

THE IMPACT OF CLIMATE CHANGE IN SUNDARBAN AND ITS CATASTROPHIC EFFECT

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ABSTRACT

The Sundarbans is the world's largest contiguous mangrove forest and is a designated world heritage site. It has the largest mangrove diversity in the world including several threatened floral and faunal species. It is located in the south west part of Bangladesh in the estuary of river Ganges covering 436,570 ha of land (3.2% of the global mangrove forest). Due to climate change the Sundarbans faces several challenges. With rising sea levels, islands are disappearing and the increasing salinity in the water and soil has severely threatened the health of mangrove forests and the quality of soil and crops. With risk of the Sundarbans submerging, there is an urgent need for global reduction of emissions and replacement of fossil fuels with renewable energy. It is also needed to promote plantation of local saline resistant seeds. Since increases in flooding and sea level rise are quite likely, these two risks are clustered together. The remaining risks, while also potentially important, have much lower likelihoods of being realized as a result of climate change. The Sundarbans is an innocent victim of accelerating global warming and climate change and faces a direct threat to its very existence. This paper provides an overview of some of the core challenges of Sundarbans that faces as a result of climate change. The main scheme of this paper is to represent the catastrophic effect in Sundarbans and presenting a proposal for sustainable management of Sundarbans ecosystem.

Keywords: Sea level rise, salinity, submergence, disaster, climate change

1. INTRODUCTION

Sundarbans is the world's largest contiguous mangrove forest and is a designated world heritage site which is spread approximately 9,630 square kilometers, of which 5,363 square kilometers is reclaimed area and the 4,267 square kilometers are protected mangrove forests. It is located in the south west part of Bangladesh in the estuary of river Ganges covering 436,570 ha of land (3.2% of the global mangrove forest). The Sundarbans mangrove forests have encountered five major unusual tragic events, i.e. cyclone in 1988 and 1991, the Asian tsunami in 2004, cyclone Sidar in 2007 and cyclone Nardis in 2008 within a very short period of time. Sundarban area is cyclone-prone, monsoonal and lowlying as a result of which changes in climate have significantly impacted the area, flora, fauna and the population living within it. These disturbances have caused enormous amount of damage to the standing vegetation of the Sundarbans mangrove forest and plantation in coastal afforestation. In Sundarban, world famous Royal Bengal tiger (*Panthera tigris*) found along with other wildlife at most risk (Ahmed, 2006). The tiger is a widely-distributed species, breeding parameters may vary between the five extant sub-species in response to different climates, habitats, prey densities, and other environmental parameters. By top dying Sundri and Gewa is threatened, due to salinity and pest infestation (Rahman, 1995). Reduction of Sundri and Gewa indicates that all plant species along with other terrestrial and aquatic species in the Sundarbans could be ruined by climate change. Due to climate changes potential loss of economic value of all the ecosystems services can be studied, as currently the Sundarbans generates significant economic value from the provisioning and cultural services (Uddin et al., 2013). The rise in salinity in the Sundarbans has been intensified by rise in sea levels and deep entry by saline water. However, a primary cause for rise in salinity and resultant change in the ecological patterns is because of increased consumption of upstream freshwater and release for very little freshwater into the Sundarbans. The lack of freshwater has caused several creeks to turn completely saline, with only the monsoons providing freshwater supply. About 77% areas of whole Sundarbans will be flooded by more than 1 m depth due to 88 sea level rise in 2100. In addition to increasing inundation, salinity pattern will be changes in the Sundarbans due to sea level rise and change in upstream freshwater flow. The low saline area (0-1ppt) would decrease from 10.8% in base condition (2001) to 4.0% with 88 cm sea level rise in 2100 (CEGIS, 2006). The fisheries resources of the Sundarbans will be compressed, not the production inside Sundarbans only, rather reducing the supply of sufficient commercially important fish larvae to the freshwater and marine zones due to degradation of the quality of the fish nursing

