsibility of planning, designing and implementing water supply and sanitation services in rural areas, upazila towns and Pourashavas. However, in Dhaka and Chittagong cities, the agencies responsible for providing water are the Dhaka Water Supply and Sewerage Authority (DWASA) and the Chittagong Water Supply and Sewerage Authority (DWASA). Local Government Engineering Department (LGED) also installs water supply facilities throughout the country excluding the areas where WASA is present.

DPHE has supervisory staff at Zila (district) and Upazila (sub-district) levels and is represented at union parishad level by tube-well mechanics and masons. In each of the district level office an executive engineer is assigned. Zila Parishads (district councils) composed of elected and appointed members are involved in planning, implementation and monitoring of development activities of the districts. They mainly supervise the administrative and technical support of water supply and sanitation. Similarly, Upazila Parishad, Paurashava (Municipalities) and Union Parishad also comprises elected representatives and selected employees. They provide institutional support to the local people. However, these authorities are under the supervision of DPHE along with LGED.

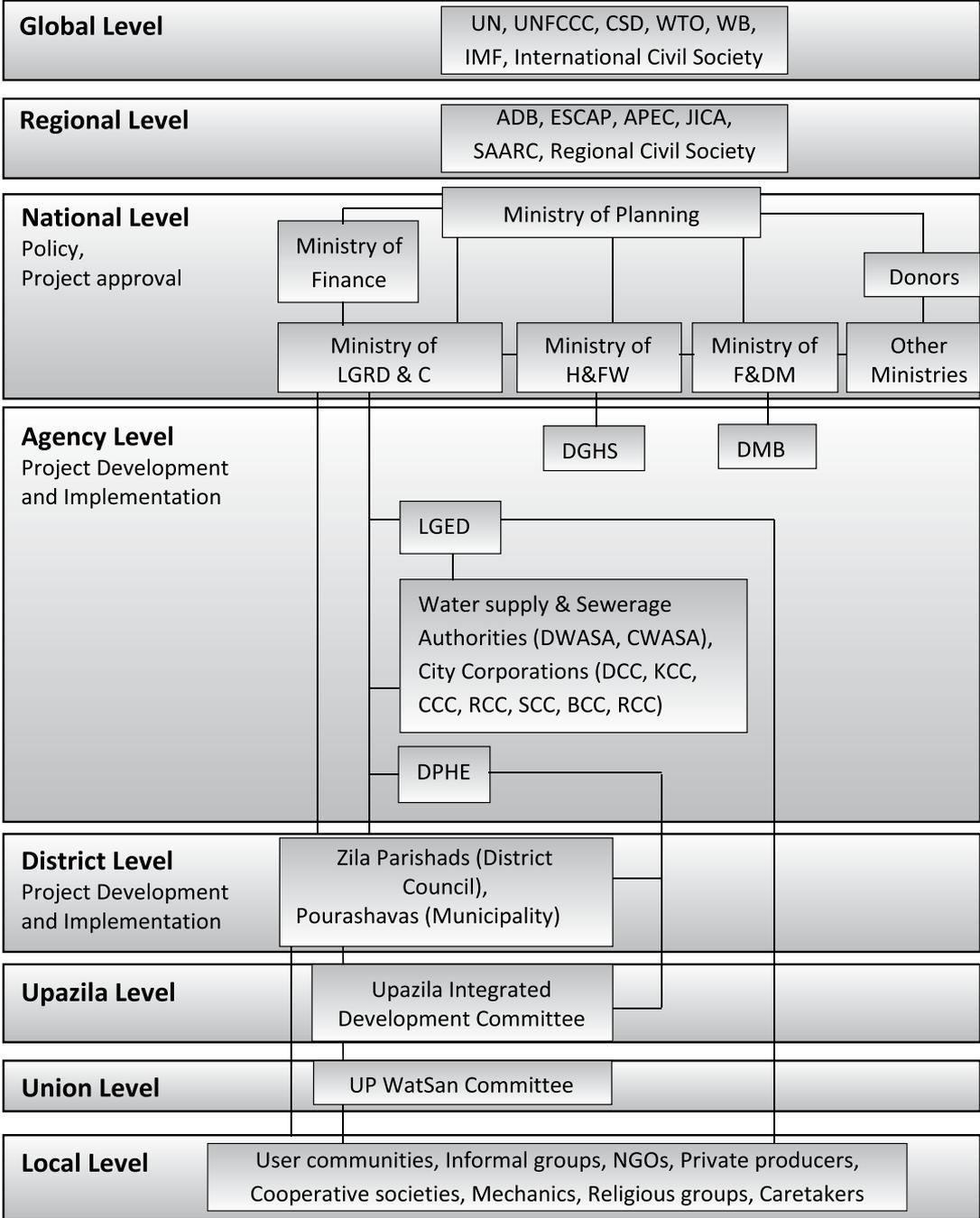


Figure 5.1: Proposed institutional framework for mainstreaming of adaptation of water supply services (Adopted and modified from UNDP, 2008; BHWDB & CEGIS, 2012)

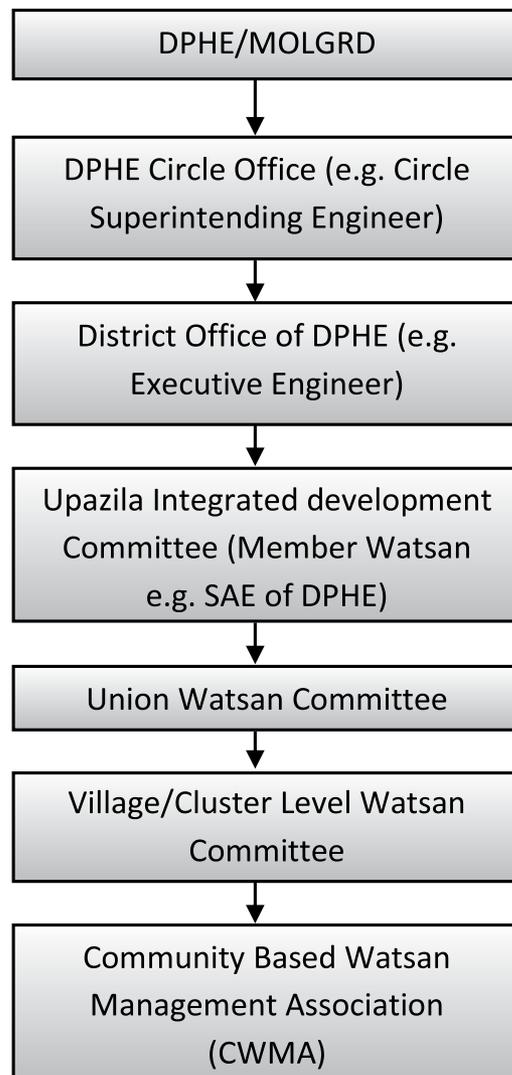


Figure 5.2: Proposed Institutional Arrangements for Water Supply and Sanitation System for Adaptation (Adopted and modified from BHWDB & CEGIS, 2012)

Within the Upazila Parishad, Upazila Unnayan Samannaya Committee (Upazila Development Coordination Committee) exist which is chaired in turn by union parishad chairmen. This committee plan, implement and evaluate water supply system. Union Parishads promotes hygiene education and generate awareness about health and hygiene. The Union Parishads have Union Water Supply and Sanitation Committees comprised of Ward member as chairman and community leaders and DPHE representatives and has very important part to play in distribution of tube-wells. Households that are in need of water supply facilities and services are identified by the DPHE and Upazila committees along with the Union Parishads. At the grass root level, the individual communities or households operate and maintains their individual facilities. Coordination has to be achieved at each of the district, thana and union levels by the respective coordination committees.

At the global level, overall guidance will be sought from the United Nations Framework Convention on Climate Change (UNFCCC) with support from the World Bank (WB), International Monitoring Fund (IMF) etc (Figure 5.1). Community based adaptation can be achieved through creation of regional committees that are linked with the national level agencies as well as the local communities (Figure 5.2). NGO's along with the government agencies and the user communities have important role to play in mainstreaming adaptation within the development activities and also part of our life for ensuring safe water for all.



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Annex A

Projects from Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009

Project Title	Adaptation in health sector
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, , Bagerhat, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To find out the social and economic cost of disease and • To monitor the adaptive measures on the impacts of climate change
Description	<p>Recent studies by the International Centre for Diarrheal Disease Research, Bangladesh (ICDDR) shows that Diarrheal diseases are on the increase, which they attribute partly to increased flooding and drainage congestion. Global warming will also raise temperatures in the summer season.</p> <p>It is necessary that the monitoring of diseases linked to climate change is upgraded and research undertaken to develop adaptive strategies.</p>
Lead Implementing Agency	Ministry of Health and Family Planning in association with research centres (IDCCR,B) and others.

Project Title	Water and sanitation program in climate vulnerable areas
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To ensure improved and safe water supply services • To provide adequate and hygienic sanitation services
Description	<p>Due to climate change Bangladesh is expected to face unavailability of fresh flow of surface water and ground water. The hazard prone areas vulnerable to floods, cyclones, storm surges, salinity intrusion will be at high risk. The availability of drinking water (both quantity and quality) needs regular monitoring. Accordingly, climate adaptive strategies for water supply and sanitation needs to be developed. The activities may include:</p> <ul style="list-style-type: none"> • Monitoring of changes in water quality and quantity available for drinking. • Forecasting of the future changes under climate change scenarios. • Make a plan and investment in additional water supply and sanitation facilities.
Lead Implementing Agency	Ministry of Local Government, Rural Development and Cooperative and various local government bodies, DPHE and NGOs in rural and urban Bangladesh.

