Climate Change Impacts on River System and Navigability in Bangladesh

Bangladesh is the most vulnerable to climate change due to its geographic location, deltaic formation and high population density. As it is located at the downstream of the mighty Ganges-Brahmaputra-Meghna (GBM) river system and drains about 90% runoff generated from the basins outside of the country, floods are frequent and cause greatest economic and human losses to the country.The flooding problems are exacerbated by sediment transported by the three major rivers- the Ganges, Brahmaputra and Meghna. Bangladesh is also highly vulnerable to the effects of sea-level rise—including increased salinity of ground and surface waters.

Climate change is no longer something to happen in future, it is here and now. Bangladesh is among the countries which are expected to be worst affected by climate change.Significant changes in climate and their impacts are already visible regionally, and are expected to become more pronounced in the next decades.According to fifth assessment of IPCC, projected temperature increases over Bangladesh are in the ranging of 1 to 3°C by 2100 for RCP4.5.The projection of rainfall widely varies from model to model but most of them agree with increasing rainfall during monsoon and decrease during dry season.Extreme weather events are projected to increase in frequency in South Asia, including heatwaves and high rainfall. Tropical cyclone intensity is also expected to rise by 10 - 20% as sea surface temperature rises by 2 - 4°C. Glacial and sea-ice melt and expansion of the oceans with increased temperature mean that a rise in sea level is certain. The minimum change, suggested by most of the conservative climate change models, is for a 40 cm rise by the end of the century.Historical records show increasing trend for temperature in Bangladesh.Since 1960, there has been widespread warming over Bangladesh during both the hot season (March to May) and cool season (December to February).There has been a reduction in the number of cool nights and increase in the number of warm nights over the period 1970-2000.There was a small increase in total precipitation over Bangladesh since 1960.River siltation has been observed on the rivers of south-west region.Water logging and drainage congestion also observed at the coastal region of Bangladesh due to increased rainfall, river siltation and sea level rise.Coastal erosion has also been observed at the Sundarban area and Chittagang-Tekhnaf shoreline.Navigable length of the rivers has been reduced rapidly over the past decades.According to the study of NEDECO (1963), 12000 km of waterways was navigable during 1960s where as presently it has reduced to about 4500 km in which only 2500 km is navigable during dry season.

The key drivers of change, directly influencing the navigation on inland waterways, are the meteorological parameters: precipitation and air temperature. These parameters primarily determine the water supply in the navigable river sections as well as sea level. The changes, especially in the water supply, will alter the occurrence of extreme hydrological conditions and thus will indirectly change the navigability of waterways. Since the river hydrology is interrelated with river morphology, the latter is an indirect driver of change to navigation.

The impacts due to change in rainfall, temperature, and sea level rise have and will continue to impact inland navigation primarily in terms of water depth and velocity, resulting in changes in sedimentation patterns. As Bangladesh is located at the downstream end of three large river basins (the Ganges, the Brahmaputra and the Meghna), a small change in rainfall in the area might reflect a huge change in water availability in Bangladesh. A study conducted by CEGIS (2012) revealed that 10% increase in annual rainfall results 22, 16 and 14% increase in annual flow for the Ganges, Brahmaputra and Meghna River

respectively. This study have shown that the monsoon flow would increase by 5-17% for the GBM basin by 2050s. Therefore, increased rainfall during monsoon will increasethe water level and velocity, and resultant changes in sedimentation processes such as bank failure, local scour, and locations of aggradation and degradation. Changes in water levels which impact the movement of sediment, and hence channel maintenance activities, will be required, depending on the locations and specific impacts. Changes in water level and velocity can also impact maneuverability and operational efficiency of navigation structures. On the other hand, low water availability during dry season due to the decrease in rainfall will result decrease in navigability of rivers during dry season. A number of navigation route will be disconnected due to the lack of adequate draft for navigation.

In the event of climatechange, both sediment supply and sediment transport are subject to change.The change in water quantitywill alter the sediment entrainment into therivers because of changes in soil erosion. An increase in soil erosion is related to an increase of effectiveprecipitation.The changes in sediment load will cause changes in riverbed erosion and river dune development, as well as changes in floodplain sedimentation, and therefore will require an adaptation of sediment management, i.e. dredging or artificial sediment supply.

The increase of temperature might reduce the water availability during dry season through increase of evaporation.According to CEGIS (2012), 1^{0}C increase in temperature will result 2-2.6% reduction of annual flow for the GBM basin. There is a maximum of 19, 4 and 14% reduction of monthly flow during dry season by 2050s in the Ganges, Brahmaputra and Meghna River respectively. The reduction of flow in combination with the upstream water diversion might significantly reduce the navigability of rivers especially in the upper part of Bangladesh during dry season. In addition, increased temperature also results sea level rise through thermal expansion of water and snow melting. Mean sea level has increased in the recent past, and will continue to rise in future, possibly at anaccelerated rate. According to IPCC (2007), predicted global sea level rise is 0.18 to 0.59 m for different climate change scenario by 2100.Although sea level rise would have no direct impact on navigation itself, yet it would affect port infrastructureand the standard of service of coastal and port structures. It may allow greater penetrationof wave energy to the coastline and into ports, causing increased coastal erosion in areas with asoft coastline. It may also increase the salinity of bays and estuaries.Other potential impacts include more sedimentation at river outlets, development of submerged reefs,changes in exchange processes and current speeds between ocean and inland seas.

Wind conditions could be affected by temperature and other climate changes in a number of aspects. The seasonal distributions of wind speeds and directions, and the frequency, pathways and/or durationsof storms and hurricanes may be changed due to climate change.The consequences of strong wind may be the interruption of navigation and reduced maneuverability of a vessel.

Another important aspect of navigation is visibility. Due to climate change, the intensity of fog, rainfall, haze etc. might be increased which will ultimately reduce the visibility. Reduced visibility may lead to speed reductionor even collision with waterway vehicles, infrastructure and submerged reefs.

Navigation, like many other sectors, will face serious risks from climate change, withunstable and unfavorable weather conditions causing navigation difficult or even impossiblein some areas. Appropriate mitigation and adaptation measures could minimize the impact of climate change and it would be the most popular mode of transport in future.