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SUNDERBAN MANGROVES, POST AMPHAN: AN OVERVIEW

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Abstract: The Sundarbans comprise a cluster of small low-lying islands (less than five metres in height) in the Ganga-Brahmaputra-Meghna River delta. It is the largest continuous mangrove forest in the world. Cyclone Amphan was the first super cyclone to form in the Bay of Bengal since 1999, and one of the fiercest to hit West Bengal in the last 100 years. As per the initial estimate, about 1,600 sq km area in the Sunderbans suffered damage. Mangroves have the potential to adapt to sea level rise, catch runoff from soil erosion leading to accretion of coastal areas, and are of course impressive 'blue carbon' sinks. Mangroves, salt marshes, and sea grasses form much of the earth's blue carbon sinks and most importantly in the context of cyclones, act as a dampener. The cyclone wrought much less damage because of the delta's mangroves. A gendered approach to mangrove conservation is necessary in order to promote innovative, sustainable and equitable conservation.

Index Terms - Sunderban, mangrove ecosystem, biosphere reserve, Amphan, blue carbon sink, community based conservation

I. UNIQUE ECOSYSTEM

"There is no prettiness here to invite the stranger in. Yet, to the world at large, this archipelago is known as the Sundarban, which means the beautiful forest," Amitav Ghosh had written in his novel *The Hungry Tide*. However after Cyclone Amphan, the Sundarbans have become completely unrecognizable. The Sundarbans comprise a cluster of small low-lying islands (less than five metres in height) in the Ganga-Brahmaputra-Meghna River delta. It is the largest continuous mangrove forest in the world. The 10,000 square kilometre region stretches along the coast of Bangladesh (where 60 percent of the forest lies) and India. The mangrove forests are home to the Royal Bengal Tiger. 54 of the 102 islands have human settlements in the Indian Sundarbans.

Communities constantly live on the edge with tiger and crocodile attacks, erosion, rising sea levels (at the rate of nearly 8mm/year) and climate change linked extreme events. Analyses of cyclonic events in the Bay of Bengal over a period of 120 years indicate a 26 percent rise in the frequency of high to very high-intensity cyclones over this time period. Amphan became the second supercyclonic storm over Bay of Bengal since the 1999 Odisha supercyclone. The frequency and magnitude of events such as cyclone Amphan are likely to increase with warmer sea surface temperatures, and communities are also increasingly facing a range of other climate impacts due to long term climate change. This calls for more attention to the necessary efforts needed to help decision-makers and vulnerable communities better anticipate and manage climate risks.

II. IMPACT OF AMPHAN ON SUNDERBAN

Cyclone Amphan was the first super cyclone to form in the Bay of Bengal since 1999, and one of the fiercest to hit West Bengal in the last 100 years. As per the initial estimate, about 1,600 sq km area in the Sunderbans suffered damage. The news came at a time when the UNESCO World Heritage Site is already battling the onslaught of various components of climate change and the Forest Survey of India has pegged a loss of more than 2% mangrove cover in the delta between 2017 and 2019. The mangroves act as a natural shield for Kolkata from the impact of cyclones like Amphan.

About 28% of the Sunderbans has been damaged by Amphan, according to official reports, 1200 sq km of the 4,263 sq km forests had been 'destroyed'. The Indian Sunderbans, an area south of the Dampier Hodges line, is spread over 9,630 sq km, of which the mangrove forest accounts for 4,263 sq km. The damage has been mostly in the Patharpratima and Kultali areas of South 24 Parganas and much more on the Indian side of the Sunderbans than on the Bangladesh side. The areas worst hit by Cyclone 'Amphan' are Ghoramara Dweep and Kalinagar in Kakdwip, Naamkhana, Bakkhali, Frasergunj, Sagar and Pathor Pratima Island in South 24-Parganas. On trees turning yellow and red in the Sunderbans after the cyclone, it is felt that the phenomenon was mostly due to salinity (The Hindu, 09.06.2020). Despite efforts for massive plantation drives, it may take years to restore the mangroves. Experts say the mangroves not only reduce wind speed but break the waves during a storm surge caused by a cyclone.

The Sundarbans is Bengal's first line of defence from the violent storms that periodically arise in the Bay of Bengal. However, the people of this region pay a heavy price for this. Four days after Amphan hit, the Sundarbans region of West Bengal is in shock. Livelihoods have been lost, houses torn down, power systems dislocated and mobile networks blacked out. Most ominously, the intensity of the storm has meant salt water from the sea has backed up into farmlands in the delta, rendering them useless for the next few years. Nearly 17,800 hectares of agricultural lands may have been damaged because of saline water from seas entering the farms. Apart from erosion, opening up of creeks might lead to overflow of saline water into villages compelling all to think of salt tolerant varieties of rice (News 18, 21.05.2020).