Project Title	Improvement of flood forecasting and early warning systems
Location	Bagerhat, Barguna, Barisal, Bhola, Chandpur, Gopalganj, Jessore, Jhalokati, Khulna, Lakshmipur, Narail, Patuakhali, Pirojpur, Shariatpur
Key Objectives	<ul style="list-style-type: none"> • To increase lead times • To strengthen dissemination mechanisms
Description	<p>Recent observation shows that the Flood Forecasting and Warning Centre (FFWC) of the Bangladesh Water Development Board (BWDB) issues flood levels forecasts for 24, 48 and 72 hours which are released through e-mails as well as placed on a web-site.</p> <p>It is important that this is used by flood forecasters, together with information on river stages to improve forecasts for floodplain communities on while it would be helpful to communities and the authorities to have longer range forecasts, even though they are not always reliable.</p>
Lead Implementing Agency	Ministry of Water Resources and its various agencies; civil society organizations active in disaster management and media

Project Title	Improvement of cyclone and storm-surge warning systems
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To develop improved cyclone and storm surge warning system • To disseminate the warnings
Description	Gaps in the CPP network were exposed during Cyclone Sidr. There is thus an emergent need to review the system for making necessary improvements. Turbulent seas occur virtually over the year, which adversely affect the fishing practices and livelihoods of fishermen. To make it more relevant to communities it has recently been revised and yet to be put in to practice. Campaigning can be useful.
Lead Implementing Agency	Ministry of Food and Disaster Management, Bangladesh Red Crescent Society, NGOs and CBOs (community based organizations) working in the coastal areas and media

Project Title	Awareness raising and public education towards climate resilience
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To ensure disaster preparedness • To improve resilience according to community standard
Description	<p>Climate change is likely to be an increase in climate-related natural disasters. An increase in the magnitude and intensity of floods, agricultural droughts, storm-surges and cyclones, and other disasters (e.g., coastal and river bank erosion and landslides by heavy rainfall and drainage congestion in urban areas) is making the situation worst.</p> <p>So there is a need to raise awareness among communities and officials and some areas where urgent attention may be given include shelter management, search and rescue and health issues during and after disasters</p>
Lead Implementing Agency	Ministry of Food and Disaster Management, Bangladesh Red Crescent Society, NGOs, CBOs working in the coastal areas, media (print and electronic)

Project Title	Repair and maintenance of existing flood embankments
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To ensure continued flood protection through embankments • To rehabilitate existing flood embankments
Description	<p>For embankments along major rivers a 50 year return period was used. Due to lack of proper maintenance many of these embankments are in poor shape. The embankments are cut by local people to drain water from the land into the rivers in so many places. These points remain vulnerable to breaches, though these gaps are filled in again. Sometimes the appurtenant structures, such as sluices and regulators no longer function properly. By saying this it is very important to rehabilitate existing river flood embankments so that they are fully functional and able to provide the level of security for which these were constructed.</p>
Lead Implementing Agency	Ministry of Water Resources and its agencies

Project Title	Repair and maintenance of existing cyclone shelters
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To ensure that the cyclone shelters are safe and functional • To provide protection from cyclones
Description	The entire coastal belt of Bangladesh is vulnerable to cyclones and storm surges and the existing coastal embankments can be overtopped by high storm surges. However, during Cyclone Sidr, many people who sought refuge in cyclone shelters were afraid of their safety because of the poor condition of the structures. As storm surge may hit the coast of Bangladesh, anytime, and at any location, cyclone shelters along the entire coastal belt must be immediately made fully functional and operational.
Lead Implementing Agency	Ministry of Food and Disaster Management, Red Crescent Society, private sector under their CSR programmes and NGOs

Project Title	Improvement of urban drainage
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To prevent drainage congestion and urban flooding due to heavy rainfall • To maintain the pollution free urban environment
Description	By using historical rainfall data the current storm drainage systems of the major cities were designed and these design capacities will be exceeded in future. The major impacts of climate change is likely to be an increase in the number of episodes of short duration and heavy rainfall which will result in water logging due to drainage congestion. In existing cities, the drainage capacity of the sewer system must be improved as well as adequate sewers must be designed and constructed.
Lead Implementing Agency	Ministry of Local Government and Rural Development with the Local Government Engineering Department, Dhaka WASA, Chittagong WASA

Project Title	Adaptation against floods
Location	Bagerhat, Barguna, Barisal, Bhola, Chandpur, Gopalganj, Jessore, Jhalokati, Khulna, Lakshmipur, Narail, Patuakhali, Pirojpur, Shariatpur
Key Objectives	<ul style="list-style-type: none"> • To identify the vulnerable flood prone areas • To plan flood proofing measures
Description	Report by the IPCC predicted that monsoon rainfall could increase by at least one-third over the next fifty years which would result in the over-topping of existing flood embankments. Climate change scenarios is needed to estimate future river flows and flood risks while a plan to upgrade structural measures against likely future floods can be made. Once a new flood vulnerability map and associated Digital Elevation Model is developed, flood proofing measures may be planned, especially in the most vulnerable areas, including chars.
Lead Implementing Agency	Ministry of Water Resources and its agencies

Project Title	Adaptation against future cyclones and storm-surges
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To ensure that the coastal area and its islands can adapt to the future cyclones and storm surges • To protect people and reduce damages of properties from cyclones and storm surges
Description	The entire coastal belt of Bangladesh is vulnerable to cyclones and storm surges. Existing embankments and shelters would be repaired. This programme would provide for protection against future increases in tropical cyclones and storm surges, due to climate change. An extensive network of polders has already been constructed in Bangladesh. However, the heights of the dykes will need to be raised further. There are some additional lands and small islands, which need to be protected through the construction of new polders. The capacity of the existing sluices and regulators as well as water management structures will need to be assessed and remedial measures undertaken, where necessary.
Lead Implementing Agency	Ministry of Water Resources, Ministry of Environment & Forest, Ministry of Food & Disaster Management

Project Title	Climate change modelling at national and sub-national levels
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To develop, maintain and update a detailed and operational General Circulation Model (GCM) for Bangladesh • To simulate future climate change conditions under different scenarios and assumptions
Description	<p>Global warming and climate change are caused by increasing concentrations of green house gases caused by anthropogenic factors. Temperature rises will vary in different parts of the world and used a number of global circulation models to generate future climate scenarios.</p> <p>As to generate more precise climate change scenarios for Bangladesh, it is necessary to develop appropriate GCM models should be calibrated down to district and sub-district levels and teams of specialists should be able to work on selected model/models, to simulate future conditions under different scenarios and assumptions. The models would predict climate change scenarios with increasing precision.</p>
Lead Implementing Agency	Bangladesh Meteorological Department, Universities, research organisations, FFWC

Project Title	Preparatory studies for adaptation against Sea Level Rise (SLR) and its impacts
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To predict Sea Level Rise (SLR) and its impacts • To identify the impacts due to SLR
Description	<p>The main culprit of climate change is sea level rise (SLR) caused by the thermal expansion of sea water and the melting of snow and ice. These factors may be compounded locally by tectonic activities. The sea level rise threatens the low-lying coastal belt and small islands. Our coast is protected with 4 to 5 meter high dykes and will be further protected with additional planned polders. The main impacts of SLR are salinity ingress causing the rivers in the coastal belt to become brackish or saline. This would have serious impacts on production of food grains which would also adversely affect agriculture. There is no data collection agenda to monitor SLR.</p>
Lead Implementing Agency	Ministries of Defence, Shipping, Agriculture, Industries and Energy and Power

Project Title	Macroeconomic and sectoral economic impacts of climate change
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To find out the economic impacts of climate change at national, regional and local level • To plan adaptation and mitigation strategies
Description	<p>Bangladesh has been experiencing strong economic growth in recent years. The impacts that climate change will have on</p> <ol style="list-style-type: none"> 1. macro-economic growth and stability; 2. different sectors of the economy, and 3. different regions and socio-economic groups, in the short, medium and long terms. <p>This agenda will evaluate the impact of climate change on the macro economy and carry analyses. Women and children are expected to be more adversely affected by climate change than men and the analyses will use gender-disaggregated data where possible.</p>
Lead Implementing Agency	Ministry of Finance, sectoral ministries, Ministry of Women Affairs, Ministry of Social Welfare, Ministry of Chittagong Hill Tracts, Universities, Research Organisations

Project Title	Management of urban waste
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To ensure livable cities by lowering GHG (methane) emissions. • To ensure a clean city through proper management of urban waste.
Description	<p>Urban wastes of Bangladesh, is mainly composed of organic materials and thus produce methane (CH₄) as they decompose. Contribution of methane to global warming is much higher than that of carbon dioxide. While ensuring a cleaner city Proper management of urban waste could thus be an important area for mitigation.</p>
Lead Implementing Agency	Ministry of Local Government, private entrepreneurs

Project Title	Revision of sectoral policies for climate resilience
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To integrate climate change issues into development policy and action • To make the sectoral policies adaptive to climate change
Description	The government and people of Bangladesh realized that climate change is threatening many sectors. Our food, water, energy and livelihood security are threatened. Climate change management needs to be integrated into the development activities of different sectors. Sectoral policy statements need to be modified to take account of and become consistent with climate change impacts and their management. There is also a need for a National Climate Change Policy to guide the integration of climate change issues into development planning and to provide a framework for sectoral policies.
Lead Implementing Agency	MoEF, Cabinet division

Project Title	Mainstreaming climate change in national, sectoral and spatial development programmes
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To incorporate Climate Change issues under the development process at all levels • To ensure development of climate resilient development programs
Description	Bangladesh government is committed to integrate climate change into all aspects of national, sectoral and spatial development in the country. This will require: (a) incorporating climate change into policies, plans, programmes and projects; (b) establishment and building the capacity of ministries and agencies so that they are able to do this; (c) focusing, to start with, on those specific sectors, where climate change will be a key issue (e.g., water, agriculture, food, disaster management, health, forests, energy and power, transport and communication, women affairs and Chittagong Hill Tracts).
Lead Implementing Agency	All relevant ministries; Planning Commission

Project Title	Strengthening institutional capacity for climate change management
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To strengthen the capacity of the organizations. • To implement climate change focused development programs.
Description	Climate change issues in national and sectoral development require strong organisations and a strong institutional framework to ensure that the activities are sustained over the next several decades and beyond. Some of the organisations will be new; others will have to be reformed and strengthened. There is a pressing need to strengthen a number of existing organisations that are already underperforming in implementing the regular development programme.
Lead Implementing Agency	All relevant sectoral agencies, private sector, NGOs and others

Project Title	Main-streaming Climate Change in the Media
Location	Barguna, Barisal, Bhola, Jhalokati, Khulna, Patuakhali, Pirojpur, Chandpur, Chittagong, Cox's Bazar, Feni, Lakshmipur, Noakhali, Gopalganj, Shariatpur, Bagerhat, Jessore, Narail, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To raise public awareness across the country. • To raise awareness among the print and electronic media.
Description	Media has been pro-active in mounting public awareness on climate change issues for last two decades in Bangladesh. But journalists who have been very much alive in sensitizing the country on various environmental issues. cannot give the scale of climate-induced adverse impacts on the national economy, livelihoods and eco-systems, the people requires to more aware while Bangladesh vibrant print and electronic media can play that effective role in a very comprehensive manner to help bring in positive changes in public opinion to make policy changes. Bangladesh media is very much active by raising national negotiation capacity by infusing public debate on climate change issues in both print and electronic media.
Lead Implementing Agency	Ministry of Environment and Forests, Ministry of Information, Press Institute of Bangladesh

Annex B

Projects from National Water Management Plan (NWMP), 2004

Project Title	Water Supply and Distribution Systems (e.g. General and community based pipe water supply)
Location	Barguna, Barisal, Bhola, Patuakhali, Pirojpur, Chandpur, Lakshmipur, Noakhali, , Bagerhat, Khulna, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To provide safe and reliable water supply system for all inhabitants. • Develop major new well fields and surface water sources for bulk water supplies. • Improvement of main water distribution system based on existing DTWs and new surface sources
Description	Improvements and extensions of the water supply systems are necessary for ensuring safe water for all. Therefore this program will help accomplish the objective through a combination of public/private sector and NGO initiative.
Lead Implementing Agency	GoB, BWDB, MoI, MoH, DoE, WARPO, City corporations and NGOs.

