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RESEARCH ARTICLE

VULNERABILITY OF THE *SUNDARBANS* DUE TO CLIMATE CHANGE IN BANGLADESH

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Abstract: This study endeavors to decipher the possible affects on the *Sundarbans* due to rapid climate change by reviewing the existing literature, interviews with experts and forest officials and FGD with different stakeholders. Increase in salinity, sea level rise natural calamities etc. are the main vulnerabilities of the *Sundarbans*.

Key Words: Climate change, salinity, biogeochemical processes, mangrove, *Sundarbans* Reserve Forest

Introduction

Climate is generally defined as average weather and usually described as in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years (the classical period if 30 years). Observations can show that there have been changes in weather, and it is the statistics of changes in weather over time that identifies climate change. Changes in climate affect natural resources, such as water resources, forest resources, and communities depending on those resources. The climate change is a real threat to ecosystem and biodiversity. Some people depended on the *Sundarbans* are now compelled to change their traditional occupation and migrate elsewhere from their ancestral habitat in search for their livelihood. The shrinking of mangrove areas due to adverse effect of climate change is claimed to have negative effect on the economy of the country. This is because many industries which depend on raw materials from the *Sundarbans* will be threatened and lead to large unemployment. Expected sea level rise due to climate change will inundate the coastal land covered by the mangrove forest. Existing biodiversity in the affected areas will certainly face problems of survival because of lacking of space, shelter, cover and food shortage. Land dwelling particularly grass and browsers and predator animals are expected to be the most sufferer of the arboreal and aerial ones. Red jungle fowl, swam francolin, hare fin feet, burrowing porcupine, spotted deer, wild boar, tiger etc. will fast face the shortage of their habitats, foods and shelters. Pneumatophore in the Sundarbans will go under water and mangrove trees will eventually die due to the depletion of oxygen. Complete inundation will lead the herbaceous plants to death. Some flying animals may have the options to leave the place but they will face serious competition for their survival for the access to food, space and living requirements. This paper identifies the vulnerability of the coastal mangroves - the *Sundarbans* to sea level rise and other climate change impacts. The impacts of climate change on the *Sundarbans* and the opportunities and challenges faced in mainstreaming adaptation responses to ameliorate some of these impacts are discussed in the paper.

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Materials and Methods

The general approach for the work is to highlight the results available in literature on impacts, adaptation and vulnerability to climate change for the *Sundarbans* in Bangladesh. The analysis was conducted by interviews with individuals from key government agencies, NGOs, as well as FGD with stakeholders.

Results and Discussion

Impacts of climate change on the Sundarbans: The *Sundarbans* will severely be affected under changed climatic situation. This mangrove depends largely on the freshwater supply along the Ganges system. Under climate change induced aggravated low-flow conditions, the Gorai system might not be able to supply adequate quantum of freshwater. The problem is likely to be compounded by withdrawal of surface flows in the upstream areas to offset increasing moisture stress. In such a scenario, salinity is likely to penetrate far inland and the salinity regime, on which the succession process of the vegetation of the forest depends, will be disturbed, leading to a gradual decline in the forest vegetation. It is inferred that poor quality shrubs will dominate with increasing salinity and high-value timber species will gradually disappear (Ahmed *et al*., 1998). The recent research findings suggest that vegetation health index for Sundri species (*H. fomes*) would deteriorate significantly (CEGIS, 2006). Climate change is expected to have a significant effect on the flow regimes of the major rivers in Bangladesh, including the Ganges. Since the viability of the *Sundarbans* rests on the hydrology of the Ganges and its tributaries which supply the fresh water, climate change is expected to have significant impact on the *Sundarbans*.

A rise in sea level would occur under climate change which would cause increased backwater effect in the major distributaries of the Ganges and tend to push the saline front further inland. The final location of the saline front during the monsoon will therefore be the result of two opposing effects: enhanced freshwater flows and enhanced backwater effect, and is hard to predict precisely. The backwater effect would also reduce the discharge of freshwater flow from the northern reaches of the tributaries of the Ganges resulting in a relatively prolonged inundation of the forest land.

Increased rainfall intensity – which is also anticipated in the region - would caused enhanced erosion upstream and result in increased availability of sediments, particularly along the Ganges and its distributaries. The latter affect in combination with prolonged flooding. Such a change would be relatively more pronounced in the Bangladesh side of the forest and may slightly offset permanent inundation of the forest floor.

The effects of climate change on the *Sundarbans* would be considerably more critical during the dry season that extends from November to April. Different climate models predict a decrease in precipitation during this period which might further reduce freshwater flows, which will encourage enhanced withdrawals upstream for irrigation. This reduction in freshwater inflows into the Sundarbans could be exacerbated by increased evapo-transpiration losses and water use on account of rising winter temperatures. Reduced freshwater flows coupled with sea-level rise would consequently further enhance the dry season salinity levels in the Sundarbans. The reduction in freshwater flows would only deteriorate with time and the lowest water levels would be expected in March. As a response to reduced flow regime the salinity front would penetrate inland inside the forest areas. As a consequence of salinity penetration in the *Sundarbans*, majority of the mesohaline areas will be transformed into polyhaline areas, while oligohaline areas would be reduced to only a small pocket along the lower-*Baleswar* river in the eastern part of the forest.