ground. Potential loss of economic value of all the ecosystems services due to climate changes can be studied, as currently the Sundarbans generates significant economic value from the provisioning and cultural services. The forest depended livelihoods are mostly dependent on the provisioning services of the Sundarbans. The livelihoods pattern indicates that most of them were engaged in collecting fish followed by fuel wood, crab, honey and golpata, rather engaged in timber cutting, as because of impose of moratorium on timber felling. Most of the respondents (55%) earned 76%-100% of their total income from the provisioning services of Bangladesh Sundarbans, whereas in Cambodia almost 94% people consider themselves totally reliant on the mangrove forests (Benard, 2007). The impacts of climate changes on the ecosystem services of Sundarbans will directly impact the highly forest dependent livelihoods. Further, the existence of Sundarbans would save the neighbouring community from cyclone and storm surges, as it did in the recent years when Cyclone Sidr hit the area in 2007 (IPAC, 2010). Although historically the management of approach for the Sundarbans focused on the revenue generation from the forest through systematic management (FD, 2010), new exemplar of management should look forward considering the potential impacts of climate change, ecological integrity, sustainable harvesting and ensuring continuing the ecosystem services of the Sundarbans for next generations of human as well as the ecosystem itself. The ecosystem services of the Sundarbans Reserve Forest can be categorized under four types provisioning, cultural, regulatory and supporting services. The most common provisioning services are timber, fuel, wood, fish, palm, honey and waxes, medicinal plants (De Groot et al., 2002). There are 291 fish species in the Sundarbans. Around 3.5 million people living around the SRF are directly or indirectly dependent on the ecosystem services of the forest. Recognizing the ecological and socio-economic importance, the SRF was stated as 'Ramsar site' in 1992 and the UNESCO has recognized three wildlife sanctuaries (around 140,000 ha area) of this forest as a "World Heritage Site" in 1997. Over 3.5 millions of people living around the Sundarbans are directly or indirectly dependent on ecosystem services (Giri et al., 2007). Timber, fisheries and other non-timber forest products (NTFP) are the main products of the forest. Also, the Sundarbans serves as coastal protection and reduces winds and storm surges, coastal flooding and coastal erosion (SCBD, 2009). The suitable area for Sundri and Gewa under different sea level rise development was taken from the estimate of CEGIS (2006) and available past records of timber stock and price were taken (IRMP, 1998). The objectives of this paper is to (1) represent the change in land use pattern at different time periods, (2) change statistics of mangrove extent, (3) represent cumulative area change in Khulna and Satkhira region, (4) represent the catastrophic effect in Sundarbans, (5) represent a proposal for sustainable management of Sundarbans ecosystem.

2. METHODOLOGY

The study considers the Sundarbans mangrove forest and the neighbouring forest dependent livelihoods in Bangladesh. Both primary and secondary data were used for analysis of impacts of climate change on ecosystem services and dependent livelihoods. On the other hand, the impacts of climate change on the forest dependent livelihoods was revealed using households survey of the livelihoods groups and relating their forest dependency to the likely changes in the Sundarbans ecosystem services on which they depend. Present status of livelihood reliance on the Sundarbans was harnessed through household survey with semi-structured questionnaires in two adjacent villages of Sundarbans (Uttar Southkhali and South Southkhali under Sarankhola Upazila (sub district) of Bagerhat district, Bangladesh). The forest and agricultural lands (land use land cover classes) are categorized by two in year 2001 (in square km) and in year 2009 (in square km) and change statistics of mangrove extent and cover for the last two –and-a-half centuries. In last centuries the catastrophic effect on Sundarbans occurs due to temperature change, change in forest cover and so many reasons. The 1990 to 2000 study actually tracks changes in temperature in the Sundarbans from 1965 to 2000. It finds that there is a clear rise in air temperature over both land and sea. The observed rise is 0.019 degrees Centigrade per year over the Bay of Bengal, and a similar rising trend is also observed in the Sundarbans. The study estimates that if this trend continues, temperature in this area is expected to rise by one degree Centigrade by 2050.

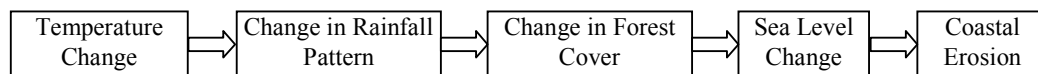


Figure 1: Catastrophic changes of coastal Forest the Sundarbans due to temperature changes

In figure 1, it is shown that the coastal erosion occurs mainly due to temperature change. When temperature increased then the rainfall pattern changed drastically. So, after the changing of forest cover, sea level change and then coastal erosion happens.