Project Title	Storm water Drainage
Location	Barguna, Barisal, Bhola, Patuakhali, Pirojpur, Chandpur, Lakshmipur, Noakhali, Comilla, Feni, , Bagerhat, Chuadanga, Jessore, Jhenaidah, Khulna, Satkhira
Key Objectives	<ul style="list-style-type: none"> • Develop adequate and efficient drainage system. • Develop storm water drainage network including gravity or pumped systems, open or covered drainage network and, drainage areas for stormwater retention to reduce peak flows.
Description	The rehabilitation, improvement and extension of the stormwater drainage system is necessary to ensure proper drainage and avoid flooding problems. This program will mitigate stormwater drainage problem by ensuring a properly planned drainage system. This project will be funded by GoB.
Lead Implementing Agency	GoB, BWDB, MoI, MoH, DoE, WARPO, City corporations and NGOs.

Project Title	Impacts of Salinization on Water Management of the Sundarbans under Climate Change
Location	Barguna, Bagerhat, Khulna, Pirojpur, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To develop a much improved state of knowledge of the relations between the ecological health of the Sundarban forests reserve and aquatic environment • To provide clear guidance on long term water management needs for the Sundarbans forest.
Description	<p>For different occupational groups, better social and environmental facility generation and the development of eco-tourism, the Sundarbans Biodiversity Project has been taken that aims initially to identify a management system for the biodiversity conservation of the forest and fishery resources and expanding economic opportunities. Along with this further research is urgently needed to understand the linkages between the impact of salinity intrusion on the water system and the ecology of the area.</p> <p>Although initial attempt has been made recently through collection of salinity data from the forest area. Increase in salinity brought about by the changes in upland channel flows has been widely attributed as being the main reason for top-dying of the Sundari trees that are found throughout most of the forest given the good correlation between salinity levels and potential wood production. In addition to salinity factors such as water level, tidal cycles, flow velocities, sediment loads, turbidity, micro-nutrient concentrations and other elements would also make an impact on the growth and sustainability of different species.</p> <p>The program will provide for an extensive scoping exercise followed by a period of data collection and analysis and a review and update of climate change factors, concluding with a set of recommendations for salinity control and improved water conditions favorable to the ecology of the area.</p>
Lead Implementing Agency	DoF, WARPO, DoE, BWDB

Project Title	Preparation of Regional River Management Plan
Location	Barguna, Barisal, Bhola, Patuakhali, Pirojpur, Chandpur, Lakshmipur, Noakhali, Comilla, Feni, , Bagerhat, Chuadanga, Jessore, Jhenaidah, Khulna, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To ensure proper management of rivers. • To improve the many facets of river management.
Description	<p>Proper functioning and management of the river system is one of the major thrusts of government's policy and this work has to be done within a framework of decentralized and devolved management responsive to end-user needs. This program forms part of a comprehensive suite to improving the many facets of river management as well as river development. Therefore, river management plans at regional level need to be prepared to provide the overall guidance and ensured proper management of rivers.</p>
Lead Implementing Agency	BWDB, LGED, BIWTA, GoB and NGOs

Project Title	Flood Proofing of the National, Regional and Key Feeder Roads
Location	Barguna, Barisal, Bhola, Patuakhali, Pirojpur, Chandpur, Lakshmipur, Noakhali, Feni, Bagerhat, Chuadanga, Jessore, Jhenaidah, Khulna, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To target at the flood proofing needs of key portions of Bangladesh's highway network. • To raise embankments in high risk areas.
Description	Although this is a long-term program with national coverage; but as the costs would be very high if incurred in the context of a stand-alone exercise it has been assumed that embankment raising will be carried out when it is emergency for major maintenance or re-surfacing, with priority given to high risk areas in the case of national and regional roads. As the work involves simply the raising of existing roads, environmental impacts would be minimal.
Lead Implementing Agency	GoB, LGED

Project Title	Land Reclamation and Afforestation
Location	Barguna, Barisal, Bhola, Patuakhali, Pirojpur, Chandpur, Lakshmipur, Noakhali, Feni, , Bagerhat, Chuadanga, Jessore, Jhenaidah, Khulna, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To empolder new sea land and estuary by means of embankments, internal drainage and other works. • To plant up existing coastal lands, where feasible as well as to plant up newly accreted land as it reaches the stage where afforestation will be viable and effective.
Description	<p>It has been found that there will be some new accretion and estuary by 2025 and some limited areas of existing coastal land do not have sufficient protection (NWMP, 2004). So it is necessary to accelerate the land accretion process in the estuary and sea with the help of technology. Land reclamation estuary and sea offers a good opportunity to meet the land demand for increasing population.</p> <p>On the other hand afforestation of coastal land with mangrove species provides protection against cyclone storm surges and embankment erosion and helps to stabilise newly accreted land. Financial and other constraints have prevented the full area being afforested yet.</p>
Lead Implementing Agency	GoB

Project Title	Environmentally Critical Areas and Integrated Wetland Management
Location	Barguna, Pirojpur, Bagerhat, Khulna, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To provide the necessary protection and sustainable use measures in the water sector. • To define and refine the necessary water requirements.
Description	<p>This programme is going to review all major waterbodies or types of waterbodies discussed in the NWMP and most vulnerable areas as new ECAs. Recommendations of provisions for protection of waterbodies in rural areas if necessary will be included on changes to the laws and regulations.</p> <p>ECA water requirements will be progressively refined and measures to ensure minimum water requirements for ecological purposes are maintained-including, for example, critical areas, levels, depths and durations/seasonality. Most importantly the program will be subsumed into an integrated wetlands management programme, addressing the ecological needs and not merely water needs.</p>
Lead Implementing Agency	DoE, WARPO, MoEF, BELA and other NGOs

Project Title	Household (Bari) Level Cyclone Shelter
Location	Barguna, Barisal, Bhola, Patuakhali, Pirojpur, Chandpur, Lakshimpur, Noakhali, Feni, , Bagerhat, Chuadanga, Jessore, Jhenaidah, Khulna, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To provide safe havens in the form of concrete framed building, one in each bari (household) in the coastal area. • Ensuring easy access to women.
Description	<p>Cyclone shelters are the major means of protection against cyclone surges and they are made of substantial concrete and brick buildings set on columns above cyclone surge level. The major at-risk population is located in many regions like south central and south east region and few people are at risk in the extensive coastal zone of south west due to the protection provided by the Sundarbans mangrove forest. Since many shelters are located outside of risk area, the effective shelter provision by means of conventional multi-purpose cyclone shelter is quite expensive. So an alternative approach is to decentralize shelter provision and thereby reduce shelter size, by introducing household (bari) level shelters. Bari-level cyclone shelter includes a 1m high parapet wall, to ensure that the total protection reaches a height 6m above natural ground level.</p> <p>In the long run this type of local level shelter would be cheaper as well as more effective than the conventional one with higher social benefit and no significant environmental impacts.</p>
Lead Implementing Agency	GoB

Project Title	Arsenic Mitigation
Location	Barguna, Barisal, Bhola, Patuakhali, Pirojpur, Chandpur, Lakshmipur, Noakhali, Feni, , Bagerhat, Chuadanga, Jessore, Jhenaidah, Khulna, Satkhira
Key Objectives	<ul style="list-style-type: none"> • To make provision of safe drinking water in arsenic affected areas. • To provide short time solutions that can be used in the household. • To highlight the need to raise public awareness, health education, basic training on arsenic mitigation techniques and importance of choice among the available solutions. • To prioritize the poor and women as the main domestic water managers.
Description	<p>The arsenic issue is a serious water problem which potentially affects the health and wellbeing of millions. Estimates of the numbers at risk depend on the permissible level of arsenic in drinking water. The Bangladesh standard is less than 50 microgram per litre and the WHO standard is less than 10 microgram per litre.</p> <p>Based on current available data, the proportion of the population using an improved drinking water source is 85.5% (93.3% in urban and 83.8% in rural areas) following the Bangladesh standard. Using the WHO guideline for arsenic, 75.2% of the population uses improved drinking water source where 85.3% is in urban and 73% is in rural areas. (BBS, 2009)</p> <p>The majority of those at risk are poor and they live in both urban and rural areas. In these areas, greater dependence is on shallow HTWs where high levels of arsenic contamination occur. The program will provide short term solutions like arsenic filters fitted to HTWs and mini Tara pumps, arsenic removal kits which can be used in the household, pond sand filter and re-excavation of wells.</p>
Lead Implementing Agency	LGED, DPHE, GoB, NGOs

