Climate Risk Screening Report

Proposed Multitranche Financing Facility and Technical Assistance Grant

BAN: Third Public-Private Infrastructure Development Facility

Summary

Climate Projection

Temperature: Annual mean temperature within the project area is projected to increase by 2.47^0 Celsius against the baseline period (1960-1990). The highest temperature rise is projected to occur in the month of January (>2.7^0C), and the lowest rise is projected for the month of July (<2.1^0C). Spatially, temperature rise is slightly lower over the coastal regions (Chittagong, southern Khulna, and Barisal divisions) and higher over inland regions.

Precipitation: Annual precipitation is projected to increase by 131mm, or 5.8% increase over the baseline period. Increase in annual total precipitation is projected to occur overwhelmingly (96.7%, 127mm) during the monsoon season from May to October. No significant change is projected for the dry seasons (November-December, and January-April). Spatially, Sylhet is projected to experience a much higher increase in annual precipitation (>200mm), followed by northern Dhaka, eastern part of Rangpur and Rajshahi (160mm-200mm), then Chittagong Hill Tracks (100-150mm), and the lowest increase in precipitation (<100mm) is projected to occur over the central, south, and southwestern parts of the country.

Climate Impact

1). Impact on Safety and Integrity of Physical Structures

Bangladesh is prone to flooding, lightning, hailstorms, cyclones, tornadoes, sea level rise, etc. The intensity of all hydro-meteorological hazards is projected to increase in the future due to changes in climate. This will have profound implications to the safety and integrity of all physical structures of large infrastructure investment projects, particularly within the coastal regions which are more susceptible to climate change impact. All planned projects (from all sectors) within the coastal regions will naturally fall within a high risk category.

2). Impact on Renewable Energy Generation

The most feasible forms of renewable energy generation would be wind and solar. Wind power projects are likely to be located along the coastal areas since these areas are endowed with the most abundant wind resources. In terms of resources endowment in the future, climate change may not have a significant impact and in fact, wind speed along the coast is projected to increase. However, in terms of structural safety, since wind turbines are most vulnerable to cyclone wind, the project design will be governed by wind load.
For solar power generation, the ideal locations are the northwestern part of Bangladesh (Rangpur, Rajshahi, and northern Khulna), the climate impact will be manifested in the forms of increased rainy days (which will increase solar intermittency), and prolonged dry spells (which will affect foundations of solar towers).

3). Impact on Transmission and/or Connection to the Grid

Substations will be prone to flood risks which are projected to increase in the future. Tropical cyclones can devastate overhead transmission lines. The intensities of tropical cyclones and tornadoes are generally projected to increase in the future due to global warming. Higher temperatures cause decreased transmission efficiency, sagging of transmission lines, and de-rating of transformers. Temperature rise also results in an increase in thunderstorm activity and consequently lighting strikes on power systems.

Draft Report

C Y Ji

September 9, 2016

Screening Template

Date: 2016-09-06-09

1. Project Information

Project Title/No.	Country/Province	Sector/Type	Modality/Amount	Stage
Third Public-Private Infrastructure Development Facility / 42180-016	Bangladesh / All	Finance / Infrastructure Finance and Investment Funds	MFF ADB: $526m	RRP

Current Project Components[1]	**1. Increased available long-term debt financing for infrastructure projects including some innovative public-private partnership interventions.** 1). At least 8 subprojects, including 2 medium-size to large-scale RE subprojects are financed under PPIDF3 utilizing the $526 million resource envelope. **2. Catalyzed take-out financing for infrastructure projects.** 1). At least 1 eligible subproject refinanced by IDCOL (2016 baseline: not applicable. Take-out financing were only introduced under PPDIF3). **3. Strengthened institutional capacity of Infrastructure Development Company Limited (IDCOL).** 1). Integrated risk management framework approved by IDCOL Board and implemented as certified by an independent consultant; 2). Treasury management framework approved by IDCOL Board and implemented as certified by an independent consultant; 3). Integrated resource management system approved by IDCOL Board and implemented as certified by an independent consultant; 4). Safeguards capacity building plan for improving social and environmental risk mitigation and gender equality results approved by IDCOL's Board and implemented as certified by an independent consultant 5). IDCOL's mid-term business and strategy plan submitted and approved by IDCOL's Board and key recommendations implemented as certified by an independent consultant.
Project Area	The whole country.

2. Climate Projections

<table>
<tr><th>Variable</th><th>Baseline (1960-1990) and Projection (2050s, Ensemble Mean)</th><th></th></tr>
<tr><td>Temperature</td><td>Annual mean temperature within the project area is projected to increase by 2.47^0 Celsius against the baseline period (1960-1990). The highest temperature rise is projected to occur in the month of January (>2.7^0C), and the lowest rise is projected for the month of July (<2.1^0C). Spatially, temperature rise is slightly lower over the coastal regions (Chittagong, southern Khulna, and Barisal divisions) and higher over inland regions.

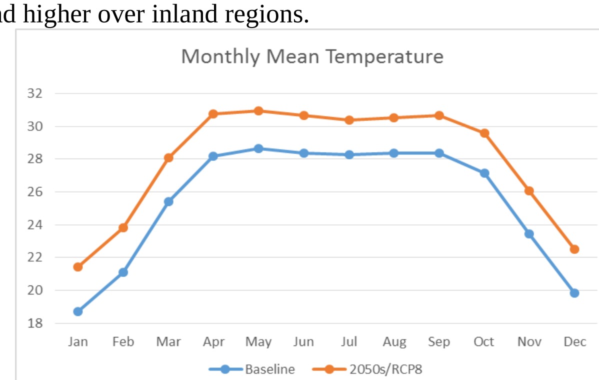


Figure 1. Baseline and Projected Monthly Mean Temperature of the Bangladesh.</td><td></td></tr>
<tr><td>Precipitation</td><td>Annual precipitation is projected to increase by 131mm, 5.8% increase over the baseline period. Increase in annual precipitation is projected to occur overwhelmingly (96.7%, 127mm) during the</td><td></td></tr>
</table>

[1] ADB, 2016. Report and Recommendation of the President to the Board of Directors, People's Republic of Bangladesh: Third Public-Private Infrastructure Development Facility. September, 2016.

<table>
<tr><td></td><td colspan="3">monsoon season from May to October. No significant change is projected for the dry seasons (November-December, and January-April). Spatially, Sylhet is projected to experience a much higher increase in annual precipitation (>200mm), followed by northern Dhaka, eastern part of Rangpur and Rajshahi (160mm-200mm), then Chittagong Hill Tracks (100-150mm), and the lowest increase in precipitation (<100mm) is projected to occur over the central, south, and southwestern parts of the country.

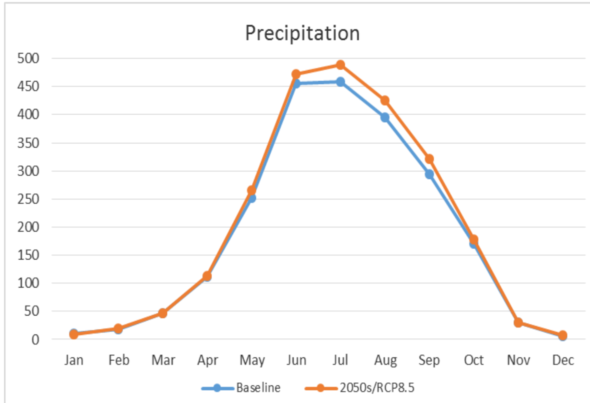


Figure 2. Baseline and Projected Monthly Precipitation of Bangladesh.</td><td></td></tr>
<tr><td colspan="5">3. Screening Natural Hazard</td></tr>
<tr><td>Type</td><td>Overall Risk/Hazard</td><td>Climate Impact[2]</td><td>Climate Variables/Confidence</td><td></td></tr>
<tr><td>Earthquake</td><td>Moderate[3]</td><td>N/A</td><td></td><td></td></tr>
<tr><td>Evaluation</td><td colspan="3">Low Risk: Rajshahi, northern and eastern Dhaka,
Medium/High Risk: Chittagong, Sylhet.