High intensity cyclonic storm surge, induced by a general rise in sea surface temperature, is also likely to have compounding effect on salinity intrusion along the coastal areas of Bangladesh, including the *Sundarbans*. A simple frequency distribution of all observed cyclonic activities in the Bengal delta suggests that these events usually occur twice per annum: in late May and in

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early November (Haider *et al*., 1991). Cyclones are usually formed in a complex process where the sea surface water temperature is exceeded beyond the threshold value of 27 degree Celsius. Since climate change will cause an increase in mean sea surface temperature, it may be expected that the excess heat energy will be dissipated in the form of increasing number of high intensity cyclones. Unfortunately, such high intensity cyclones are often associated with high storm surges. It may be argued that intensity of storm surges is likely to be increased under climate change scenarios, particularly in the latter part of the 21st century. Cyclonic storms would cause severe damages to the forest, its inhabitants and resources. A high intensity event in 1986 and Cyclone SIDR in 2007 devastated the *Sundarbans*, drowned thousands of its magnificent animals including the threatened species, the Royal Bengal Tiger. The wind associated with cyclone also devastated vegetation of a large part of the forest. Influenced by climate change, high intensity storm surges would inundate high levees and back swamps that do not get submerged with saline water and thereby would be affected by salinity.

The natural regeneration of vegetation and forest succession depends on salinity regime (Karim, 1994; Siddiqi, 1994). Considering that the salinity regime inside the forest will significantly change as a consequence of climate change, it has been argued that increased salinity would have discernable adverse impacts on forest regeneration and succession (Ahmed *et al*., 1998). For example, the freshwater loving Sundari is projected to decline or disappear entirely under the altered situation of climate change. Areas with best quality standing timber predominated would be replaced by inferior quality tree or shrub species. Under such conditions vegetation canopy would become sparse and plant height would be reduced significantly. With such a dramatic series of anticipated changes in forest vegetation under climate change, the productivity of the forest would be severely constrained. Chaffey *et al*., 1985, demonstrated that total merchantable wood volume per unit area of forest land decline with increasing soil and river salinity. Preliminary estimates suggested that, disappearance of oligohaline areas combined with decreasing mesohaline areas would result into over 50% loss of merchantable wood from the Sundarbans (Ahmed *et al*., 1998).

Since the composition of vegetation has profound effect on distribution of forest fauna, a change in forest succession would in turn affect the long-term sustainability of the ecosystem. Considering the timeframe of such changes and the land-use patterns inland, it is highly unlikely that forest species would have sufficient time or room to migrate inland in response to these changes.

Adaptation options for the Sundarbans: The most useful adaptation aiming at saving the *Sundarbans* from sea-level rise induced submergence would be to modify the threats of permanent inundation. Since most part of the projected sea level rise would occur from tectonic subsidence, it would not be quite possible to stop the processes involved. However, efforts must be made to figure out ways to enhance sedimentation on the forest floor, by means of guided sedimentation techniques. Controlled and guided sedimentation will have a balancing influence on subsidence process and could help delay permanent inundation of the forest floor.

The second most important adaptation strategy will be to reduce the threats of increasing salinity, particularly during the low flow period. This may involve a range of physical adaptations to offset salinity ingress, including increasing freshwater flows from upstream areas (Ganges in India), resuscitation of existing river networks towards improving flow regime along the forest; and artificial enhancement of existing river networks to facilitate freshwater flow regime along the rivers supplying freshwater to the western parts of the forest.

For the sustenance of the forest in its natural state about 240 cumec water should be allowed to flow through the *Gorai* river system, particularly during the critical dry period of April (Mirza, 1998). The actual amount of water flowing along the Gorai River in 1995-96 was about 52 cumec, which was far below that the standard flow regime. The Gorai River is an important source of

freshwater supply to the southwest region of Bangladesh and is the only remaining major spill channel of the Ganges River flowing through the region where the Sundarbans is located at its southern most part. Dry season Gorai flows have particularly been affected by the building of the Farakka barrage on the Indian side. The most visible impact has been in the form of bringing morphological changes along the Gorai ─ since 1988, the river has been completely disconnected from the Ganges during every lean season. As a result only the base flow of the Gorai river system, contributed predominantly by seepage, was able to reach the *Sundarbans* during the dry season.

Conclusion

The effect of water diversion as a result of the Farakka barrage on dry season flows and salinity levels in the *Sundarbans* was in fact comparable (if not higher) than the impact that might be experienced several decades later as a result of climate change. Adaptation of the *Sundarbans* to climate change might therefore not just be local but requires cross-boundary institutional arrangements. Climate change risks should also not distract from aggressively addressing other critical threats, including shrimp farming, illegal felling of trees, poaching of wildlife, and oil pollution from barge traffic, that might already critically threatening the fragile ecosystems such as the *Sundarbans* even before significant climate change impacts manifest themselves.

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