Annex C

Figures

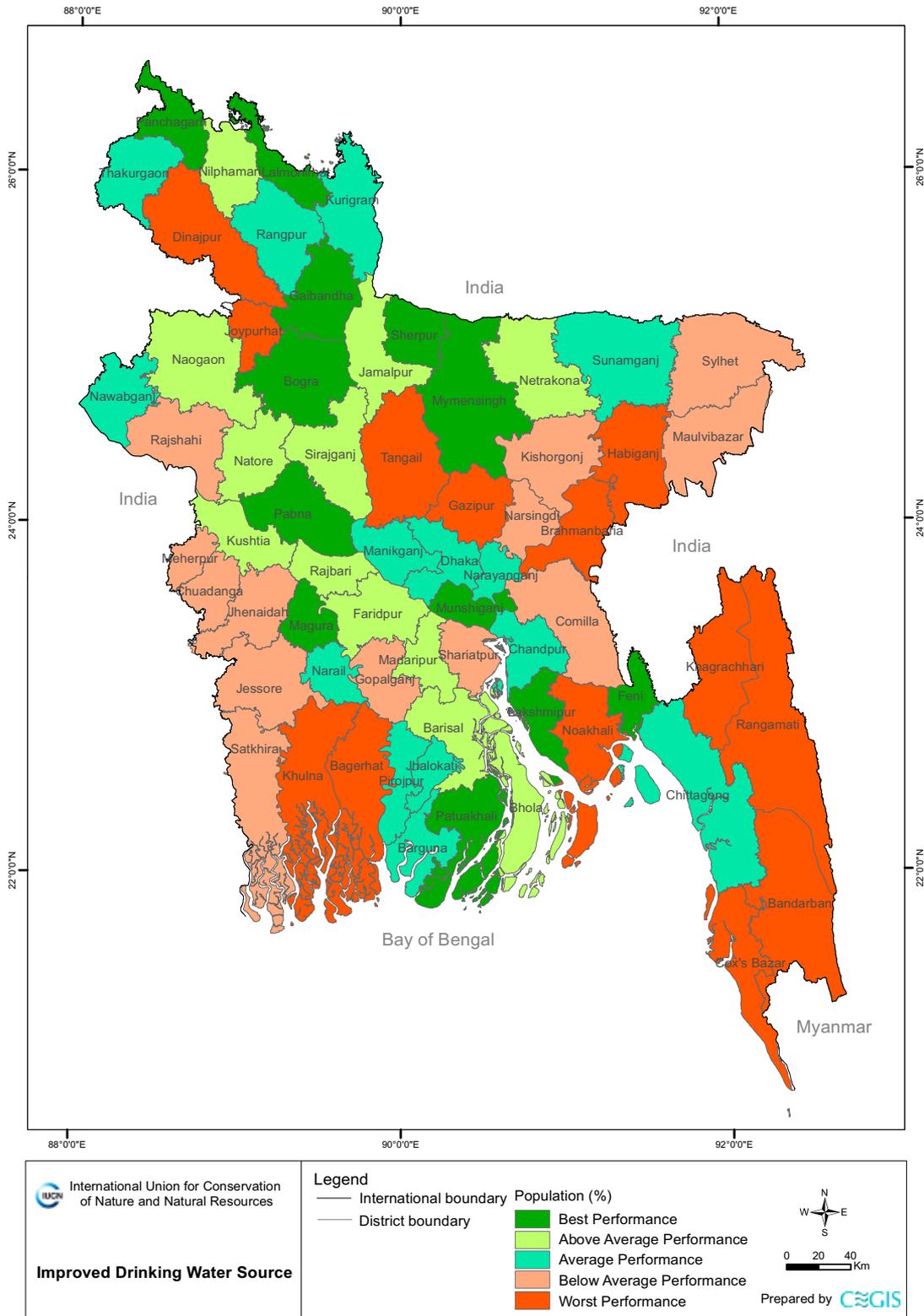


Figure 1.1: Improved drinking water sources by district (Source: BBS, 2009)

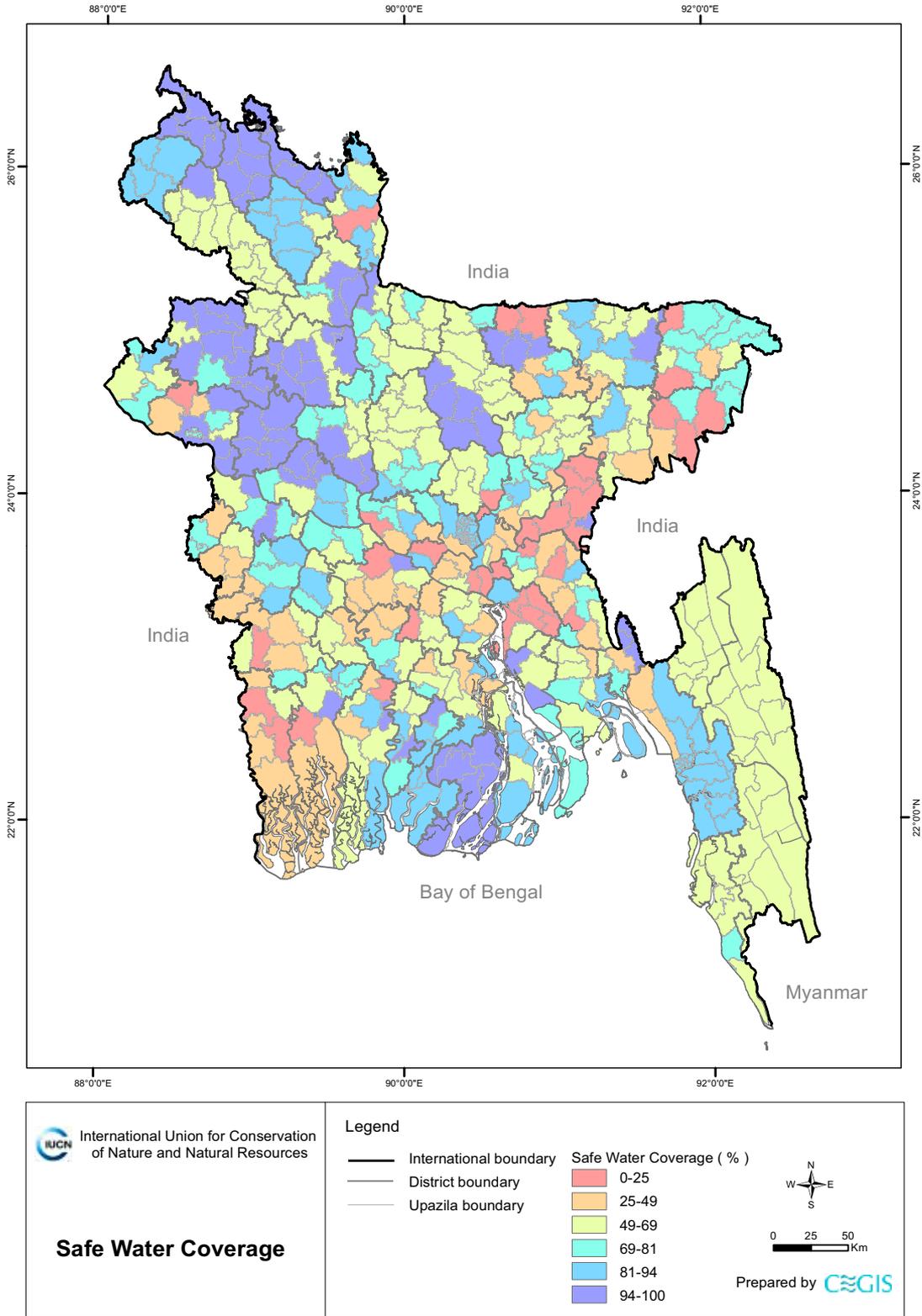


Figure 1.2: Safe water coverage by upazila (Source: BBS, 2009; JICA 2010)

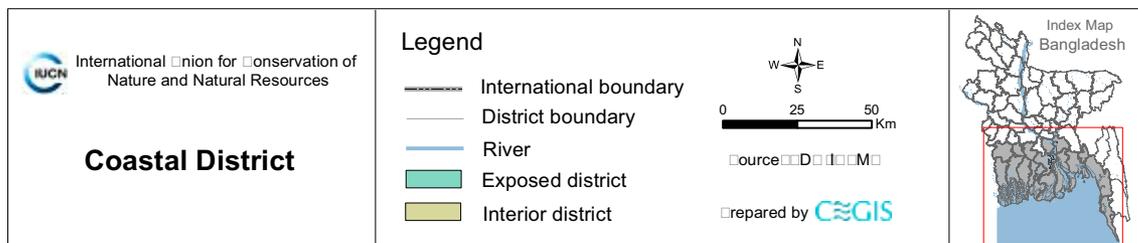
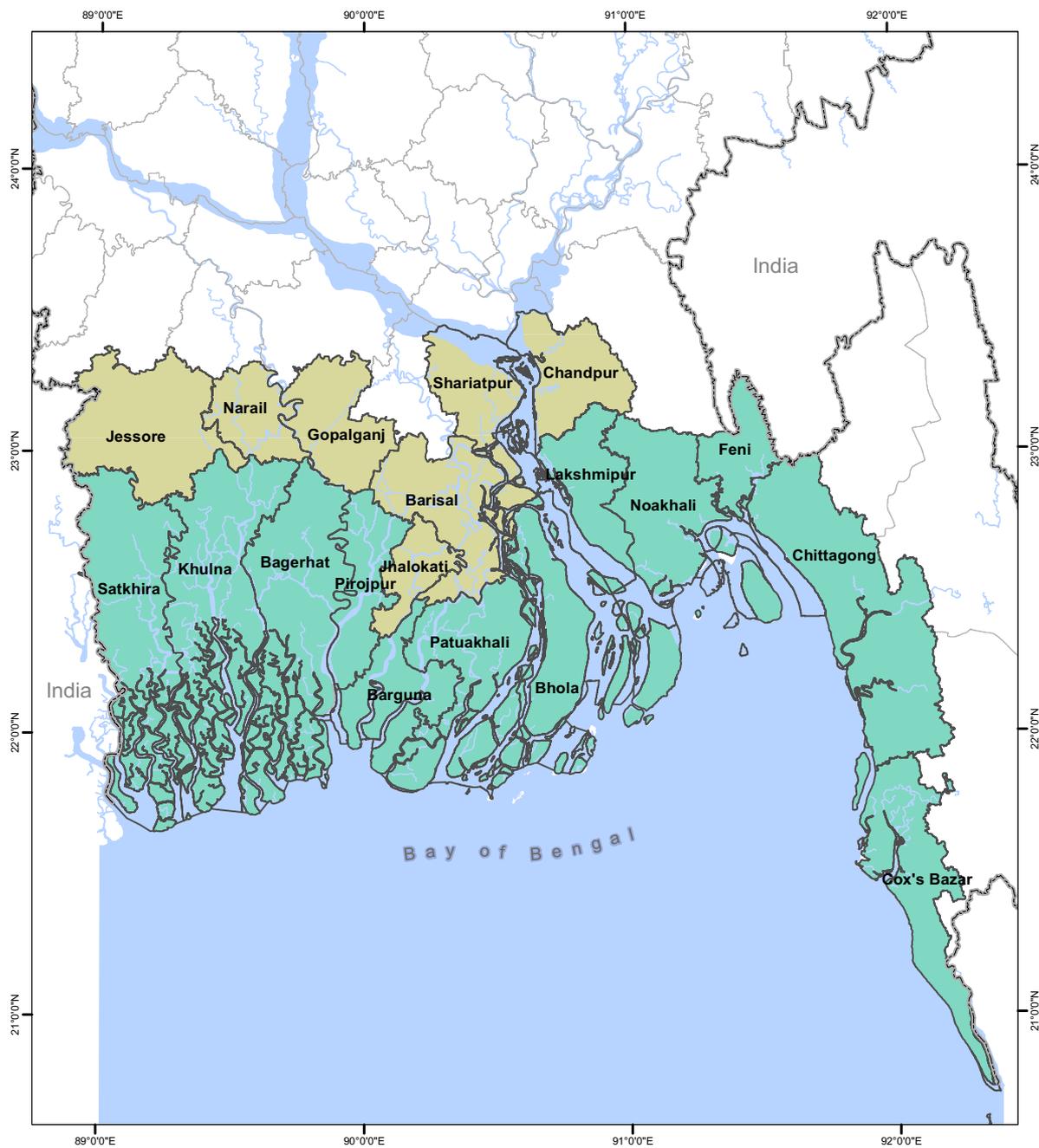