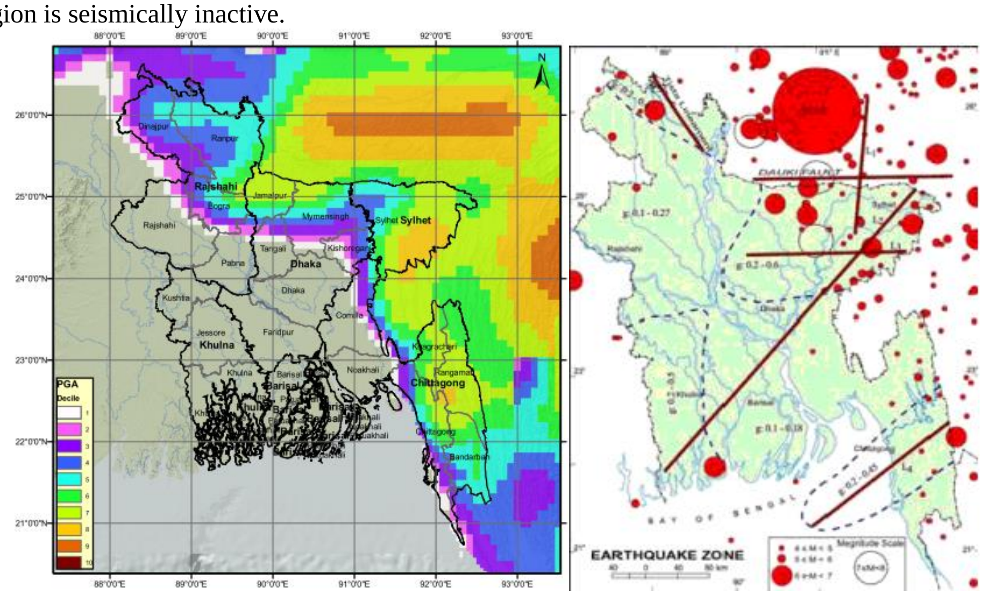
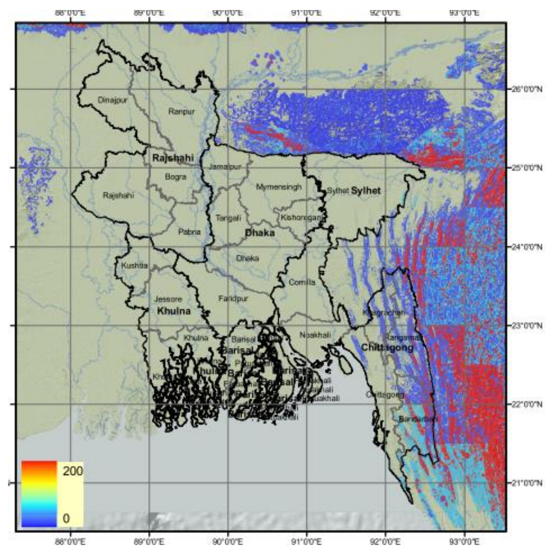
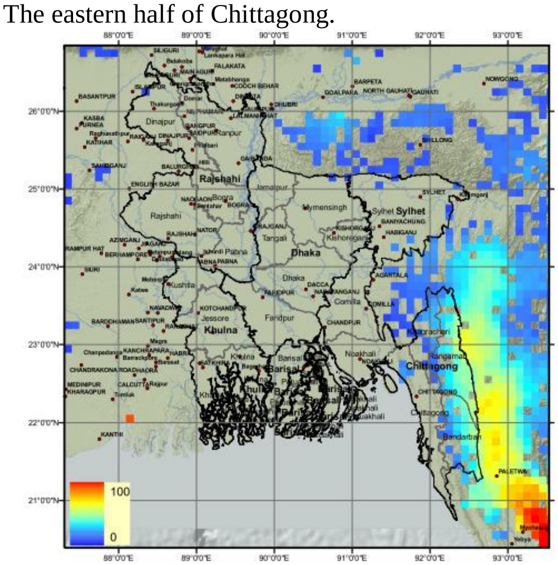
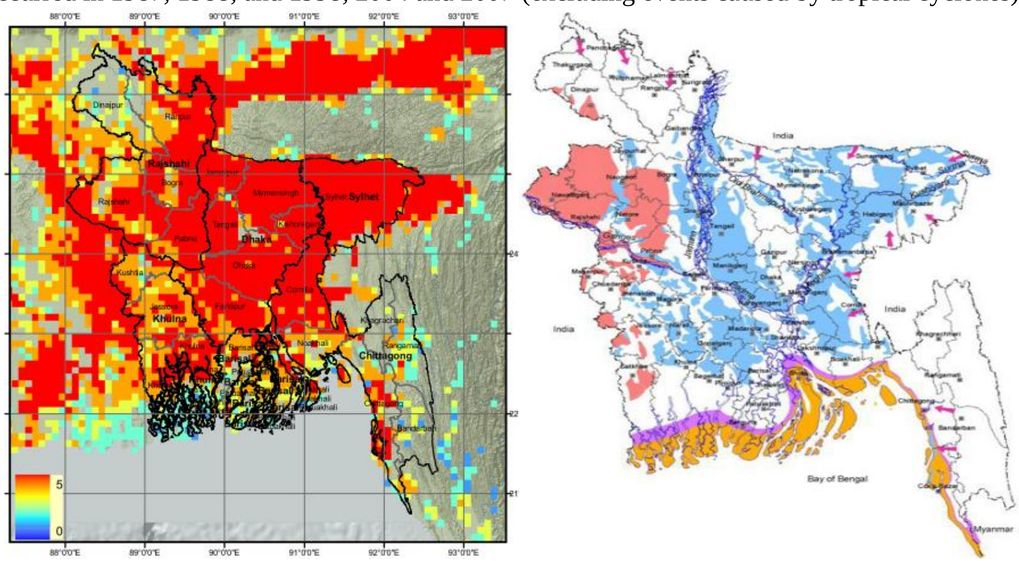
The north, northeastern, and eastern parts of Bangladesh are prone to seismic activities. The delta region is seismically inactive.


Figure 3. Left: Peak Ground Acceleration (PGA) of the Project Area. Right: Major earthquakes in Bangladesh and adjacent regions[4].</td><td></td></tr>
<tr><td>Landslide Triggered by</td><td>Medium</td><td>N/A</td><td></td><td></td></tr>
</table>

[2] Only climate impact on renewable energy generation is evaluated. Impact on other sector infrastructure is ignored.
[3] The assessment is based on World Seismic Hazard Map.
[4] http://www.saarc-sadkn.org/countries/bangladesh/hazard_profile.aspx.

Earthquake				
Evaluation	The eastern part of Chittagong is prone to a medium risk of landslides triggered by seismic activities.			
Landslide Triggered by precipitation	Medium/High	High	Increased Monsoon Intensity/Medium	
Evaluation	The eastern part of Chittagong is prone to a medium to high risk of landslides triggered by rainfall. Due to hill cutting for property development in some areas of Chittagong, the risk of landslides has substantially increased. The episode in 2007 was the most devastating event in the recent history.  Figure 4. Hazard Map of Landslide Triggered by Rainfall.			
Climate Change Implications	Research[5] shows that the trends of heavy precipitation (>100mm) events in the last 50 years is increasing as compared to precipitation events less than 100mm. Precipitation during the monsoon season (May to October) within the state is projected to increase by 6.3% and the frequency of extreme rainfall events is projected to increase. More frequent landslides may occur in the future.			
Forest/Wild Fire	Low/Medium	Medium	Rising temperatures/Low	
Evaluation	Low to Medium Risk: The eastern half of Chittagong.  Figure 5. Fire Hazard Map of Bangladesh.			

[5] B. N. Goswami, V. Venugopal, D. Sengupta, M. S. Madhusoodanan, 2 Prince K. Xavier; Increasing Trend of Extreme Rain Events Over India in a Warming Environment, Science 1 December 2006: Vol. 314. no. 5804, pp. 1442 - 1445.

Climate Change Implications	The relationship between meteorological conditions and fire occurrence is well known[6]. Forest fires tend to be concentrated in summer months when temperature is high and air humidity and fuel moisture are low. Rising temperatures and decreasing precipitation during the pre-monsoon period will result in reduced moisture content of fuel (i.e. biomass) thus making forests more susceptible to wildfire. Forest fire season is also expected to lengthen due to global warming.			
Flood	High	High	Increased Monsoon Intensity/Medium	
Evaluation	Bangladesh is one of the most flood-prone countries in the world. About 75% of the Bangladesh landmass is approximately only 10m above sea level, and 80% is in the floodplains of the large Gangetic delta. A huge inflow of water from upstream catchment areas coinciding with heavy monsoon rainfall in the country, a low floodplain gradient, congested drainage channels, the major rivers converging inside Bangladesh, tides and storm surges in coastal areas, and polders that increase the intensity of floodwater outside protected areas. Different combinations of these various factors give rise to different types of flooding[7]. During catastrophic floods about two-thirds of the country may be affected[8]. Irregular floods of high magnitude can have disastrous effects. Flooding occurs on an annual basis. During the last 50 years, at least 7 mega floods have occurred, affecting about 35-75% of the land area. Major flooding recorded in recent years occurred in 1987, 1988, and 1998, 2004 and 2007 (excluding events caused by tropical cyclones).  Figure 6. Left: Flod Hazard Map of Bangladesh. Right: Spatial Vulnerability of Bangladesh to Various Types of Floods. Source: WARPO-Halcrow et al., 2004. [From: World Bank, 2010. Annex 9]. Floods in Bangladesh can be classified into four categories (Ahmad et al. 1994; Ahmed et al. 2000): flash floods, (2) river floods, (3) rainwater floods, and (4) coastal floods. **1). Flash floods**: Flash floods usually take place in the hilly areas during the pre-monsoon months of April and May. Runoff due to exceptionally heavy rainfall in upland areas causes flash floods. Flash floods occur within a short period of time and last from a few hours to a few days. Flash floods occur frequently—sometimes several times a year—mauling standing crops and destroying physical infrastructure at the foot of the northern and eastern hills of Bangladesh (Huq et al. 1996).			

