Climate change: Whispering from the Sunderbans

Sunderbans is the transitional zone between freshwater supplied by rivers and saline water pushed by the Bay of Bengal. Sundari, the pioneer tree species will suffer from 'Top dyeing' disease with the increase of salinity. Salinity increases the tree mortality rate by reducing the production of new leaves, leaf longevity and the leaf area.

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DUE to increased rate of emissions of greenhouse gases (carbon dioxide, methane, nitrous oxide, ozone and chlorofluorocarbons) from different sources such as burning of fossil fuels, deforestation and other human activities, the rate of global temperature increase accelerated from +0.6°C over the past century to an equivalent rate of +1.0°C per century in the past two decades (Natural Resource Defence Council, USA 2006). Sea-level rise as a consequence of global warming is caused by increase in seawater temperatures resulting in thermal expansion of water and melting of glacier and polar iceberg (Kennedy et. al. 2002). The climate change has already affected the ecosystems of northern hemisphere including the coastal forests.

The out flow of water from Bangladesh is the third highest in the world, next to the Amazonia and Congo basin. Major rivers of Bangladesh flow from north to south, silting up the mangroves delta and draining into the Bay of Bengal. The mangroves delta is also a region of transition between the freshwater of the rivers originating from the Ganges and the saline water of the Bay of Bengal. The ecosystems as well as the luxuriant biodiversity of Sunderbans have strong interactions with marine environments. The Sunderbans is considered as the largest single halophytic mangroves unit in the world. It has been declared as a UNESCO World Heritage Site and Ramsar Site. The environmental parameters with the direct influences on Sunderbans in terms of global climate change are sea-level rise, natural calamities like cyclones, temperature rising, salinity and drought. The structure and composition of Sunderbans may undergo major change, depending on the severity of human disturbances and predicted climate change.

The vegetation of the Sundarbans differs greatly from other non-deltaic mangroves and upland forests. It is a tropical moist forest having a mosaic pattern of old growth and successional vegetations. A total of 334 plant species were recorded in 1903 (Prain 1903). Sundari and Gewa are the dominant species throughout the old growth forests with uneven distributions of Dhundul and Kankara. Sometimes successional forests are dominated by Keora, aquatic plants and dune vegetation. There are strong correlations among vegetations, salinity, freshwater flushing, silting, inundation and mudflat accretion. Golpata, Hantol and Goran are also indicator plant species of these ecosystems.

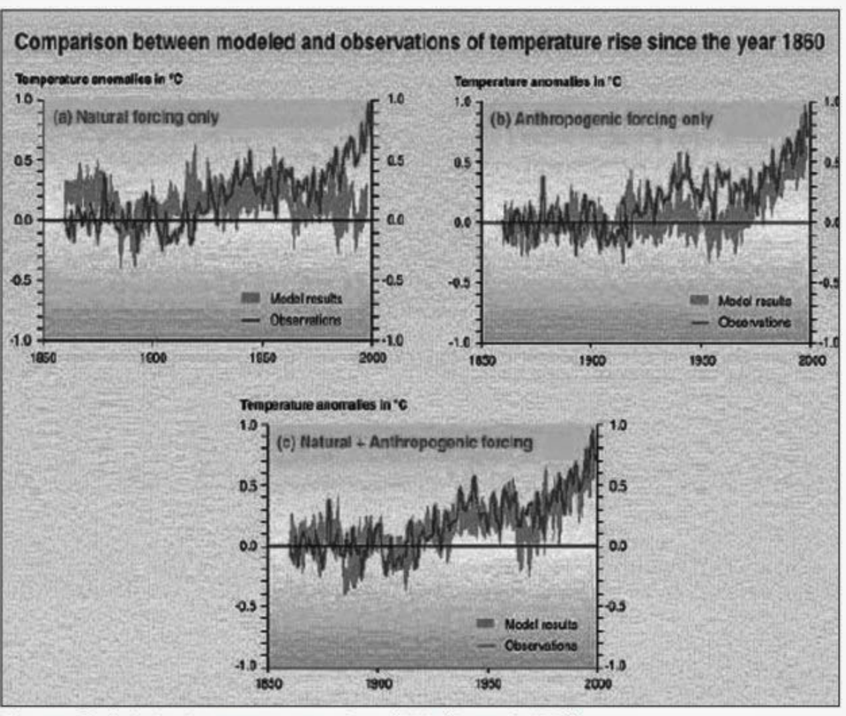


Figure: Global rise in temperature since 1860 (Boesch 2002)