Figure 2.1: Coastal zone of Bangladesh

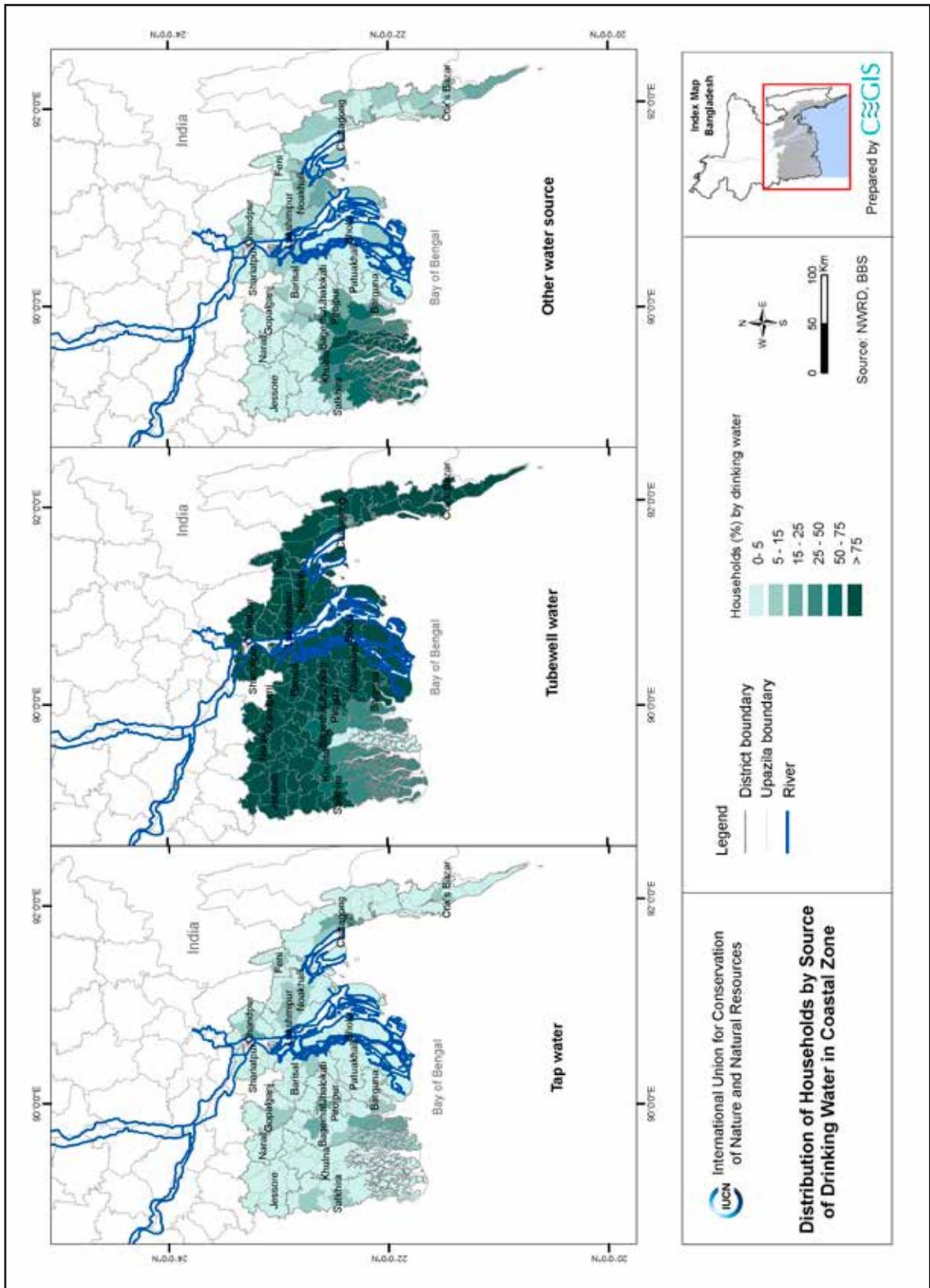


Figure 2.2: Distribution of households by source of drinking water in the south west, south central and coastal region

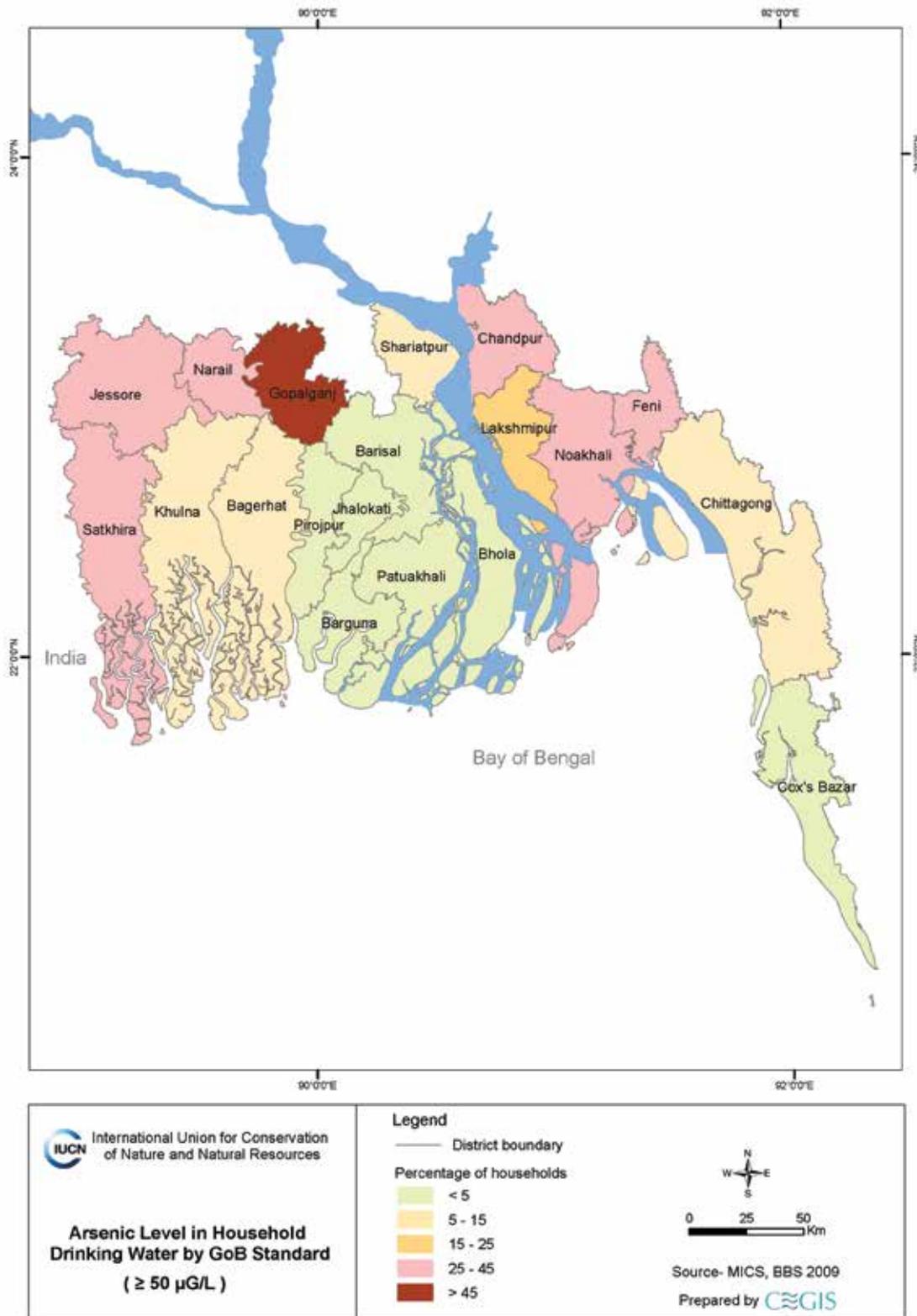


Figure 2.3: Proportion of the households with arsenic contamination in drinking water by GoB standard of greater than 50 micrograms/litre (Source: BBS, 2009)

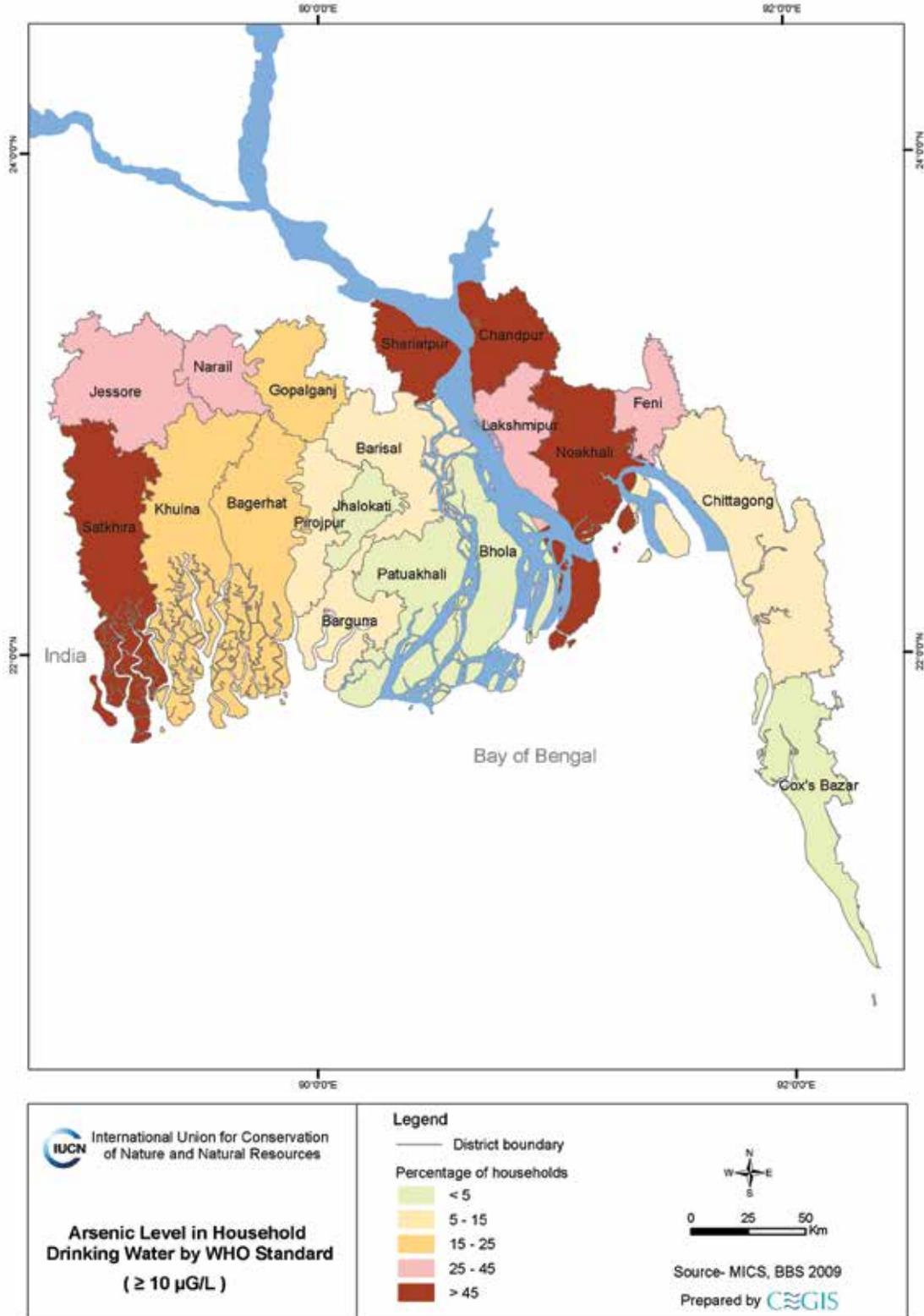


Figure 2.4: Proportion of the households with arsenic contamination in drinking water by WHO standard of greater than 10 micrograms/litre (Source: BBS, 2009)