[6] Chandler, C., Cheney, P., Thomas, P., Trabaud, L., and Williams, D., 1983. Fire in Forestry, Vol I. Forest Fire Behaviour and Effects, John Wiley, New York, p.450.

[7] Ahmed, A.U. and Mirza, M.M.Q, 2000, 'Review of Causes and Dimensions of Floods with Particular Reference to Flood '98: National Perspectives'. In Q.K. Ahmad, A. K. A. Chowdhury, S.H. Imam, M. Sarker, (Eds.) Perspectives on Flood 1998, The University Press Limited, Dhaka, pp.142.

[8] Ahmad, Q.K. (Ed.), 2000, Bangladesh Water Vision 2025: Towards a Sustainable Water World, Bangladesh Water Partnership (BWP), Dhaka, 73p.

	Flash floods cause extensive damages to crops and property, particularly in the haor areas of Bangladesh. **2). River flooding**. Most inland districts of the project area are prone to high risks of river flooding (Padma, Jamuna, and Mehgna). Flooding occurs on an annual basis. The most hazardous situation of flooding is when the backflows of the 3 rivers are synchronized. The timing of the peak discharges on the three rivers on average does not coincide, with the Brahmaputra peaking in July and August and the Ganges (Padma) in August and September. The Brahmaputra (Jamuna) starts rising in March due to snow melt in the Himalayas, while the Ganges starts rising in early June with the onset of the monsoon. Monsoon rainfall occurs in the Brahmaputra and Meghna basins earlier than the Ganges basin due to the pattern of progression of the monsoon air mass. The synchronization of backflows of the major rivers accounts for the floods in the years 1954 (30 days), 1974 (27 days), 1987 (30 days), and 1988 (30 days). The synchronization accentuated the disastrous and catastrophic flood of 1988[9]. **3). Rainwater floods**: Heavy rainfall over the floodplain and terrace areas in Bangladesh causes rainwater floods. Runoff from heavy pre-monsoon rainfall (April-May) accumulates in floodplain depressions and in the lower parts of valleys within the Madhupur Tract. During the monsoon, local rainfall and the rising water level of adjoining rivers add to the pressure. Thus, the extent and depth of rainwater flooding varies within the rainy season and from year to year, depending on the amount and intensity of local rainfall and on contemporary water levels in the major rivers. **4). Coastal floods**: Coastal areas of Bangladesh are vulnerable to high tides as well as storm surges during cyclones. In the 1960s, 123 embankments and supporting infrastructure were constructed to protect low-lying coastal areas against tidal floods and salinity intrusion. Marginal areas outside the embankments are prone to tidal inundation. During cyclones, embankments are often overtopped/breached by storm surges and large areas are flooded.	
Climate Change Assessment	Under the conditions of rising temperature, precipitation is more likely to arrive in the form of heavy rains accompanied by an increase in flood risk[10, 11, 12, 13, 14]. 1). River Flooding River floods result from snow-melt in the high Himalayas and heavy monsoon rainfall in the foothills of the Himalayas, the Assam Hills, the Tripura Hills, and the upper Brahmaputra and Ganges floodplains outside Bangladesh[15]. River floods generally occur during the monsoon. By 2050s, annual precipitation is projected to increase by 6% under the worst-case scenario, and the increase is overwhelmingly projected to occur during the monsoon season from May to October. "Wet extremes are projected to become more severe in many areas where mean precipitation is projected to increase…In the Asian monsoon region and other tropical areas there will be more flooding" (IPCC, 2007[16]). A study by the Institute of Water Modeling[17] on the impacts of climate change on monsoon flooding found a 22% increase in the peak discharge of the Ganges at	

[9] Rashid, A. K. M. M., Dibalok Singha, and Hasina Imam, 2006. Climate Change Vulnerability in Bangladesh: Strategic Position of DSK/DCA in the field of climate change adaptation initiatives in Bangladesh. Published by the Dustha Shastha Kendra (DSK).
[10] Allen, M. R., and W. J. Ingram, 2002. Constraints on the future changes in climate and the hydrological cycle, Nature, 419, 224–232, doi:10.1038/nature01092.
[11] Goswami, B. N., V. Venugopal, D. Sengupta, M. S. Madhusoodanan, and Prince K. Xavier, 2006. Increasing trend of extreme rain events over India in a warming environment, Science, 314, 1442–1445, doi:10.1126/science.1132027.
[12] Min, S. H., X. Zhang, F. W. Zwiers, and G. C. Hegerl, 2011. Human contribution to more-intense precipitation extremes, Nature, doi:10.1038/nature09763.
[13] Trenberth, K. E., 1998. Atmospheric moisture residence times and cycling: Implications for rainfall rates and climate change, Clim. Change, 39: 667–694. doi:10.1023/A:1005319109110.
[14] Trenberth, K. E., A. Dai, R. M. Rasmussen, and D. B. Parsons, 2003. The changing character of precipitation, Bull. Amer. Meteor. Soc., 84, 1205–1217, doi:10.1175/BAMS-84-9-1205.
[15] Ahmad, Q. K., N. Ahmad, and K. B. S. Rasheed, eds. 1994. Resources, Environment and Development in Bangladesh with Particular Reference to the Ganges, Brahmaputra and Meghna Basins. Dhaka: Academic Publishers, Dhaka.
[16] http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-10-1.html.
[17] IWM. Impact Assessment of Climate Change and Sea Level Rise on Monsoon Flooding. Dhaka, BD: IWM, 2008.

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<td colspan="3">
Hardinge Bridge (in close proximity to Bheramara), assuming a 13% increase in precipitation over the Ganges-Brahmaputra-Meghna (GBM) basin under the A1FI scenario. Winston et al.[18] projected the effects of climate on Bangladesh for three different periods – up to 2030, 2050 and 2080, for which the projected increases in temperature are 0.750C, 1.550C and 2.40C respectively with median precipitation increase of 1.4 and 6%. Discharge during the monsoon (May to September) by 2050 would increase and the increment in August and September would be about12% for the Ganges River. Studies also found that the number and intensity of extreme rainfall events have increased since 1960 especially the intensity, attributable to global and regional warming. Additionally, accelerated melting of glaciers in the headwaters of Ganges also contributes to increased river discharge (the Gangotri Glacier is receding at a rate of 40 yards per annum due to global warming). The risks of river flooding is likely to escalate due to climate change.

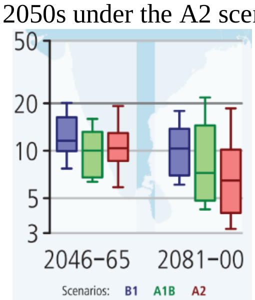
2). Flash Flooding and Rainwater Flooding
The risks of flash flooding caused by extreme rainfall events are likely to aggravate. For South Asia as a whole, the 20-year return period of extreme precipitation events is projected to be shortened to 10-year return period in 2050s under the A2 scenario (Figure 7).


Figure 7. Projected return periods for a daily precipitation event that was exceeded in the late 20th century on average once during a 20-year period (1981–2000)[19].

Analysis of ensemble models by UNEP indicates that models are broadly consistent in indicating increases in the magnitude of 5-day rainfall maxima. Annually, 5-day maxima change by -6 to +71mm by the 2090s. These increases are most evident in JJA and SON (wet season) rainfall, when changes of 0 to +62mm in JJA and -7 to +49mm in SON are projected in 5-day maxima for the 2090s[20].

Rainwater flood risk is also expected to aggravate in the future, since monsoon rainfall (May to October) is projected to increase by a large amount (127mm, 6.2%) under the worst-case scenario (RPC8.5).

3). Coastal Flooding
Flood risks along the coastal areas of Bangladesh are expected to become exacerbated due to sea level rise (which is virtually certain) and increase in cyclone intensity (hence aggravated storm surge). The situation will be worse for areas where severe coastal erosion is ongoing.
</td>
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<tr>
<td>Drought</td>
<td>Medium</td>
<td>Low</td>
<td>Rising temperatures/High
Increasing Precipitation/Low to Medium</td>
<td></td>
</tr>
</table>

[18] Winston, H. Y., M., Alam, H. Hassan, A. S. Khan, A. C. Ruane, C. Rosenweig, D. C. Major, and J. Thurlow, 2010. Climate Change Risks and Food Security in Bangladesh. London, UK: Earthscan.