After Cyclone Sidr, experts had predicted it would take 40 years for the Bangladesh Sunderbans to revive, but that is not exactly the case. As per historical records, Dhoblat village in Sagar block was abandoned by people in 1843 after a series of cyclones had struck it since 1833. But Nature (mangroves) has reclaimed the land there now. According to a recent study carried out by DECMA (Delta Vulnerability and Climate Change: Migration and Adaptation), in the aftermath of Aila, between 2014 and 2018, it was found out that 64% of the migration from the Sundarbans regions happens due to economic distress resulting out of unsustainable agricultural opportunities. In the winter of 2019, a decade after cyclone Aila, Sundarbans was once again going back to growing legumes and vegetables other than the single paddy crop – Aman (The Wire, 26.05.2020).

III. ROLE OF SUNDERBAN ECOSYSTEM

IIIA. Sunderban Mangroves and Blue Carbon storage

The capacity of mangroves, sea grasses and salt marshes to sequester carbon dioxide from the atmosphere is becoming increasingly recognized at an international level. Of all the biological carbon, also termed as 'green carbon', captured in the world, over half (55%) is captured by mangroves, sea grasses, salt marshes and other marine living organisms, known more specifically as 'blue carbon'.

Mangroves have the potential to adapt to sea level rise, catch runoff from soil erosion leading to accretion of coastal areas, and are of course impressive 'blue carbon' sinks. Mangroves, salt marshes, and sea grasses form much of the earth's blue carbon sinks. Blue carbon has been defined as "the carbon stored, sequestered or released from coastal ecosystems of tidal marshes, mangroves and seagrass meadows" (Herr et al. 2012). These marine and coastal ecosystems store large amounts of carbon in the plants and the sediment below them. When these ecosystems are degraded or destroyed **-** which is occurring at annual rates of 0.7% to 2.1% for mangroves, 1% to 2% for salt marshes, and 1.2% to 2% for sea-grass meadows **-** significant amounts of carbon dioxide are released into the atmosphere, contributing to climate change risk (Pendleton et al. 2012).

Sunderbans form the most carbon rich forests in the tropics with high carbon sequestration potential, meaning their degradation and loss substantially reduce our ability to mitigate, and adapt to, predicted changes in climatic conditions. Their degradation also releases large amounts of 'blue carbon' stored in sediments to the atmosphere, a process that has been underestimated until recently.

These coastal vegetations sequester carbon far more effectively (up to 100 times faster) and more permanently than terrestrial forests. Further, studies have shown that per hectare, mangrove forests store up to five times more carbon than most other tropical forests around the world. This ability of mangroves and other coastal vegetation to store such large amounts of carbon is, in part, due to the deep, organic rich soils in which they thrive. The entangled root systems of mangroves, which anchor the plants into underwater sediment, slow down incoming tidal waters, allowing organic and inorganic material to settle into the sediment surface. The sediments beneath these habitats are characterized by typically low oxygen conditions, slowing down the decay process and rates, resulting in much greater amounts of carbon accumulating in the soil. In fact, mangroves have more carbon in their soil alone than most tropical forests have in all their biomass and soil combined.

Carbon offsets based on the protection and restoration of coastal vegetation could therefore be far more cost effective than current approaches focused on terrestrial and peat forests, even before taking into consideration the enormous additional benefits to fisheries, coastal protection, and the livelihoods of coastal inhabitants. Therefore, cutting down mangroves means releasing larger amounts of carbon into the atmosphere. This in turn causes the wet soil to dry up, leading to the release of even more stored carbon into the atmosphere. Estimates suggest a range of between 150 million to 1 billion tonnes of CO_2 is emitted annually due to the destruction of mangrove forests globally. Thus, at the global scale, coastal wetland destruction could account for 1-3% of industrial emissions; a number that is on the rise as more and more coastal wetlands are destroyed every year around the world. Thus, mangrove forests offer a unique and highly efficient approach to climate change mitigation and adaptation.

The United Nations Framework Convention on Climate Change (UNFCCC) has considered conserving and restoring forests an important aspect of climate change mitigation through its REDD+ (reduced emissions from deforestation and degradation) mechanism. Broadening these approaches to include other natural systems, such as blue carbon ecosystems, could help reduce emissions from the degradation and destruction of these areas as well. UNFCCC has called for the sustainable management, conservation, and enhancement of "sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol including … oceans as well as … other coastal and marine ecosystems." It is therefore possible to integrate coastal ecosystems into UNFCCC mechanisms that already exist **(**Herr *et al*. 2012).