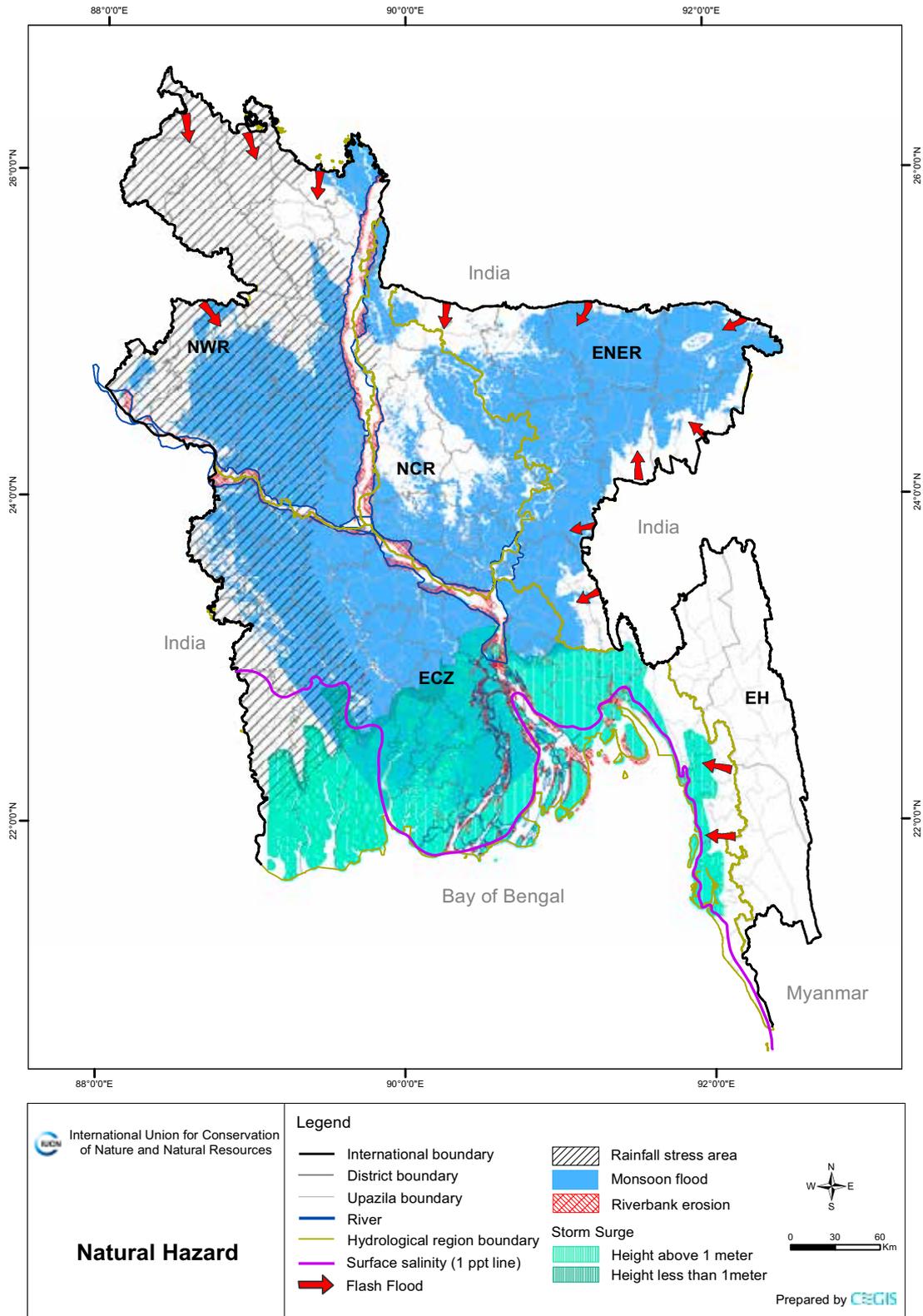


Figure 2.5: Multiple hazard map of Bangladesh (Source: NWRD; WB, 2010)

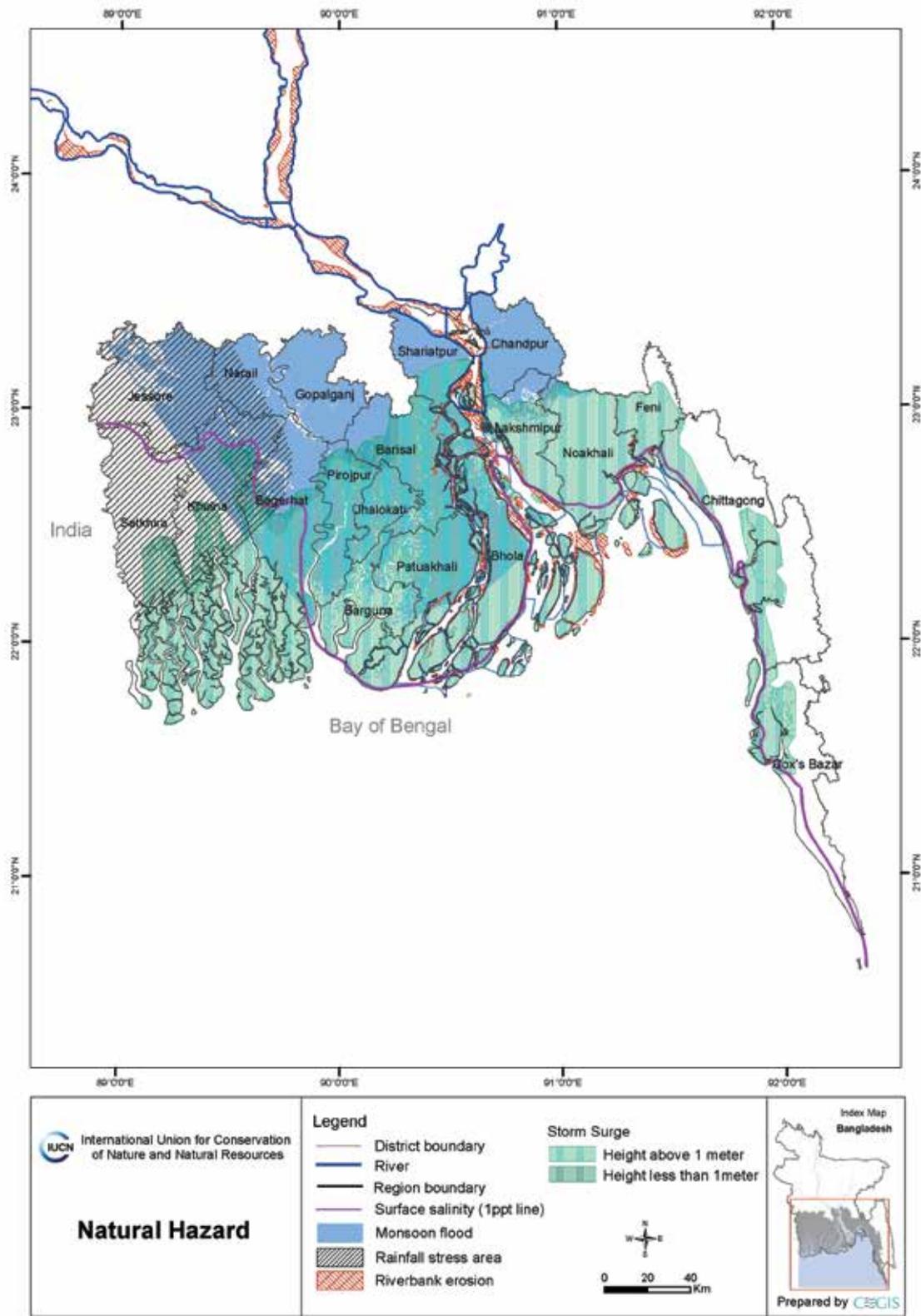


Figure 2.6: Multiple hazard map of the coastal zone (Source: NWRD; WB, 2010)