[19] The box plots show results for regionally averaged projections for two time horizons, 2046 to 2065 and 2081 to 2100, as compared to the late 20th century, and for three different SRES emissions scenarios (B1, A1B, and A2). Source: IPCC, 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

[20] A. Karmalkar, C. McSweeney, M. New, and G. Lizcano, UNDP Climate Change Country Profiles – Bangladesh.

Evaluation	Drought affects soil moisture and thermal dynamics. Frequent wetting and drying of soils may affect the stability of foundations of pylons and substations.			
Climate Change	Soil moisture loss through evapotranspiration is projected to increase as a result of projected increase in annual mean temperature (2.5^0 Celsius by 2050s under the RCP8.5 cescenario). The risk of drought may elevate to a higher level.			
Cyclone Wind	High	High	Increased Cyclone Intensity/ Low[21]	
Evaluation	All project sites are prone to a high risk of cyclone wind. Bangladesh is one of the most cyclone-prone countries in the world. The project area is affected by strong winds brought by cyclones originating from the Bay of Bengal during April-May and October-November periods. Cyclone Aila in 2007 caused a widespread blackout in Bangladesh. Strong winds from cyclones cause tower and conductor damage and more faults due to galloping (and tree-falling).			
Climate Change Assessment	Most studies[22,23,24,25] for the North Indian Ocean agree that the frequency of tropical cyclones is declining, while the intensity of cyclones has been observed to have increased. It is extremely difficult to confirm whether the impact of climate change has exceeded the natural variability and has manifested a detectable signal. In terms of historical tropical cyclone activity, a 2010 WMO assessment of tropical cyclones and climate change concluded that "it remains uncertain whether past changes in tropical cyclone activity have exceeded the variability expected from natural causes." This conclusion applied to all basins around the globe[26]. Although it remains uncertain whether past changes in tropical cyclone activity have exceeded the variability expected from natural causes, future projections based on theory and high-resolution dynamical models consistently indicate that greenhouse warming will cause the globally averaged intensity of tropical cyclones to shift towards stronger storms, with intensity increases of 2–11% by 2100 (Knutson *et al.*, 2010[27]). The World Meteorological Organization's (WMO) Expert Team on Climate Change Impacts on Tropical Cyclones (i.e. hurricanes, typhoons) concluded that, if twenty-first century warming occurs as projected, there will likely be an increase, on average worldwide, in the maximum wind speed of tropical cyclones of +2 to +11 % and in rainfall rates of approximately 20% within 100km of the storm center. The experts concluded that the total number of tropical cyclones worldwide will likely either decrease or remain unchanged. However, a likely increase in tropical cyclone intensity means that the frequency of the strongest tropical cyclones will more likely than not increase under the projected warming scenarios (WMO, 2010, Info Note No.62). Predicted changes in extreme wind gusts related to climate change assumes that maximum wind gusts will increase by 2.5, 5 and 10% per degree of global warming[28]. Tropical cyclones are expected to become more intense with larger peak wind speeds and heavier precipitation[29]. According to IPCC (2007), "there is less certainty about the changes in frequency and intensity of tropical cyclones on a regional basis than for temperature and precipitation changes… however, extreme rainfall and winds associated with tropical cyclones are likely to increase in South Asia".			

[21] The confidence level is low due to the fact that there exists a large degree of uncertainty regarding the future scenarios of cyclone activities within the North Indian Ocean.
[22] Niyas, N. T., A. K. Srivastava, and H. R. Hatwar, 2009. Variability and trend in the cyclonic storms over North Indian Ocean. Met. Monograph No. Cyclone Warning, 3/2009.
[23] Habib, A., 2011. Climate Change: Bangladesh Perspective. Available at http://www.dccc.iisc.ernet.in/22July2011-Policy/Arjumand-Habib.doc.
[24] Hussain, M. A., S. Abbas, and M. R. K. Ansari, 2011. Persistency analysis of cyclone history in Arabian Sea. The Nucleus, 48(4):273-277.
[25] Webster, P. J., G. J. Holland, J. A. Curry, and H. R. Chang, 2005. Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. Science, 309:1844-1846.
[26] http://www.gfdl.noaa.gov/global-warming-and-hurricanes.
[27] Knutson, T. R., McBride, J. L., Chan, J., Emanuel, K., Holland, G., Landsea, C., Held, I., Kossin, J. P., Srivastava, A. K. & Sugi, M., 2010. Tropical cyclones and climate change, Nature Geoscience, 3, 157 - 163 (2010). doi:10.1038/ngeo779.
[28] Hay, J., 2006. Climate Risk Profile for the Maldives. Final Report.
[29] IPCC AR4, 2007. Executive Summary.

<table>
<tr><td></td><td colspan="3">Data from 1795 to 2009 indicate that frequency of the cyclones has shown an increasing trend along with their intensity[30]. Simulations[31] of tropical cyclones in the Bay of Bengal from the regional climate model (PRECIS) show an increase in the frequency of cyclones in the Bay of Bengal during the late monsoon (August and September) under A2 compared to the baseline (1961-1990). The risks of both wind and surges are expected to escalate.</td><td></td></tr>
<tr><td>Cyclone Surge</td><td>High</td><td>High</td><td>Increased Cyclone Intensity/Low[32]</td><td></td></tr>
<tr><td>Evaluation</td><td colspan="3">High Risk: All coastal regions of Bangladesh.

Coastal Bangladesh is undisputedly the most surge-prone area in the world. Several factros contribute to the highest surge hazard: shallow bethymetry, coriolis effect, convergence effect, tidal efect, river effect, island effect, and cyclone track effect, all of which act to amplify storm surge. Damages caused by cyclones are mostly caused by storm surge, rather than the wind speed as is usually perceived to be. The December 1970 Bhola Cyclone claimed a half million lives. Storm surges higher than 9m are not rare in southern Bangaldesh and can cause severe damage up to 100km inland following the river systems. Syorm surge can move coastal structures and soil several miles inland within a swath as wide as 50-100 miles. Inundation by cyclone surge may cause extremely destructive damages to roads (as well as other infrastructure).

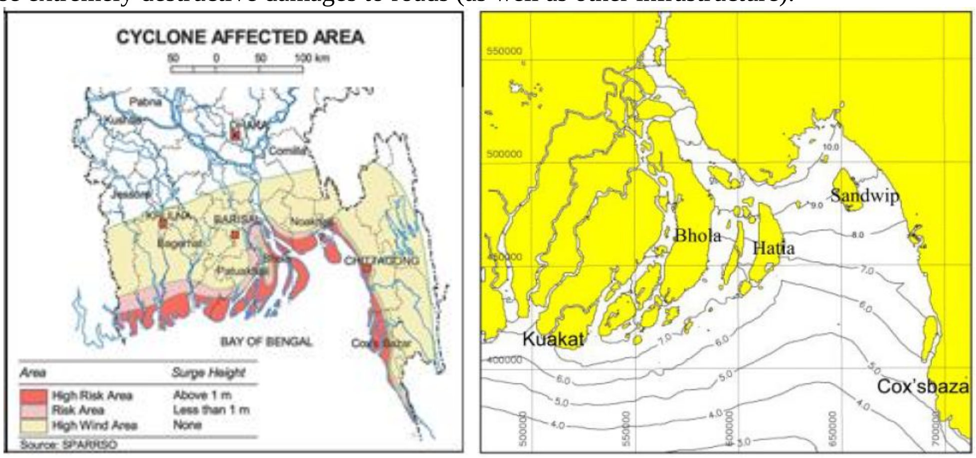


Figure 8. Left: Cyclone Surge Risk Map of Bangladesh[33]. Right: Surge height of 100-year return period[34].</td><td></td></tr>
<tr><td>Climate Change Assessment</td><td colspan="3">Unnikrishnan et al. (2011[35]) projected that, by the 21st century, the average increase in 1-in-100 year return period storm tide is about 10%. Figure 9 depicts projected storm surge inundation scenario in 2050. It should be noted that projections of storm surge are under great uncertainties[36].</td><td></td></tr>
</table>

[30] SM M. Rana, Md. Kamruzzaman, M. A. Rajib and Md. M. Rahman, 2011. Changes in Cyclone Pattern with Climate Change Perspective in the Coastal Regions of Bangladesh. Environmental Research, Engineering and Management, No. 2(56), pp. 20-27.

[31] Unnikrishnan, A. S., RameshKumar, M. R., and Sindhu, B., 2011. Tropical cyclones in the Bay of Bengal and extreme sea-level projections along the east coast of India in a future climate scenario. Current Science, 101(3), 327-331.