As per a research financed by the Union government titled "Blue Carbon Estimation in Coastal Zone of Eastern India – Sunderbans," the huge mangrove forest is rapidly losing its capacity to absorb carbon dioxide, one of the main greenhouse gases, from the atmosphere due to increase in the salinity of water, unchecked deforestation and pollution. As per the study, the mangrove forest, marsh grass, phytoplanktons, molluscus and other coastal vegetation in the largest delta on earth are the natural absorbers of carbon dioxide (CO_2).

The locked carbon in these plants is known as “Blue Carbons”. The absorption of CO_2 is a process which plays a role in reduction of the warming of the earth and other adverse effects of climate change. The researchers who conducted the study expressed concerns, especially towards the central Sunderbans, one of the three zones into which the forest was divided for the study, the other two being western and eastern. The situation, especially in the central part, is quite alarming. The capacity of the mangrove forest, especially the Byne species, to absorb carbon dioxide has declined significantly, affecting the whole ecosystem of the area. The study was focused mainly on the Byne species of mangrove. There are 34 other species of mangroves found in the forest including Keora and Genwa. Mangrove losses contributed half the total blue carbon stock reduction, followed in ranking by the degradation or loss of sea grass meadows, then tidal marshes.

The situation is worrying because less absorption of CO_2 from the atmosphere meant higher proportion of CO_2 in the atmosphere which traps heat. The main causes of such an alarming situation in the Sunderbans, are increased salinity in water and human activities like shrimp farming, kiln industries and deforestation. The mangroves thrive on fresh water, but due to lack of fresh water the height of mangroves has reduced significantly, bringing down their capacity to absorb carbons. Due to deposition of silt at the confluence of the Vidyadhari and Matla rivers, fresh water is unable to enter the Matla river resulting in rise in its salinity. Human incursion in these areas for activities like shrimp farming, setting up of brick kiln industry and deforestation has added to the problem.

As fresh water is available in eastern Sunderabans, the trees there are taller and there is less human incursion as well. The western part too was fed by a regular supply of fresh water from the Hooghly river. According to the study, if steps are not taken to remove the silt deposits at the meeting point of the Vidyadhari and Malta rivers, the situation may get worse. The report suggested dredging of the channel and afforestation besides checking shrimp farming.

IIIB. Combating Climate Change

Mangroves play a vital role in coastal ecosystems and food chains, by supporting communities of fish and shellfish. Mangroves are salt-tolerant trees and shrubs that help protect coastal areas from increasingly intense tropical storms, waves and erosion. By serving as a flood barrier, they can reduce the damage caused by storms such as cyclones. Damage and erosion to mangroves leave the coast increasingly exposed and therefore more vulnerable to storms.

Densely populated coastal areas like the Ganges-Brahmaputra Delta are the most vulnerable to deadly storms. Scientists determined that intact and healthy mangroves in the Indian state of Orissa saved many lives in a 1999 cyclone originating from the Bay of Bengal. Another study found that the 2004 Indian Ocean tsunami caused significantly less damage in areas of southeastern India protected by mangroves and other forests, and simulations show that a dense belt of mangroves can dramatically reduce the peak pressure of a tsunami wave.

The mangrove forests of the Sundarbans provide an important defence in limiting climate change impacts, providing protection to coastal areas from tsunamis and cyclones. Each year about eight storms with sustained wind speeds greater than 63km/hr form in the Bay of Bengal, with an average of two becoming tropical cyclones. Tropical cyclones Sidr in 2007 and Aila in 2009 caused extensive damage, prior Amphan.

The long term trend is for cyclone frequency to reduce slightly while cyclone intensity increases. Mangroves serve each year as a biological shield protecting coastal communities from the worst effects of storm surge. Loss of mangroves escalates the disaster risk for local populations from storm surge and flooding.

Accelerating sea-level rise due to global warming is likely to submerge the Sundarbans. This would eliminate the protection they provide against the region's increasingly intense tropical storms. By absorbing some of the force of wind and waves and serving as a flood barrier, mangroves can lessen the damage caused by cyclones and other storms. In early 2010, a disputed Sundarbans island disappeared under the rising waters of the Bay of Bengal (BBC, 2010). Scientists project that under a high emissions scenario, relative sea-level rise is likely to inundate most of the Sundarbans by mid-century, and could wipe them out by the end of the century (Nicolls *et al.* 2007). Without the mangroves of the Sundarbans to serve as a buffer, more frequent and intense storms are likely to pose a growing danger to the residents of Ganges basin including cities like Kolkata, putting lives and livelihoods at risk (Douglas 1997).