2.1 STUDY AREA

The Sundarbans (21°30'- 22°30'N, 89°12'-90°18'E) are a World Heritage site which consists of three wildlife sanctuaries (Sundarbans West, East and South) lying on disjunct deltaic islands in the Sundarbans Forest Division of Khulna District, close to the border with India and immediately west of the principal outflow of the Ganges, Brahmaputra and Meghna rivers.

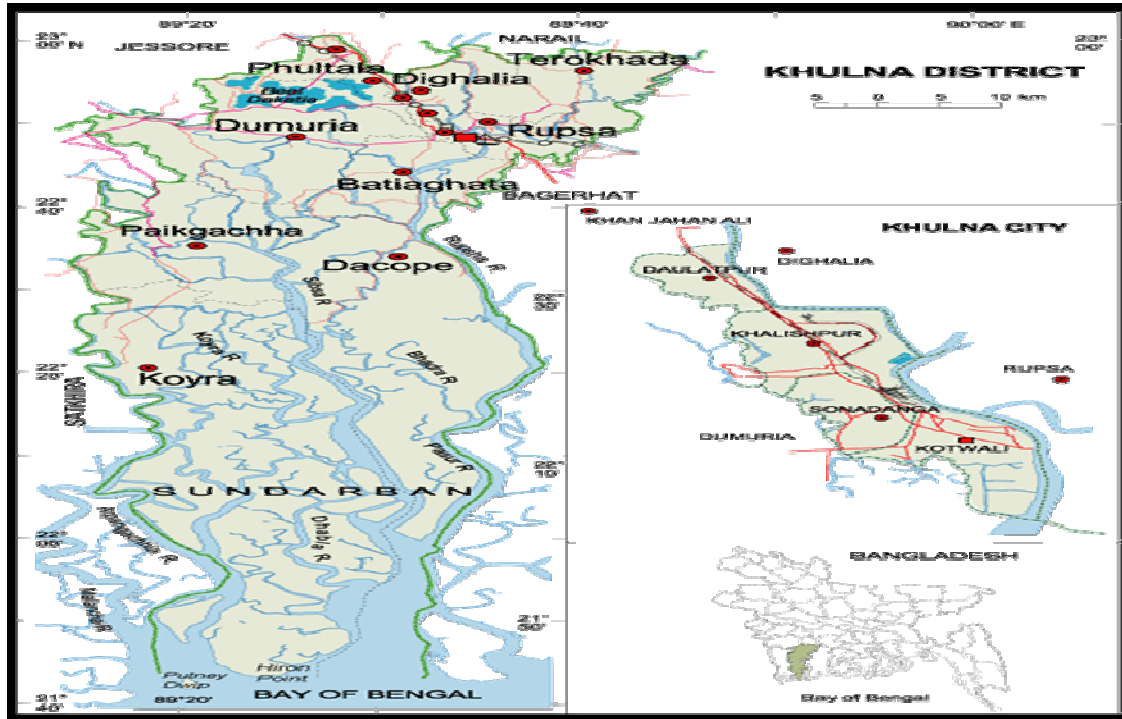


Figure 2: Location of the Sundarbans

Currently, Sundarbans is threatened by both anthropogenic and natural factors. The natural threats includes climate change induced sea level rise. It has been anticipated that the most bio diverse areas in the Sundarbans will be reduced from 60% to 30% in the year 2100 with 88 cm sea level rise compare to the status in 2001, which would ultimately reduce the production of the forest products and dependent livelihoods.

2.2 RESEARCH APPROACH

This research approaches at cause and effect of Sundarbans mangrove forest due to climate changes. And establishing a proposal model for the sustainable development.

3. RESULTS AND DISCUSSION:

In 2001, dense forest was 1655.878 sq km and in 2009, the forest was 1651.3275 sq km. Dense forest decreased within the few years and it was 4.5505 sq km. Degarded forest was 404.887 sq km in 2001 and in 2009 it was 332.008 sq ft. In 2001, Agricultural land was 2149.615 sq km and the area decreased by 458.369 in 8 years. Water body was 232.888 sq km in 2001 and in 2009, it was 1691.246sq km. In 2014 the mangrove forest was 1852 km². And area changed in % relating to previous observation was 3.8%.