[32] The confidence level is low due to the fact that there exists a large degree of uncertainty regarding the future scenarios of cyclone activities within the North Indian Ocean.

[33] http://www.saarc-sadkn.org/countries/bangladesh/hazard_profile.aspx.

[34] Kabir, M. M., B. C. Saha, and J. M. A. Hye, 2006. Cyclonic Storm Surge Modelling for Design of Coastal Polder. Institute of Water Modeling, Dhaka, Bangladesh.

[35] Unnikrishnan, A. S., M. Manimurali, and M. R. Ramesh Kumar, 2010. Sea-level changes along the Indian coast. National Institute of Oceanography, Goa.

[36] For example, the ability of the climate model to adequately simulate cyclone intensities, the statistical distributions fitted to the available data, and the short period of the observed cyclone records used for the study to establish the baseline distributions of observed cyclone characteristics, the projections therefore only represent a plausible estimate of future impact.

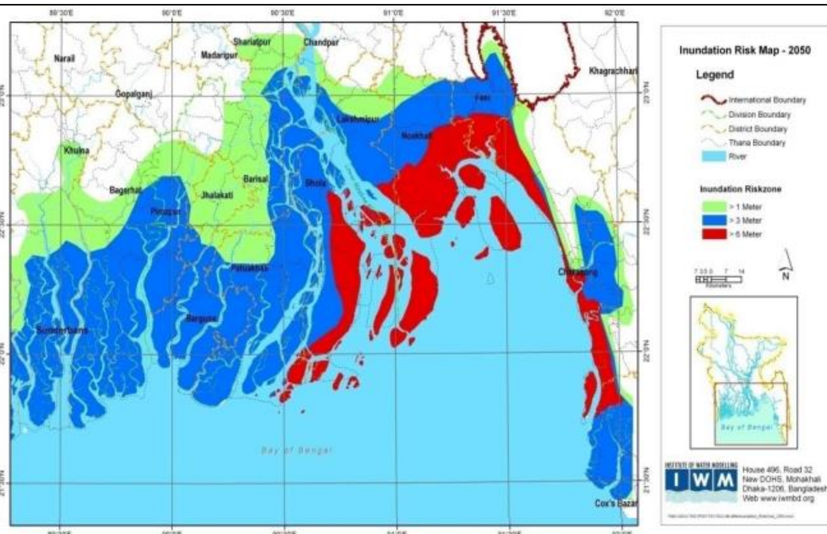


Figure 9. Projection of Storm Surge Inundation in 2050[37].

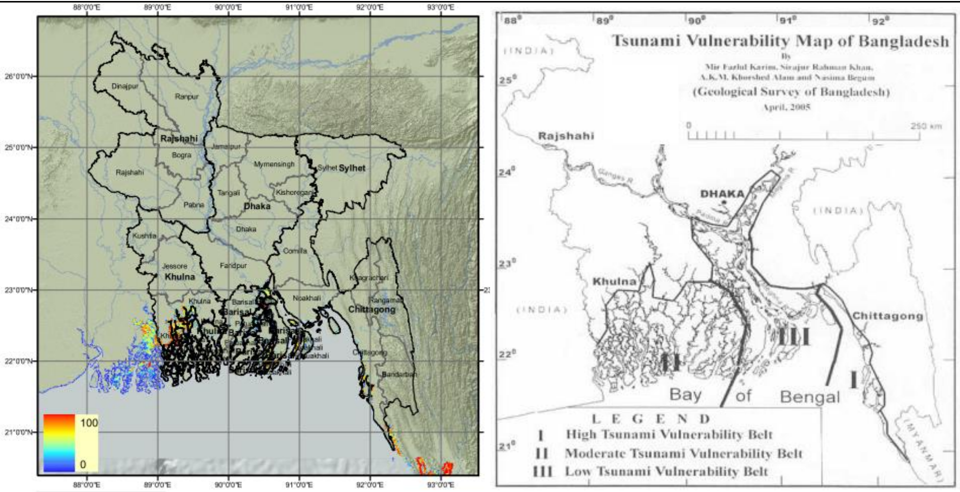
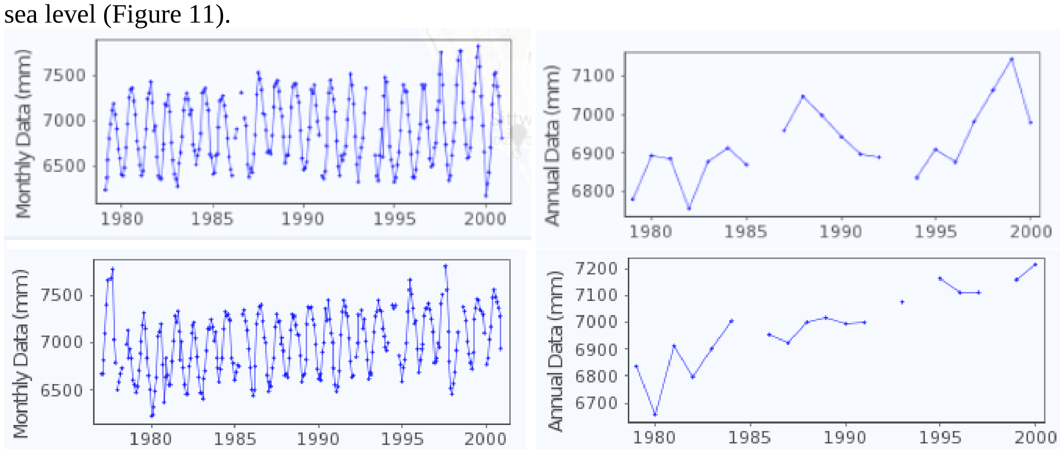
The effect of sea level rise on storm surge must also be considered for planning purposes. The effect of a higher sea level is the retreat of the current shoreline closer to existing structures and settlements. Holding all other factors constant, a storm surge occurring at a higher sea level would cause more areas inundated than a cyclone of an equal intensity at present sea level, simply because the shoreline would be further inland than today and storm surge would build from a higher base. Table 1 presents storm surge heights (m) under different sea surface temperature and sea level rise scenarios.

	Current temp. (27°C)	2°C increase	4°C increase
Wind speed (km h^{-1})	225	248	275
Surge height in m (% change)			
Sea level rise = 0.0 m	7.6 (0)	9.2 (21)	11.3 (49)
Sea level rise = 0.3 m	7.4 (−3)	9.1 (20)	11.1 (46)
Sea level rise = 1.0 m	7.1 (−7)	8.6 (13)	10.6 (40)

Table 1. Storm surge heights (m) under different sea surface temperature and sea level rise scenarios (wind speed of 225km/h corresponds to that of the April 1991 cyclone). (Source: Ali, 1996).

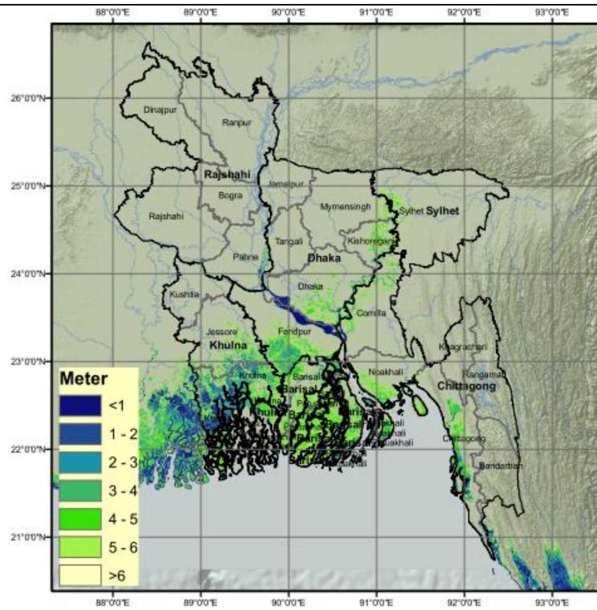
Tsunami	Low	N/A		
Evaluation	The Indo-Burma-Sumatra subduction zone is known to trigger large undersea earthquakes capable of generating tsunamis in the Indian Ocean. Indicators suggest a high potential for giant earthquakes along the coast of Myanmar. Tsunami Vulnerability Coastal Belt I (Chittagong–Teknaf coastline) is the most vulnerable. The intra-deltaic coastline is very close to the tectonic interface of the Indian and Burmese plates. The active Andaman–Nicobar fault system is often capable of generating tsunami waves.			

[37] Dasgupta, S., B. Laplante, S. Murray, D. Wheeler, 2010. Climate Change and the Future Impacts of Storm-Surge Disasters in Developing Countries.