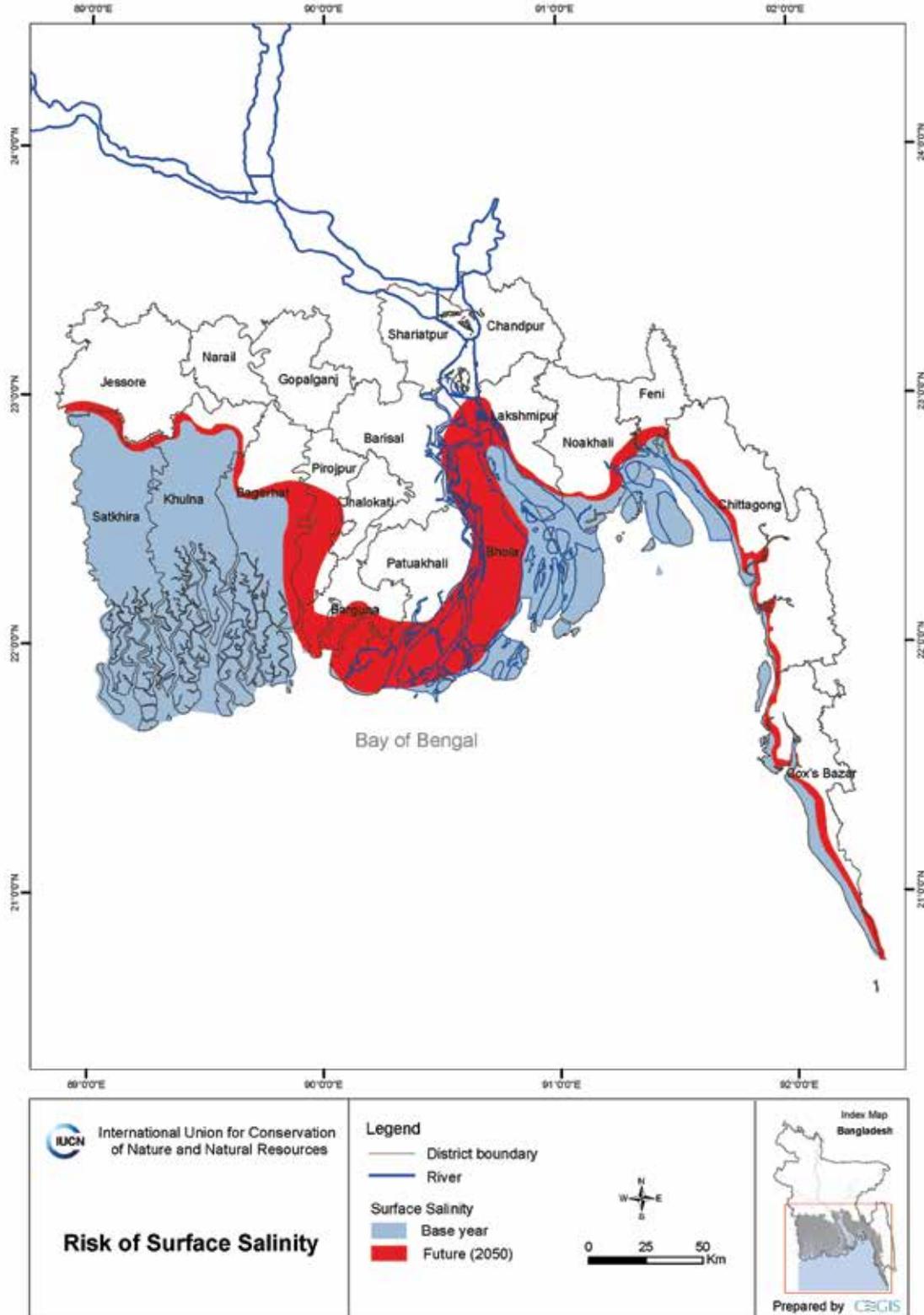


Figure 3.1: Surface water salinity condition in coastal area for 2050 (Source: CEGIS, 2011)

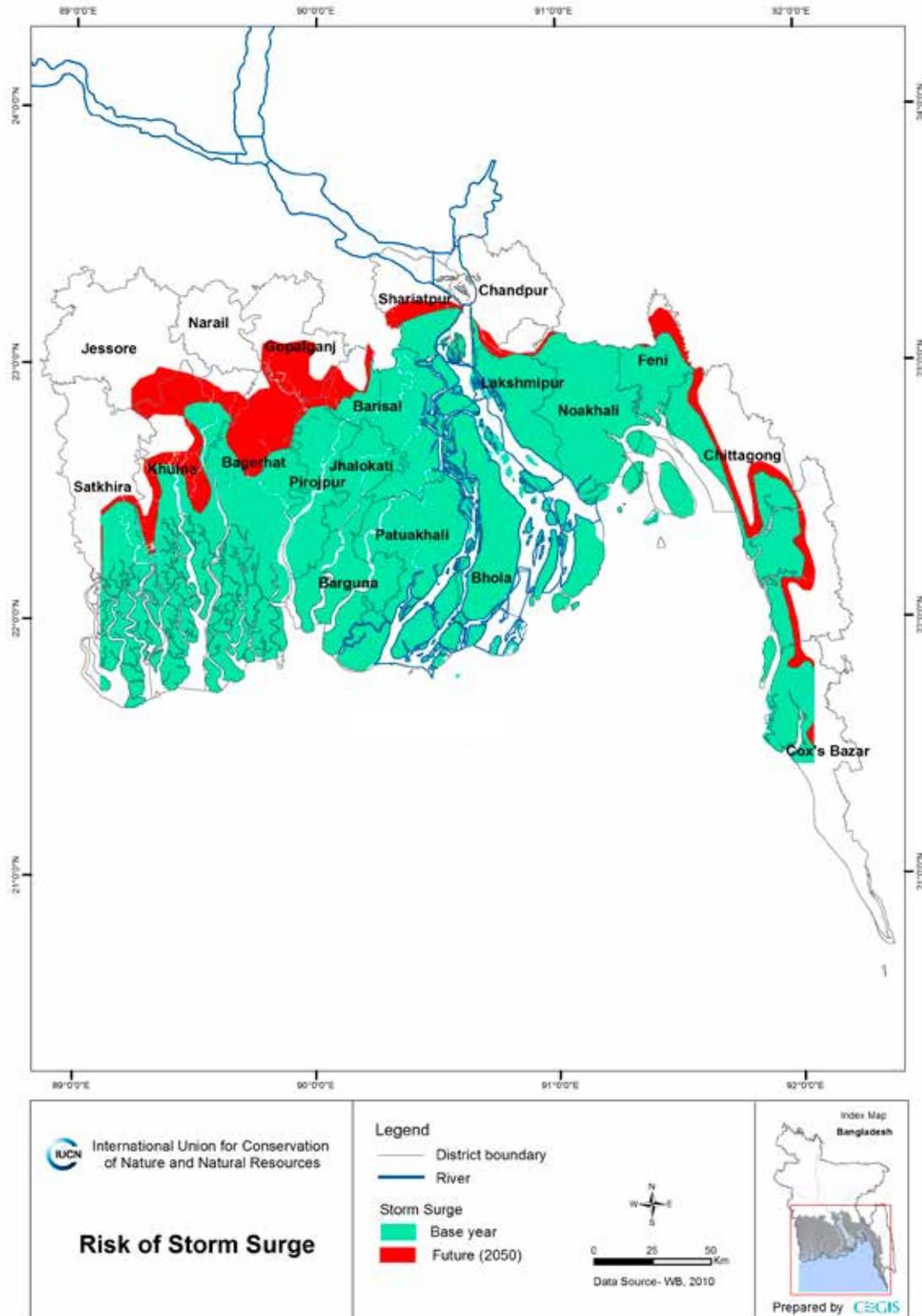


Figure 3.2: Risk of storm surge in coastal area for 2050 (Source: WB, 2010)