A total number of 375 species of birds, 55 species of mammals, 83 species of reptiles and amphibians, 150 species of fish, 50 species of shrimp and other invertebrates were recorded in the Sundarbans (The Daily Star 2009). Hog deer, water buffalo, swamp deer, Javan rhinoceros, single horned rhinoceros and the mugger crocodile became extinct at the beginning of the last century. It is the paradise of eponymous Royal Bengal tiger, salt water crocodile and spotted deer. Besides, dolphins, rhesus monkey, snakes, river terrapin, forest owl, sea eagle, Indian flap-shelled turtle, peacock soft-shelled turtle, swamp partridge, trogon, ground thrush, yellow monitor, water monitor, Indian python, fishing cats, macaques, forest wagtail, wild boar, green frog, grey mongoose, scarlet minivet, fox, ring lizard, jungle cat, flying fox, pangolin, pigmy woodpecker, brown wing kingfisher, racket tailed drongo, chital and other threatened species live in the Sundarbans.

Sea level rise

One-metre rise of sea level will destroy the whole ecosystem of Sunderbans. Dune vegetation will be submerged under water. The pioneer or indicator species Sundari will be replaced by Goran and Gewa species, which are less valuable than Sundari. All ground animals will lose their habitats. Herbivorous animals like deer, monkey and wild boar will face shortage of food. Carnivorous animals like tigers and fishing cats will face the same problem due to lack of herbivorous animals in the forest. Marine turtles, crabs, shrimps, crocodiles, frogs, snakes, fresh water fishes and dolphins will lose their breeding grounds and habitat as well. The impacts of different rate of sea level rise on Sunderbans can be projected by the study of Clough (1994).

(a) Low level rise: The old growth and successional forests will be able to keep pace with a sea level rise of 8-9cm/100 years. Few species will be highly vulnerable and many species will be threatened on islands.

(b) Medium level rise: Sunderbans will be under stress, especially islands with a sea level rise of 9-12cm/100 years. A good number of species will be vulnerable and maximum species on islands will face high risk of extinction.

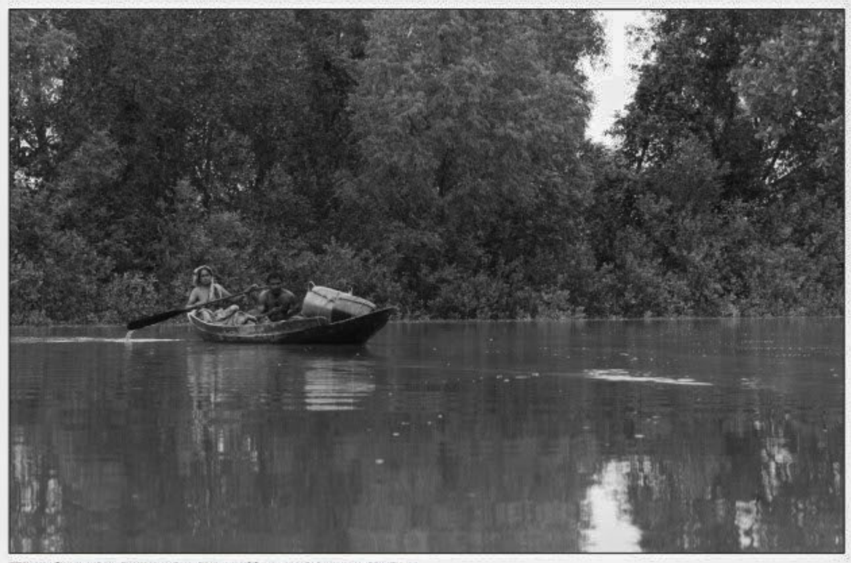
(c) High level rise: Sunderbans will be squeezed with a sea level rise of above 12cm/100 years. Loss of species will occur in short period of time on islands.

Storminess

There has been a noticeable change, almost 26 percent over past 120 years, in the frequency of cyclones in the Bay of Bengal, which may be increased further with the intensifying of El Nino in the upcoming days. Four disastrous cyclones originated in the Bay of Bengal since 2006 -- Sidr, Nargis, Bijli and Aila. Cyclones impact Sunderbans through three primary mechanisms: wind damage, storm surge, and sedimentation. The highly affected areas will become unsuitable for habitation till 2020. Most of the inhabitants will be climate refugees with the repetition of such cyclones. Strong winds uproot, topple stems, break off trunks and defoliate the canopy. Taller stems are uprooted and knocked over when a storm ashore comes. Sediments carried by storm surges are deposited on the forest floor as the surge recedes, cause plants mortality by interfering with root and soil gas exchange, leading to eventual death of the plants. Storm surges reduce the viability of seeds, seedling germination and seedling recruitment. The recovery of forest dynamics from cyclone damage can be altered by other kinds of changes to the landscape. Many exotic plant species have the ability to rapidly colonize disturbed areas, and outcompete slower-growing native trees and plant.