	 Figure 10. Left: Tsunami Hazard Map. Right: Tsunami vulnerability map of Bangladesh[38].			
Sea Level Rise	**High**	High	Increase in sea surface temperature, Melting of pole ice, etc. /Very High	
Evaluation	High Risk: The entire coastal belt as well as some inland areas. Much of Khulna, Barisal, western Chittagong, as well as southern Dhaka are prone to sea level rise. Long-term tidal gauge data at Charchanga and Khepupara shows an increase trend in mean sea level (Figure 11).  Figure 11. Long-term Observations of Monthly and Annual Mean Sea Level at Tidal Gauge Station at Charchanga (upper) and Khepupara[39].			

[38] Islam, R, 2006. Pre-and post-tsunami coastal planning and land-use policies and issues in Bangladesh. Proceedings of the workshop on coastal area planning and management in Asian tsunami-affected countries. September 27-29. 2006, Bangkok, Thailand. Compiled and edited by Jeremy S. Broadhead & Robin N. Leslie.

[39] Permanent Service of Mean Sea Level: http://www.psmsl.org/.

	 Figure 12. Elevation of the Costal Regions of Bangladesh.			
Climate Change Assessment	"In the northern Bay of Bengal, simulated changes in storminess cause changes in extreme water levels. When added to consistent relative sea-level rise scenarios, these result in increases in extreme water levels across the Bay, especially near Kolkata" (IPCC AR4, 2007[40]). Extreme sea-level projections[41] under the A2 scenario along the east coast of India (using a storm surge model developed for the Bay of Bengal, driven by winds and surface atmospheric pressure) show that a uniform sea-level rise of 4 mm/year from 1990 was included from the present levels. The 100-year return levels of extreme sea-level events are found to be higher by about 15–20% for A2 than those in the baseline for locations north of Visakhapatnam. It should also be noted that there are large local variations regarding the future sea-level rise scenarios. This is mostly due to rapid process of land accretion and land loss.			
Tornadoes	High	High	Rising Temperatures/Low	
Evaluation	Tornadoes can cause devastation to transmission lines and towers. According to the Tornado Hazard Map of India (which includes the territories of Bangladesh), the project area falls within a high tornado risk zone. Bangladesh is the country in South Asia most prone to tornadoes. On average, more than 6 tornadoes are experienced. The world deadliest tornado[42] occurred in Bangladesh in 1989. Severe local seasonal storms occur during the pre-monsoon season (March-May), popularly known as nor'westers (kalbaishakhi) which are generally associated with tornadoes. The frequency of devastating nor'westers usually reaches the maximum in April, while a few occur in May, and the minimum in March. Nor'westers may also occur in late February due to early withdrawal of winter from Bangladesh. The occasional occurrence of nor'westers in early June is due to the delay in the onset of the southwest monsoon over the region[43]. The broad rotation of a land falling tropical cyclone can also spawn tornadoes (particularly in their right front quadrant). While these tornadoes are normally not as strong as their non-tropical			

[40] http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch6s6-3-2.html.
[41] Unnikrishnan, A. S., RameshKumar, M. R., and Sindhu, B., 2011. Tropical cyclones in the Bay of Bengal and extreme sea-level projections along the east coast of India in a future climate scenario. Current Science, 101(3), 327-331.
[42] http://bangladeshstorms.com/the-worlds-deadliest-tornado/.
[43] http://www.saarc-sadkn.org/countries/bangladesh/hazard_profile.aspx.

	counterparts, heavy damage or loss of life can still occur. Tornadoes can also be spawned as a result of eyewall mesovortices, which persist until landfall[44]. Cyclones may spawn tornadoes from a day or two prior to landfall to up to three days after landfall. Statistics show that most of the tornadoes occur on the day of landfall, or the next day. The most likely time for TC tornadoes is during daylight hours, although they can occur during the night, too[45]. In South Asia, tornadoes spawned from cyclones are rare. Bangladesh experiences occasional tornadoes associated with powerful cyclones with considerable loss of life[46].			
Climate Change Implications	There are at least 2 important elements necessary for the formation of tornadoes: warm and moist air, and wind shear. The former provides energy for thunderstorm initiation and growth, and the latter helps organize a thunderstorm and create rotation. Global warming will increase the moisture content of the atmosphere. However, the wind shear may be reduced as a result of global warming due to the fact that the pole regions are warming faster than the tropics. According to NOAA[47], there is no real evidence that tornadoes are happening more often. A study[48] demonstrated that the damages caused by tornadoes in the U.S. are actually declining. Other studies[49,50,51] using climate models however point to increased tornado activities in the U.S as a result of climate change. Due to the limitations in the climate models used in the studies, future scenarios on tornadoes in a changing climate are highly uncertain.			
Lightning	High	High	Warmer Climate/Medium-High	
Evaluation	The entire country of Bangladesh is prone to lightning strikes. Lightning is one of the most serious causes of over-voltage. Lightning can result in strokes to a Phase-conductor and towers with no earth wire, and over-voltages. Transients or surges on the power system may originate from switching and from other causes but the most important and dangerous surges are those caused by lightning. The lightning surges may cause serious damages to the expensive equipment in the power system (e.g., generators, transformers, etc.) either by direct strokes on the equipment or by strokes on the transmission lines that reach the equipment as traveling waves. Additionally, lightning-originated surges can also damage, depending on their amplitude and energy content, the power components connected to these networks as well as the relevant electronic devices. The project area falls within a high risk zone. The density of lightning strikes measured as the number of flashes per square km per year for Bangladesh is about 40 based on 9-year satellite measurements (combined 1995–2003 data from the Optical Transient Detector and 1998–2003 data from the Lightning Imaging Sensor)[52].			
Climate Change Implications	The spatial distribution of lightning around the world is directly linked to climate, which is primarily driven by solar insolation. Lightning is positively correlated with surface temperature on short time scales, as well as variations in the upper tropospheric water vapor and ozone both of which are GHGs. It is generally expected that lightning activity will increase in a warmer climate (IPCC, 2007[53]) as numerous climate model simulations[54,55,56] have shown. Although the parameterizations of			

[44] http://en.wikipedia.org/wiki/Atlantic_Oceanographic_and_Meteorological_Laboratory.
[45] Novlan, D. J. and W. M. Gray, 1974. Hurricane-spawned tornadoes. Mon. Wea. Rev., 102:476-488.
[46] Lineback, N. G., 2000. Tornado Warning. Geography in the News TM. http://media.maps101.com/SUB/GITN/ARCHIVES/PDF/524_061600tornbw.pdf.
[47] http://www.ncdc.noaa.gov/climate-information/extreme-events/us-tornado-climatology#history.
[48] Kevin M. Simmons, Daniel Sutter and Roger Pielke, Jr., 2012. Normalized Tornado Damage in the United States: 1950-2011. Environmental Hazard.
[49] Trapp, R. J., N. S. Diffenbaugh, H. E. Brooks, M. E. Baldwin, E. D. Robinson, and J. S. Pal, 2007: Changes in severe thunderstorm environment frequency during the 21st century caused by anthropogenically enhanced global radiative forcing. Proceedings, National Academy of Sciences, 104, 19719-19723, doi: 10.1073/pnas.0705494104.
[50] Del Genio, A. D., M. S. Yao, and J. Jonas, 2007. Will moist convection be stronger in a warmer climate? Geophysical Research Letters, Volume 34, Issue 16. DOI: 10.1029/2007GL030525.
[51] Elsner, J. B., S. C. Elsner, T. H. Jagger, 2014. The increasing efficiency of tornado days in the United States. Climate Dynamics, August.
[52] http://thunder.nsstc.nasa.gov/data/.
[53] http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch7s7-4-4-2.html.

	lightning in the models are quite crude, the models nevertheless manage to duplicate the present global lighting climatology[57], and all of the model studies indicate that there could be less thunderstorms overall, but they could become more intense, which in turn may increase the amount of lightning by 10% for every 1 k degree global warming[58].			
Hailstorms	Low/Medium	Medium	Temperature Rise/Medium	
Evaluation	Hails are summer ice storms that can result in severe damages to transmission facilities. Based on the Global Distribution of Hailstorms[59] and the 100-year return period of hail occurrence[60], the project area falls within a low to medium risk zone. Annual mean hail-days are estimated to be about 3[61]. South Asian monsoon alters the hailstorm climatology around the Indian subcontinent, and about 75% of the hailstorms on the eastern side (around Bangladesh) occur from April through June, generally before monsoon onset[62].			
Climate Change Implications	There exists a strong positive relationship between hailstorm activity and hailstorm damage, as predicted by minimum temperatures using simple correlations. This relation suggests that hailstorm damage may increase in the future if global warming leads to further temperature increase[63]. Studies[64,65] have shown that climate change is likely to enhance hailstorm activities in the future. It can be a combined effect of El Nino and global warming, but a deeper study will be required, to know actual cause[66].			
4. Sector-Specific Climate Risks				
Sensitive Components	**Climate Variables**	**Climate Change Impact Analyses**		
Renewable Wind Energy Generation	Changes in Wind Speed, Tropical Cyclones	The current renewable energy in Bangladesh comes from biogas, hydro power, solar and wind. Biofuel generation mainly and currently there are two types of biogas plants used in Bangladesh, floating dome type and fixed dome type. Hydropower generation will be limited to mountainous areas (Chittagong Hill Tracks and Sylhet). The main renewable energy generation projects include wind power, and solar PV. Tide and wave energies are also abundant in Chittagong. The main renewable energy generation projects currently implemented are renewable wind power and solar PV.		