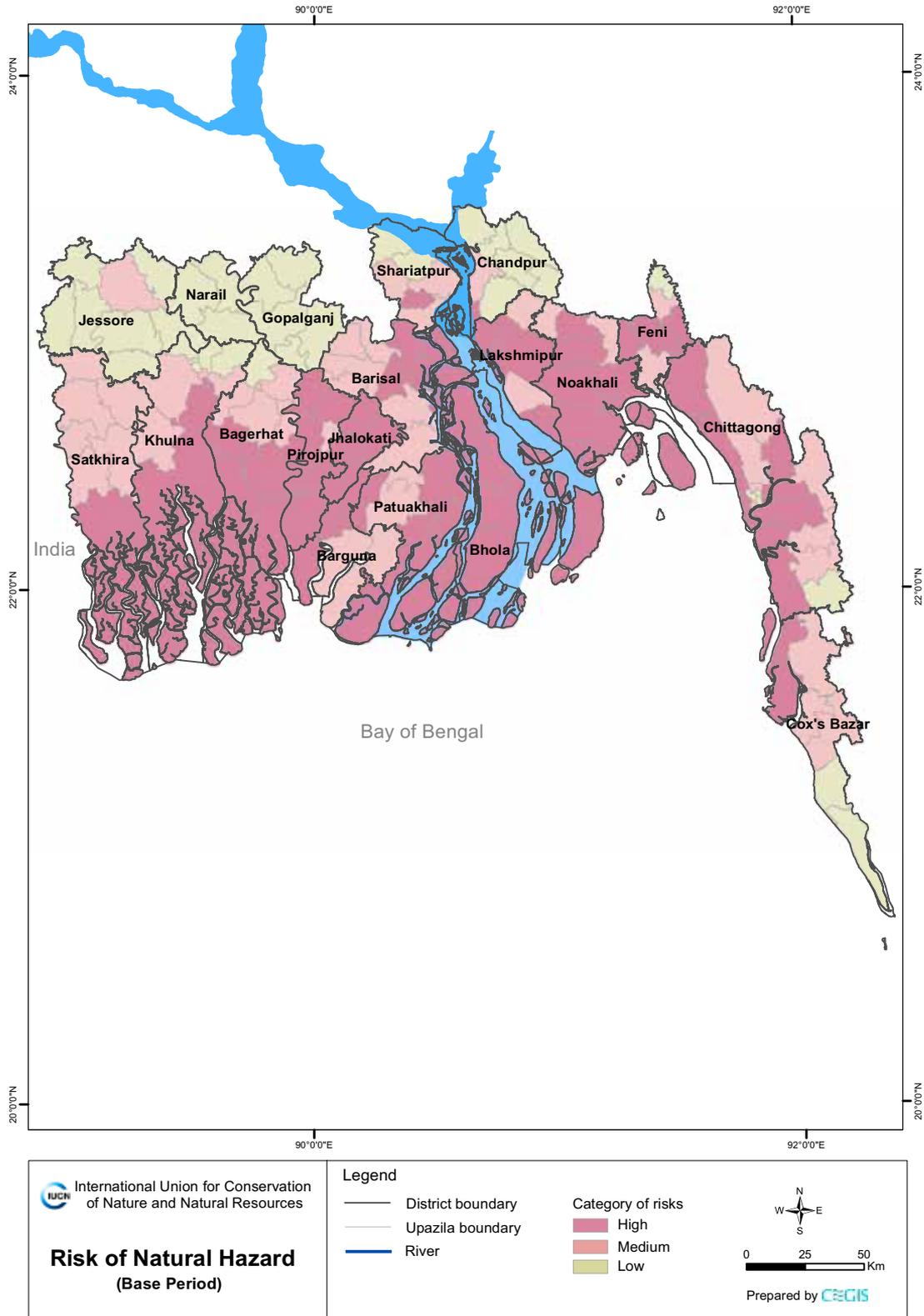


Figure 3.3: Risk of natural hazard under the base scenario

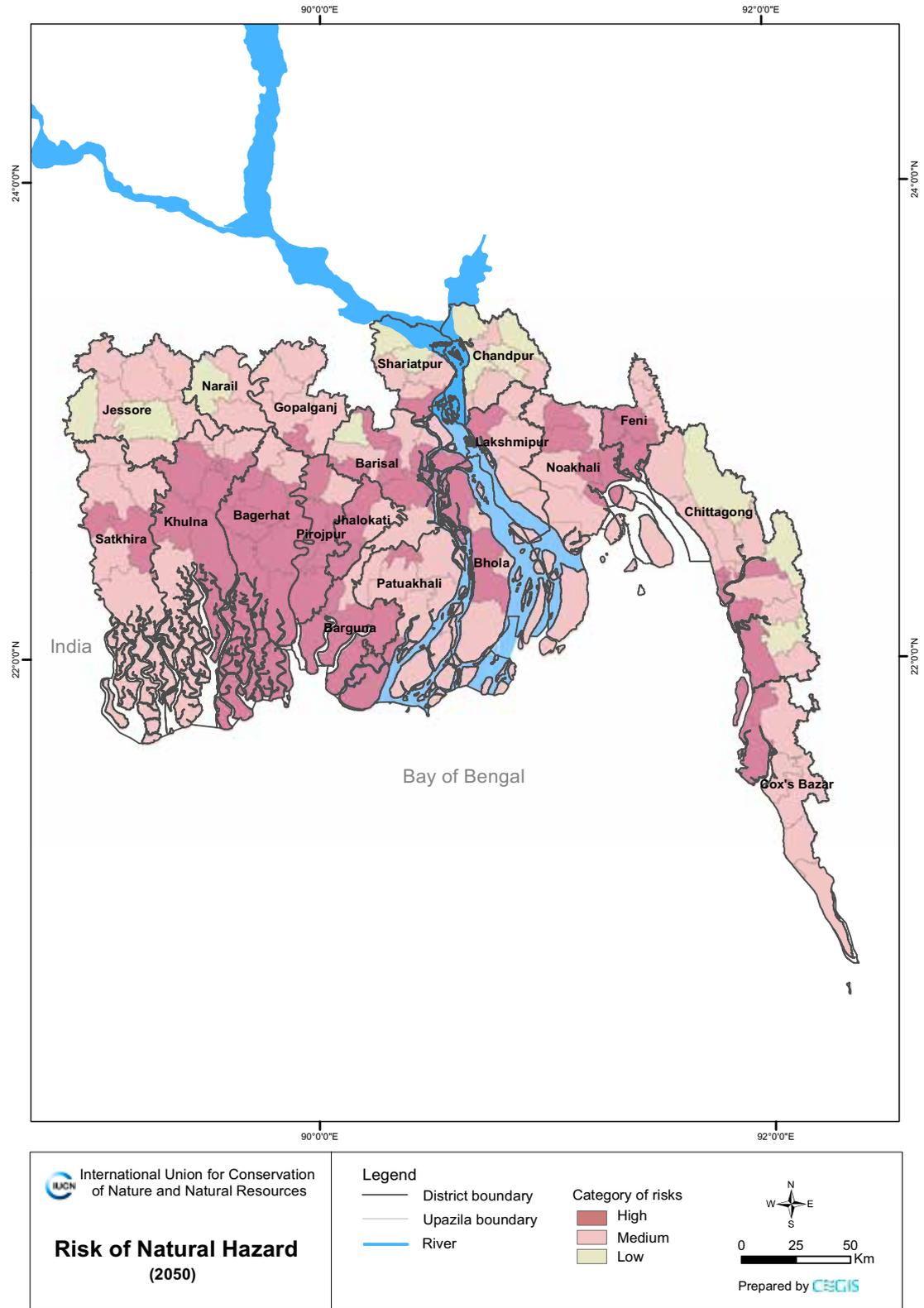


Figure 3.4: Risk of natural hazard under the climate change scenario

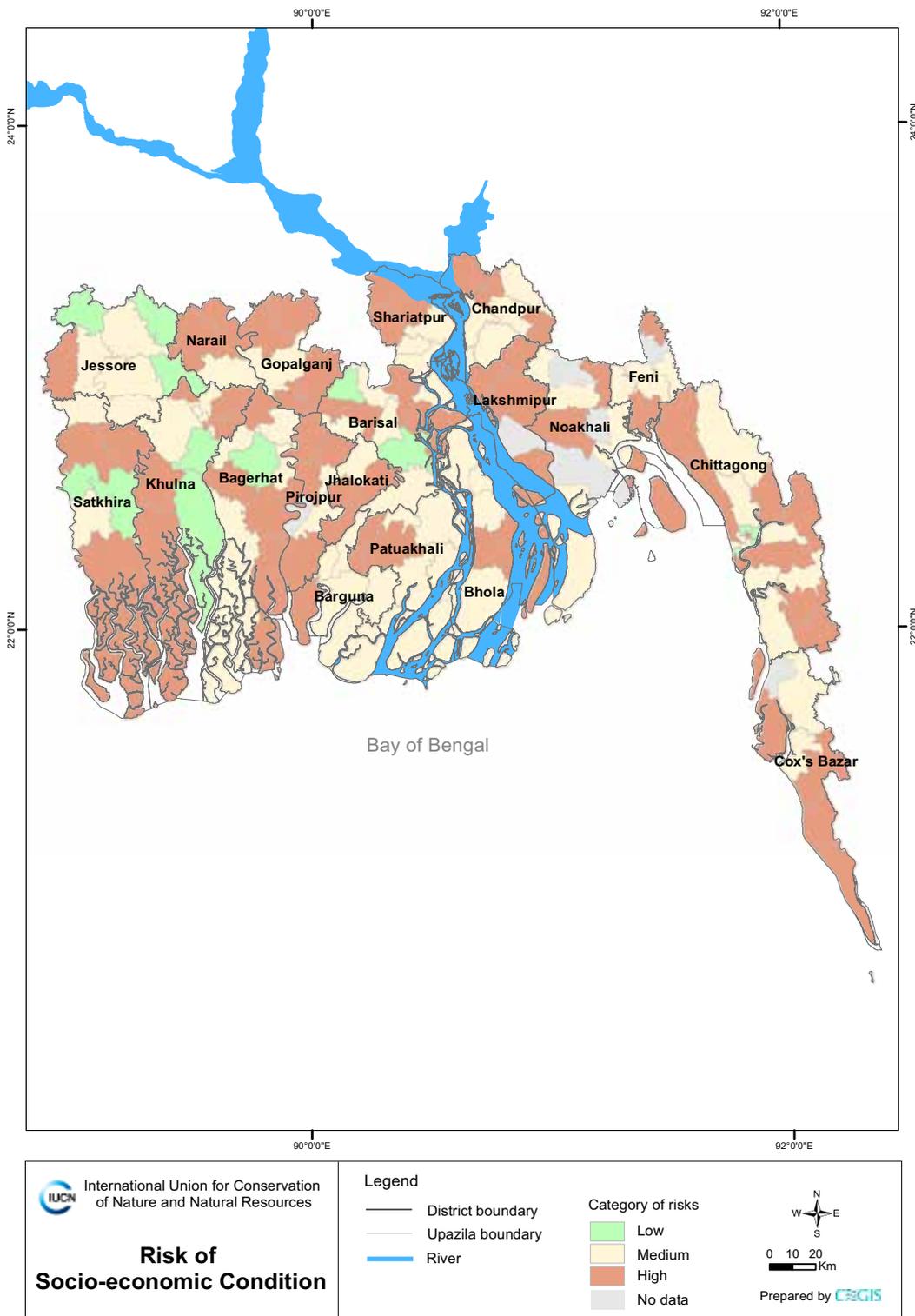


Figure 3.5: Risk due to socio-economic vulnerability

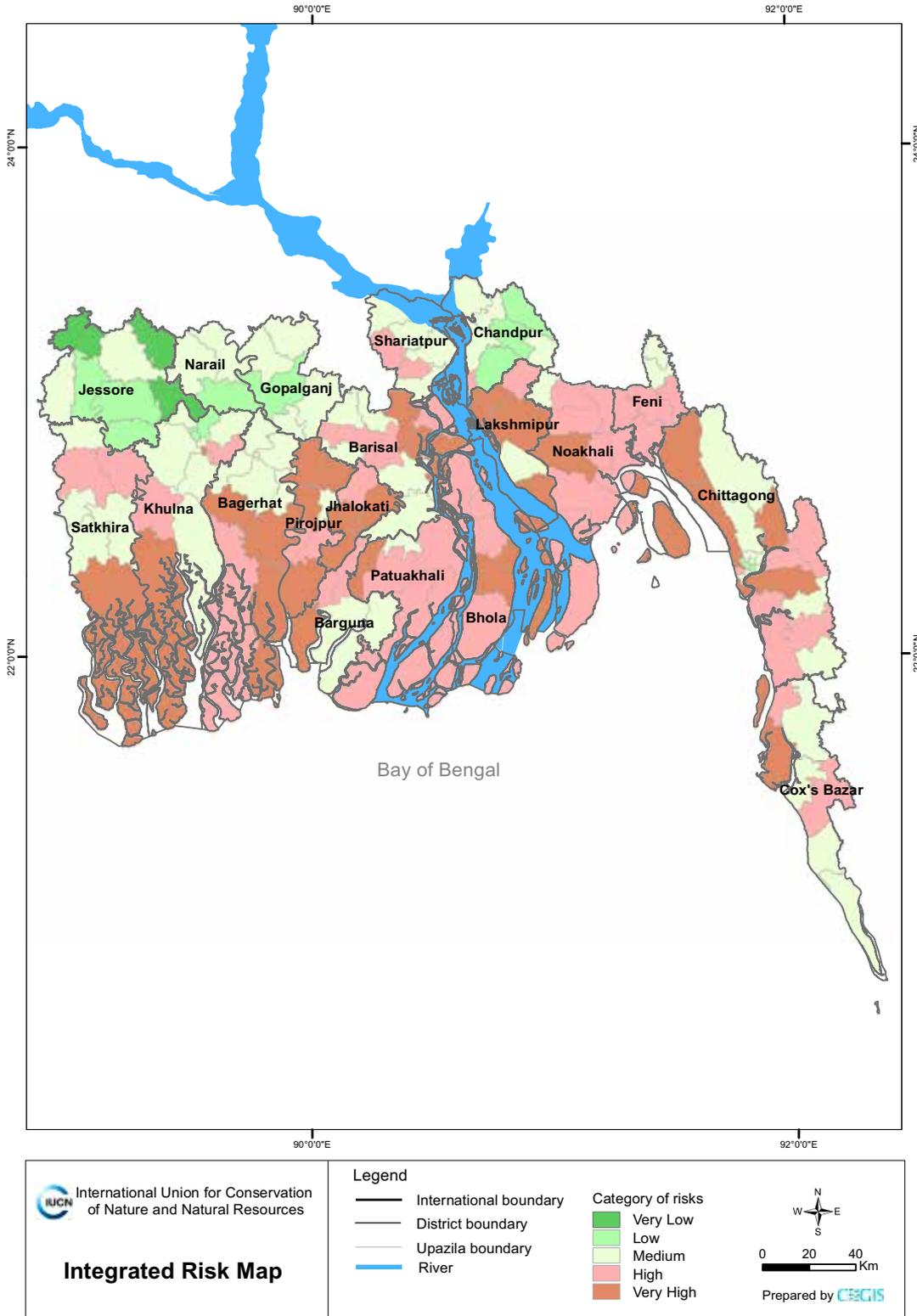


Figure 3.6: Integrated risk due to natural hazards and social vulnerability



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