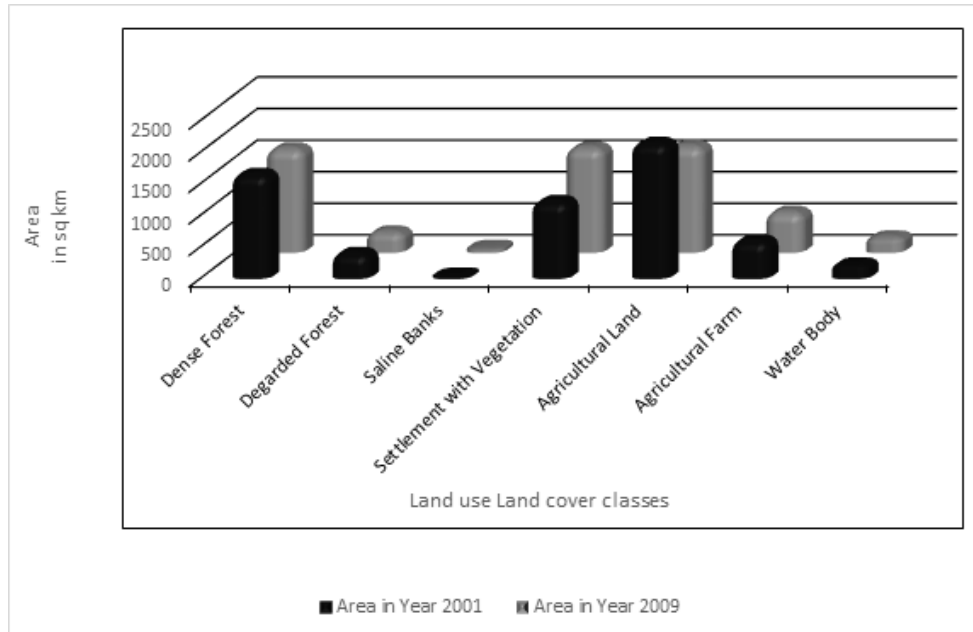


Figure 3: Change in the Land use patterns and Land cover classes in Sunderbans between 2001 and 2009.

In figure 3, Mangrove area changed within the year 2002-2009 was 3%. In 2009, area of dense forest, settlement with vegetation, agricultural farm and water bodies are greater than in year 2001. In year 2001, the area of degraded forest, saline banks and agricultural lands are greater than in year 2009. The bar chart that is shown represents the change in the Land use patterns and Land cover classes in Sunderbans in between year 2001 and 2009. In the time 2001 to 2009 dense forest decreases. For this reason temperature was increased which was the reason of increasing the sea level. The cumulative similarities are tabled as the area of mangrove forest and area change in % (per decade), shown in below:

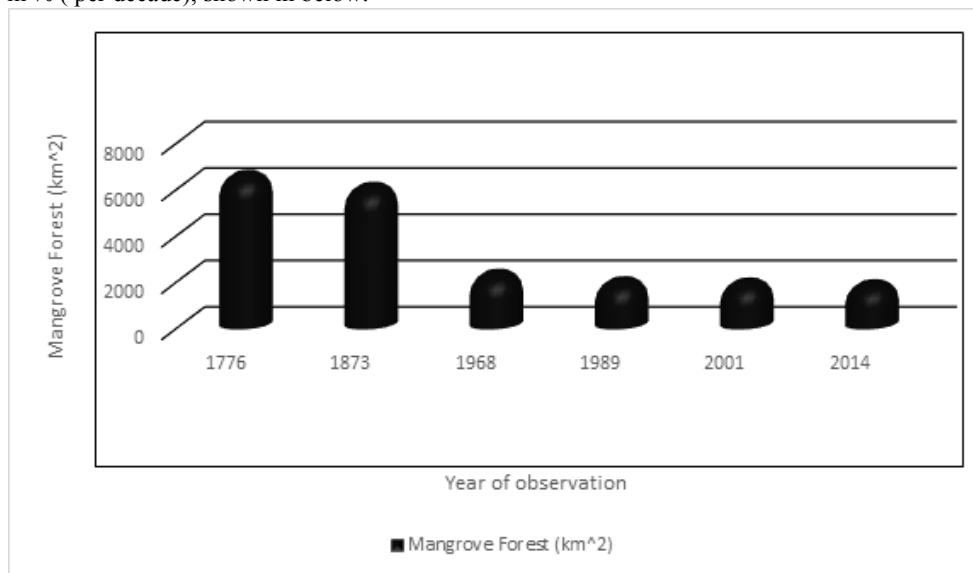


Figure 4: Change statistics of mangrove extent and cover for the last two and a half centuries

Dense forest decreased within the few years and it was 4.5505 sq km. Degarded forest was 404.887 sq km in 2001 and in 2009 it was 332.008 sq ft. For that reason the lifes of different species like Estuarine Crocodile, Fishing Cat, Common Otter, Water Monitor lizard, Gangetic Dolphin are in danger. Although the impact of climate change induced sea level rise would be visible in the long run, the altered hydrological and salinity pattern would lead to changes in the suitable habitat for plants, wildlife and fisheries. The changing physiographical condition would gradually re-shape the mangrove ecosystem and its ecosystem services. In 2001, Agricultural land was 2149.615 sq km and the area decreased by 458.369 in 8 years. Water body was 232.888 sq km in 2001 and in 2009, it was 1691.246sq km. In 2014 the mangrove forest was 1852 km². And area changed in % relating to previous observation was 3.8%. Mangrove area changed within the year 2002-2009 was 3%. Water bodies changed about 1%. Agricultural farm was 603.603 sq km in year 2001. And, 649.1 sq km in year 2009. Mudflats were 12.6135 sq km. In 2001, the area of sand was 8.0835sq km. And in 2009, the area of sand was 8.76664 sq km. In 2001, area of mangrove forest was 1926 km². . In 1989, area of mangrove forest was 1983 km². In 1968, the area of mangrove forest was 2307 km². Water bodies was changed about 1% in the time period 2002-2009. In 2009 area of water bodies was 24% that is shown in below. For the decreation of water bodies the watery lives are in dangered. As the potential climate change will change the physiographic condition, the supporting services of the Sundarbans (habitat for plants and animals, nursery ground for fisheries and wildlife) will be greatly affected. The changes in the supporting services of the Sundarbans due to climate change and sea level rise would be largely visible on the provisioning services, primarily on the trees and fisheries production. As discussed earlier, sea level rise will change the inundation and salinity pattern in the Sundarbans that will affect the suitable area for the trees.