[54] Price, C and D. Rind, 1994. Possible implications of global climate change on global lightning distributions and frequencies. Journal of Geophysical Research, 99:10823-10831.

[55] Grenfell, J. L., D. T. Shindell, and V. Grewe, 2003. Sensitivity studies oxidative changes in the troposphere in 2100 using the GISS GCM. Atmospheric Chemistry and Physics Discussions, 3:1805-1842.

[56] Shindell, D. T., G. Faluvegi, N. Unger, E. Aguilar, G. A., Schmidt, D. M. Koch, S. E. Bauer, and R. L. Miller, 2006. Simulations of preindustrial present-day, and 2100 conditions in the MASA GISS composition and climate model G-PUCCINI, Atmospheric Chemistry and Physics, 6:4427-4459.

[57] Shindell, D. T., G. Faluvegi, N. Unger, E. Aguilar, G. A., Schmidt, D. M. Koch, S. E. Bauer, and R. L. Miller, 2006. Simulations of preindustrial present-day, and 2100 conditions in the MASA GISS composition and climate model G-PUCCINI, Atmospheric Chemistry and Physics, 6:4427-4459.

[58] http://thunder.nsstc.nasa.gov/data/.

[59] Munich RE, 2011. NATHAN world map of natural hazards.

[60] Department of science and Technology, Government of India, 2005. Severe Thunderstorms - Observations & Regional Modeling (STORM) Programme- The Science Plan. Technology Bhawan, New Delhi-110016, December, 2005. Note that the map includes the entire territories of Bangladesh.

[61] Williams, L., 1973: Hail and its distribution. Studies of the Army Aviation (V/STOL Environment), Army Engineer Topo-graphic Laboratories Rep. 8, ETL-SR-73-3, 27 pp.

[62] http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-11-00130.1.

[63] Botzen, W. J. W., L. M. Bouwer, J. C. J. M. van den Bergh, 2010. Climate change and hailstorm damage: Empirical evidence and implications for agriculture and insurance. Resource and Energy Economics, 32(3):341–362.

[64] Price, C., 2009. Thunderstorms, Lightning and Climate Change. In: Lightning: Principles, Instruments and Applications. pp 521-535.

[65] Piani, F., A. Crisci, G. De Chiara, G. Maracchi, and F. Meneguzzo, 2005. Recent trends and climatic perspectives of hailstorms frequency and intensity in Tuscany and Central Italy. Natural Hazards and Earth System Sciences, 5:217–224. SRef-ID: 1684-9981/nhess/2005-5-217, European Geosciences Union.

[66] http://www.dnaindia.com/pune/report-the-reason-behind-hail-and-rain-in-maharashtra-is-it-the-el-nino-effect-or-global-warming-1968726.

		1). Locations of Wind Power Plants. The long term wind flow, especially in the islands and the southern coastal belt of Bangladesh indicate that the average wind speed remains between 3 and 4.5 m/s for the months of March to September and 1.7 to 2.3 for remaining period of the year[67]. There is a good opportunity in island and coastal areas for the application of wind mills for pumping and electrification. But during the summer and monsoon seasons (March to October) there can be very low pressure areas and storm wind speeds 200 to 300 kmph can be expected. Wind power generation projects are very likely to be located along the coastal areas since these areas are endowed with the most abundant wind resources. Most of the renewable wind power projects will be located within the coastal regions of Chittagong (e.g., Parki Beach, Chittagong, Moghnamoghat, Cox's Bazar, Hatia, Sandwip, and Monpura Islands, etc.). In terms of resources endowment in the future, climate change may not have a significant impact and in fact, wind speed along the coast is projected to increase. However, in terms of structural safety, since wind turbines are most vulnerable to cyclone wind, the project design will be governed by wind load. **2). Climate Impact on Resources Endowment** Wind power generation is susceptible to variations in atmospheric pressure, ambient temperatures, humidity, air density and of course wind velocity. Climate models suggest changes in a wide range of climate variables including wind speed, which implies changes in the quantity and timing of the wind resource, leading to changes in turbine performance and energy production, and this may have an impact on the economic attractiveness of schemes. The IPCC (2007) states that "there is evidence for long-term changes in the large-scale atmospheric circulation, such as a pole-ward shift and strengthening of the westerly winds" and that these observed changes likely will continue. These changes in circulation may directly affect the energy production of existing and planned wind projects. All GCM models project increased wind speed. Figure 13 below depicts the agreement of GCMs projecting increased wind speed at 2050 under the A2 scenario using a total of 14 GCMs (not the expected changes in wind speed). Areas of pale colors indicate regions in which a clear consensus does not exist among the models. Dark blue indicates that most of the models predict weaker surface wind speeds (i.e., only a very small percentage of the models predict stronger surface wind speeds).	

[67] The Dhaka University Journal of Science, Volume 55. University of Dhaka. 2007. p. 53.

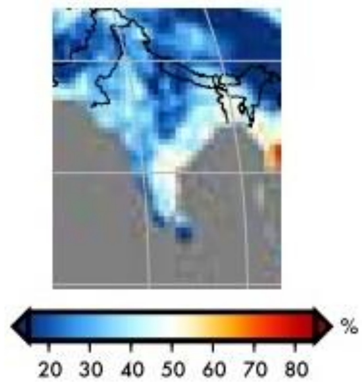


Figure 13. Percentage Of GCMs Showing Increased Annual-Mean Wind Speed Values In 2050 under A2 scenario[68].

Although a clear consensus does not exist among the models, the projections generally suggest that Bangladesh will experience increased wind speed in the future[69].

3). Main Climate Impact
Wind turbines are designed to operate at a defined range of wind speeds (typically 3 to 25m/s). Strong winds from cyclones cause tower and conductor damage and more faults due to galloping (and tree-falling). Stronger winds can totally devastate transmission and distribution systems. Projected increase in cyclone intensity will impose a serious threat to the safety of wind turbine as well as mounting structures.

Solar Power Generation	Rising Temperatures / Reduced Availability of Cooling Water, Reduced Cooling Efficiency	For solar energy generation projects, literally all divisions are endowed with abundant solar radiation (refer to Table 2 global solar insolation below).	

Month	Dhaka	Rajshahi	Sylhet	Bogra	Barishal	Jessor
January	4.03	3.96	4.00	4.01	4.17	4.25
February	4.78	4.47	4.63	4.69	4.81	4.85
March	5.33	5.88	5.20	5.68	5.30	4.50
April	5.71	6.24	5.24	5.87	5.94	6.23
May	5.71	6.17	5.37	6.02	5.75	6.09
June	4.80	5.25	4.53	5.26	4.39	5.12
July	4.41	4.79	4.14	4.34	4.20	4.81
August	4.82	5.16	4.56	4.84	4.42	4.93
September	4.41	4.96	4.07	4.67	4.48	4.57
October	4.61	4.88	4.61	4.65	4.71	4.68
November	4.27	4.42	4.32	4.35	4.35	4.24
December	3.92	3.82	3.85	3.87	3.95	3.97
Average	4.73	5.00	4.54	4.85	4.71	4.85

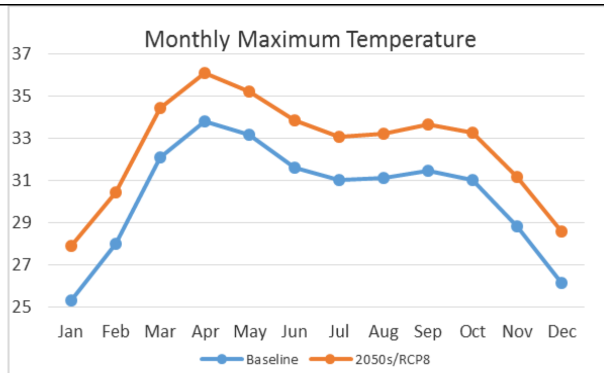
Table 2. Monthly Global Solar Insolation at Different Cities of Bangladesh (in kWh/m^2/day)[70].