IV. CHALLENGES FACING MANGROVE ECOSYSTEMS

Despite the diverse roles of mangroves, these ecosystems are often seen as valueless wastelands available for other uses. Such negligence toward protecting mangroves is leading to a faster rate of destruction for mangroves all over the world than for tropical forests. The most substantial loss of the world’s mangrove cover is due to their conversion to other land uses, such as urban area expansion, industrial development, aquaculture, agricultural development and charcoal making. Among these, shrimp aquaculture has been the single biggest driver of mangrove destruction, particularly in Southeast Asia.

One of the key challenges facing mangrove conservation is inadequate understanding of their multiple roles due to poor research, particularly in the areas of climate change mitigation and adaptation. As compared to terrestrial ecosystems, the research focus on coastal and marine systems is about a decade behind. There are isolated examples of a few very useful research studies, but a comprehensive account of the various ecological, economic and bio-physical roles played by mangrove forests is still lacking. In order to raise awareness of the multiple benefits of mangrove ecosystems, there is a need to conduct more research and also focus more on expanding mangrove areas in participation with local communities and other key stakeholders.

Unless there are deep and swift cuts in our heat-trapping emissions, most of the Sundarbans may disappear underwater, and those that remain could be threatened by saltwater incursion. A 2010 paper - *Impact of Climate Change on "Sundarbans", the largest mangrove* *forest: ways forward* (Haq, 2010) suggests changing salinity is the primary process of ecosystem degradation both through rising sea levels encroaching from the Bay of Bengal and reduced freshwater flow. The Sundarbans ecosystem is a balance between freshwater and salty ocean wetlands environments. It needs the flow of freshwater *via* the Ganges and the Gorai rivers, particularly during dry periods to balance the saline intrusion.

There is substantial dieback of Sundari trees in the forest. "Sundari trees in the Sundarbans are being destroyed following outbreak of the top-dying disease, locally known as 'agamora'. It is feared this tree species may be soon driven to extinction due to the fast spread of the disease. "The adverse effects of increased salinity on the ecosystem of the Sundarbans are manifested in the dying of tops of Sundari trees, retrogression of forest types, slow forest growth, and reduced productivity of forest sites."

Blue carbon has not emerged as a specific negotiating agenda item. Although blue carbon is not making substantial headway in official negotiations, there is still belief by several countries and NGOs that the UNFCCC process can still create incentives for blue carbon. Instead of working to get blue carbon into the process explicitly, parties might work to ensure that existing systems, such as REDD+, or the development of nationally appropriate mitigation actions (NAMAs), are relevant for blue carbon, or at least do not work against it. Additionally, the phrase blue carbon seems to be used with less frequency within the UNFCCC. Instead, it may be appropriate to modify the language to be more logically connected to the language already used by the UNFCCC.

For residents of cities like Kolkata, the greatest danger is likely to come from higher tides and more intense storms ravaging the urban greens, as witnessed in Amphan (Sen, 2020; Biswas and Sen 2020) - with storm surges unchecked by the disappearing mangroves of the Sundarbans. As sea levels rise and storm patterns shift in the Bay of Bengal, scientists project increases in extreme water levels near Kolkata (Mitchell *et al.* 2006). The choices we make today could determine whether the ecologically rich Sundarbans stay on the map - affecting the very survival of people in Kolkata and throughout the Ganges basin.

V. COMMUNITY-BASED MANGROVE CONSERVATION AND WOMEN EMPOWERMENT: THE PATH AHEAD

Community based natural resource management approach combines conservation objectives with the generation of economic benefits for rural communities. A key point underpinning the Community Based models is that local communities have inherent resource management capabilities, and therefore, only the right incentive structure needs to be established (Sen, 2011, 2014a).

India has experimented with the concept of co-management of State-owned natural resources such as forests. Although community involvement in the management of State forests has a long history, it was a few successful experiments in community involvement on State forest lands in the 1980s that sowed the seeds of Joint Forest Management (JFM). Under JFM, the state Forest Department enters into an agreement with the local community, which is allowed greater access to the forest resources as well as a share in revenue, in return for protection of the forests against unauthorized extraction, encroachment and damage. One of the important attributes of the Indian programme was involvement of women on these committees with equal say, and more importantly, equal income (Sen, 2014b, 2015). Forestry conservation and mangrove restoration work is particularly an important income source for women raising their social status.

The importance of giving women a central role in mangrove conservation is being recognized in the Sundarbans. There are reports that women across the region have become mangrove crusaders by guarding and planting their hamlets with mangrove belts. The mangrove saplings are grown in small village nurseries before being planted. In order to save the world's mangroves from degradation and disappearance, there must be a quest for new and more successful approaches to conservation and management. A gendered approach to mangrove conservation is necessary in order to promote innovative, sustainable and equitable conservation thus integrating environment with society and economy, the underlying principle of Sustainable Resource Management (Pal and Sen 2017; Sen 2014c, 2018).

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