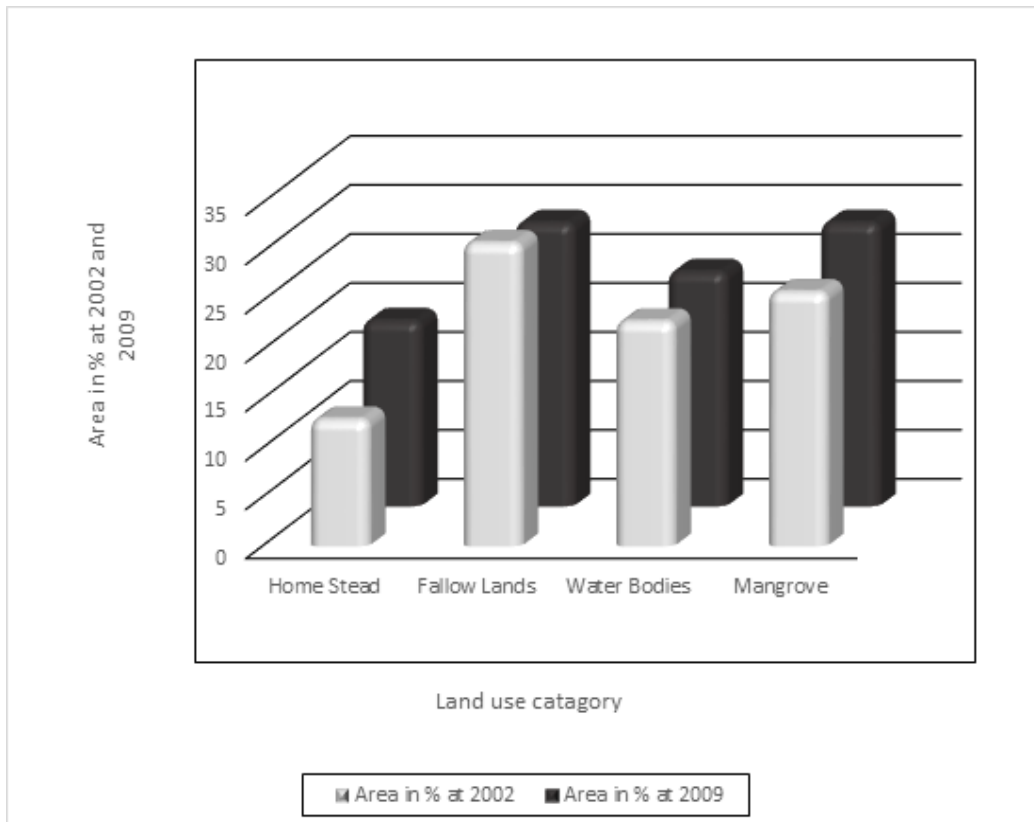


Figure 5: Land use pattern and its change in Khulna and Satkhira region 2002-2009

In the figure 5, it is shown that the area in % of home stead at 2009 is 19% and in 2002 it was 9.5%, fellow lands was 29% in 2002 and in 2009 it was 28% water bodies is 24% in 2002 and in 2009 it was 29%. Mangrove forest was 21% in 2002 and in 2009 it was 28%. So, the overall bar chart shows the cumulative pictures of the Sundarbans land such as home stead, fallow lands, water bodies, mangrove forest etc.

4. PROPOSAL FOR SUSTAINABLE MANAGEMENT OF SUNDARBANS ECOSYSTEM

A proposed model is established for the development of Sundarbans ecosystem that is shown in below:

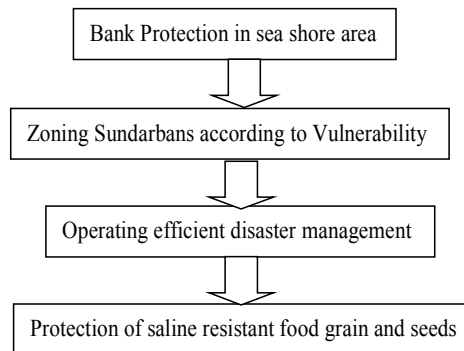


Figure 6: A proposal model for the sustainable development

In figure 6, a model developed for the sustainable development of Sundarbans. This model established for the minimization of catastrophic effect upon Sundarbans due to changing of climate. The first step is the bank protection in sea shore area. Second one is the zoning Sundarbans area according to vulnerability. The next is operating efficient disaster management. And the last one is the protection of saline resistant food grain and seeds.

5. CONCLUSIONS

Sundarbans is cyclone-prone, monsoonal and low-lying area which affected by climate change. Rainfall is heavy and humidity high (80%) due to the proximity of the Bay of Bengal. About 80% of the rainfall in the monsoon, which lasts from June to October? Mean annual rainfall varies about 1,800 mm at Khulna, north of the Sundarbans, to 2,790mm on the coast. There is a six month dry season during which evapotranspiration exceeds precipitation. Conditions are most saline in February-April, the depletion of soil moisture being coupled with reduced freshwater flow from upstream. Temperature s rise from daily minimum of 2-4 degrees Celsius (°o) in winter and maximum 43°C. In year 2009, dense forests was decreased by 0.27% with respect to year 2001. In year 2009, degraded forests was 332.008 sq km. And it was decreased about 18% in comparison with year 2001. Saline banks increased about 92.13% , with the changes of climate. Water bodies increased about 232.888 in sq km to 250.65 sq km.. Sand increased about 8.5%. In the last two-and-a-half centuries there was drastically area changed. In year 2001 to 2014, the area changed about 2.9%. In the year 1989 to 2001, the area changed about 14%. In the year 1968 to 1989, the area changed about 62%. In the year 1776 to 1873, the area changed about 7.9%.

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