The impacts of climate change upon solar resources endowment will

[68] Eichelberger, S., J. McCaa, B. Nijssen, and A. Wood, 2008. Climate Change Effects On Wind Speed. In North America Windpower, available at www.nawindpower.com.
[69] Eichelberger, S., J. McCaa, B. Nijssen, and A. Wood, 2008. Climate Change Effects On Wind Speed. In North America Windpower, available at www.nawindpower.com.
[70] Islam, M., 2002. Assessment of Renewable Energy Resources of Bangladesh. Available at http://shakti.hypermart.net/publications/ebook1.pdf.

		be manifested in changes of sunshine hours, increase in rainy days, and changes in cloud cover. However, these impacts may not be so significant in hampering harvesting of solar energy overall. The impact of climate change will mostly affect the safety of physical structures above ground which are exposed to the elements, and increased chances of operational disruptions. For projects located within the coastal areas, structural safety and integrity is of major concern, since these areas are highly prone to natural disasters such as tropical cyclones, and coastal flooding and river flooding. Sea level rise will further aggravate the flood risks. For projects located within the northern and northern western part of the country, the availability of water for wet cooling can be a significant limiting factor for power generation. Wet-cooling requires large quantities of water to be available. The region that is most suitable for solar power harvesting is generally water-deficient. Rising temperatures will result in exacerbated evapotranspiration and evaporation therefore reducing the availability of cooling water. During March-June period, maximum temperatures can reach 37^{0}C therefore even if surface water is available for cooling, the temperature of water could be too high to be used for cooling purpose.	
Power Stations and Substations	Increased rainfall intensity, sea level rise, increased storm surge / Increasing flood risks	Flooding affects many aspects of the power system, but is a major concern to substations and power plants. All substations and power station may be prone to the risks of flooding depending on the actual locations. Flooding becomes a problem for substations when the amount of water reaching the drainage network exceeds its capacity. Flooding can cause severe damage to substation equipment and may lead to interruptions in service continuity and widespread outages. Large amounts of water, rust and mud left trapped behind a flood in a substation can make repair of the equipment a sizable and lengthy restoration task. The risks of both river flooding and flash flooding at the project site are projected to escalate due to climate change. Coastal areas are more vulnerable to climate impacts (storm surge, sea level rise, and coastal erosion).	
Transmission lines **-** Reduced power transmission Efficiency	High temperatures, heat waves, dry spells / High sensitivity to ambient temperature/ Increased electrical resistance[71]	Under the worst-case scenario (RCP8.5), average monthly maximum temperature is projected to increase by 2.27^{0} Celsius by 2050s. Monthly average maximum temperature of Bangladesh is projected be higher than 36^{0} Celsius in April, and maximum temperature in May is projected to exceed 35.2^{0}C (Figure 14). For central-western Bangladesh, monthly maximum temperature is projected to reach beyond 39^{0}C in April.	

[71] Resistance is temperature dependent. As temperature rises, so does resistance. This is because the molecules in the material become more excited and interfere more with the flow of electrons. We can create superconductors, or materials that provide essentially no opposition to current flow by cooling them down to temperatures near absolute zero. This temperature, for a material, is called the *critical temperature*. Below the critical temperature, resistance drops very suddenly.

		 Figure 14. Baseline and Projected Monthly Maximum Temperature of Bangladesh. Higher temperatures cause increased power demand and lower transmission efficiency. The effect of increased ambient temperature on power transmission lines is increased resistance and reduced conductivity. In addition, high ambient temperature can cause lines to sag, de-rating of transformers, lowering of the thermal limits of transmission lines and circuit breakers.	
Overhead Transmission Lines	Tornadoes, Cyclones & Strong Winds / Increased Cyclone Intensity	Overhead transmission lines are extremely vulnerable to wind gusts. Wind is the most frequent culprit in causing damage to power lines. Wind can damage lines directly or indirectly. Falling trees and branches can easily topple wires and poles. Airborne debris can lodge in wires, causing a short circuit. Power flashes frequently illuminate the funnels and debris clouds of tornadoes, as the intense winds destroy power lines and equipment. Galloping is a violent motion of conductors caused by gusty wind which may cause displacements of cables by up to 10 feet in long spans. The displacement of galloping will typically be restricted to an elliptical zone around the static position of the line. Like Aeolian vibration, it may be reduced by adding phase-spacers. Slackening conductors may also reduce this behavior[72]. Bangladesh is among the countries most prone to the risks of tropical cyclones. Projected increase in tropical cyclone intensity is expected to cause more damages to the transmission lines in the future.	
5. GHG Emission and Indirect Impact			
GHG	SF_6.	Electric utilities of the renewable energy generation represent the largest user of SF_6.	
6. Summary of Screening Results			
Natural/Climatic Hazard	Flooding, Cyclone Wind, Cyclone Surge, Drought, Earthquake, Lightning, Tornado, and Hailstorm, Sea Level Rise. All of the hydro-met hazards are largely projected to intensify due to climate change.		
Climate Change	1). Impact on Safety and Integrity of Physical Structures The intensity of all hydro-meteorological hazards is projected to increase in the future due to changes in climate. This will have profound implications to the safety and integrity of all physical structures of large infrastructure investment projects. All planned projects (from all sectors) within the coastal regions will naturally fall within the category of high risk. 2). Impact on Renewable Energy Generation The most feasible forms of renewable energy generation would be wind and solar. Wind power projects are likely to be located along the coastal areas since these areas are endowed with the most abundant wind		

[72] Slegers, J., 2011. Transmission Line Loading - Sag Calculations and High-Temperature Conductor Technologies. Iowa State University.

<table>
<tr><td></td><td colspan="4">resources. In terms of resources endowment in the future, climate change may not have a significant impact and in fact, wind speed along the coast is projected to increase. However, in terms of structural safety, since wind turbines are most vulnerable to cyclone wind, the project design will be governed by wind load.
For solar power generation, the ideal locations are the northwestern part of Bangladesh (Rangpur, Rajshahi, and northern Khulna), the climate impact will be manifested in the forms of increased rainy days (which will increase solar intermittency), and prolonged dry spells (which will affect foundations of solar towers).
3). Impact on Transmission and/or Connection to the Grid
Substations will be prone to flood risks which are projected to increase in the future. Tropical cyclones can devastate overhead transmission lines. The intensities of tropical cyclones and tornadoes are generally projected to increase in the future due to global warming. Higher temperatures cause decreased transmission efficiency, sagging of transmission lines, and de-rating of transformers. Temperature rise also results in an increase in thunderstorm activity and consequently lighting strikes on power systems.</td></tr>
<tr><td rowspan="2">Overall Scoring</td><td>Multi-Hazard Index</td><td>Climate Impact</td><td>Category</td><td></td></tr>
<tr><td>Medium/High</td><td>Medium/High[73]</td><td>B[74]</td><td></td></tr>
<tr><td colspan="5">7. Required Action</td></tr>
<tr><td>Mainstreaming Climate Change Adaptation into PPP Programs / Projects</td><td colspan="3">The objective of the current project is to increase the long-term availability of debt financing for private sector investments in infrastructure, the project itself may be classified as Category B as it is on the financial side i.e. not the direct implementation of infrastructure projects. However, since most of the planned infrastructure projects are extremely susceptible to the current and future climate impact, the investments from the private sector must be protected from the risks of climate change to prevent potential financial losses. Although the risks of natural disasters and climate change upon PPP projects and programs can be reduced through insurance policies, ultimately it is the government who will bear the cost. The best practical solution is to build resilience into all infrastructure programs and projects to avoid or mitigate these risks. It is advised that adaptation plans be formulated and built into project design. Additional finance to implement the adaptation measures should be considered to ensure that all investment assets are protected from the impact of climate change.

The current project is set out to provide finance for the private sector investment. Since infrastructures are built to last for decades, the impact of climate change will become more pronounced in the future. Businesses need to protect their assets and seek to minimise costly disruptions such as productivity losses and supply chain interruptions resulting from disasters. Developing a suitable business resilience plan can also ensure reliable access to key resources (e.g. water and energy)[75]. Private sector engagement and innovation in disaster risk management is good for business and government. Making risk-informed decisions and investments helps limit private sector disaster losses and improves business continuity. Public-private partnership (which include both formal and informal partnerships and initiatives) can result in disaster risk management and adaptation activities that draw the expertise and resources from both governments and businesses to create resilient economies and communities[76].</td><td></td></tr>
</table>

[73] Project areas within the coastal regions are under the high risk of climate impact due to sea level rise, storm surge, cyclone wind, and coastal erosion. For inland areas, the risks are medium.

[74] Although the planned projects are under high risks of climate impact, the current project is from the finance sector, therefore the most appropriate classification would be Category B.

[75] Becker-Birck, C., Crowe, J., Lee, J., & Jackson, S., 2013. Resilience in Action: Lessons from Public-Private Collaborations around the World. Meister Consultants Group, Inc.: Boston U.S.A.

[76] Becker-Birck, C., Crowe, J., Lee, J., & Jackson, S., 2013. Resilience in Action: Lessons from Public-Private Collaborations around the World. Meister Consultants Group, Inc.: Boston U.S.A.