These cyclones do not affect the Royal Bengal tigers too much as they can swim a long distance. But the problem is that they may lose bearing. When they do not know in which direction they have to move, they may die due to exhaustion. Strong wind destroys honey bee colonies causing high mortality. Coral reefs, woodpecker, sea turtles and parrots are vulnerable to cyclones. The arboreal monkey and lizards face shortage of foods.

Coral reefs are hit hard, fractured, and sponges and sea fans are ripped from their bases. Branching corals are broken and transported over the reef top. Dunes and beaches are washed away, and large areas completely submerged. Fish dies when the decay of foliage stripped from trees lower oxygen levels in the water. Cyclones have heavier impact on wetlands and the organisms that depend on them. Ground birds are severely affected by losing their habitats, nesting and breeding sites.



The Sundarbans being affected by salinity.

Salinity

Sunderbans is the transitional zone between freshwater supplied by rivers and saline water pushed by the Bay of Bengal. Sundari, the pioneer tree species will suffer from 'Top dyeing' disease with the increase of salinity. Salinity increases the tree mortality rate by reducing the production of new leaves, leaf longevity and the leaf area (Suárez and Medina, 2005). Net photosynthesis rate, stomata conductance and transpiration rate of leaves decrease with the increase of salt concentration (Yan and Guizhu, 2007). It is believed that Royal Bengal Tigers are suffering from various diseases by drinking saline water and their normal behaviour is also being changed. Aquatic organisms will migrate inward. Many fish species and other crustaceans utilize fresh water for spawning and juvenile feeding. The Hilsa needs less salinity to lay their eggs and enter various creeks in search of sweet water. The hatchlings move towards the sea where they attain adulthood, before returning to the rivers. Migration of fish species will have an adverse effect on the economy of the country.

How to combat: Some suggestions

- Designing and establishing sea-level / climate modelling network
- Establishing databases and information systems
- Data collection of Sundarbans' resources and their uses
- Integrated coastal and marine management
- Monitoring the impact of climate change on coral reef, Royal Bengal Tiger, crocodiles and Sundari tree
- Coastal vulnerability and risk assessment
- Economic valuation of Sundarbans' resources
- Improving catchment management
- Facilitating natural regeneration and natural succession of native tree species
- Increasing waterfront setbacks in beach front areas
- Education on climate change and emergency preparedness needs to take place at all levels by incorporating it into education curricula
- Creating public awareness through mass media
- Developing coastal infrastructure
- Initiating community based coastal forestation
- Protecting existing mangroves against encroachment and cutting
- Afforestation and reforestation by salt tolerant species
- Initiating ex-situ conservation of rare species
- Establishing mechanisms to promote carbon uptake
- Raising funds for conservation programme
- Strict control of Tigers' poaching

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Butterflies: Best 'biotic-indicators' of climatic change

From 1999 to 2003 the largest butterfly --"birdwing"-- in Fashiakhali forest was found decreasing and from 2004 no trace of the "birdwing" in the forest is found. The plants on which the "birdwings" depend are very sensitive to climate change and human interference; their phenological changes have been occurred drastically and the dependant butterfly could not survive. But on the other hand, the same butterfly is still surviving in the Satsaree forset area. On the recorded data, biodiversity of all flora and fauna is in healthy condition in the Satsaree forest.

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WHEN biotic factors, abiotic-biotic and biotic-biotic interactions, biotic-biotic association stand responsive to forecast future happening by the cause of climatic changes or of any changes in any ecological area or in an ecosystem then the factors/interactions/association may be called the "biotic-indicators". Use of biotic-indicators is applicable in taking mitigation approaches to combat calamities caused because of unusual climatic changes. This is applicable especially in the case of forest conservation and for the conservation of forest biodiversity.

In this write up butterflies have been identified as the 'biotic-indicators' for the species richness monitoring system in an ecosystem and similarly for forecasting the climatic change impacts on biodiversity. It has already been found from the scientific experiments that, by using butterflies as indicators, increase of species richness and species assemblage have been augmented to 47% in a wild state. This wild state has been used as the healthy habitat for all kinds of animals

Use of butterflies as "indicators" is possible because they need three types of vegetation populations for their survival and distribution. This distribution is highly related with the phenological stages of the plants, the three types of plant population categories are larval food plants, nectar plants, and shade plants.

The butterflies use food-plants as egg laying supports. Butterfly species are very selective in plants for their egg laying activities. A female butterfly lays her egg only on a single plant on which its larva can develop by feeding on it; mainly by feeding on the leaves. These plants are so termed as food plants. Most butterflies can utilize a wide variety of flowers, including those of many cultivated varieties, as nectar sources. However, a more critical need is for the plants that provide food for the larval (caterpillar) stages, and most species will accept only one or a few species of plants at this stage.

Although the caterpillars feed on the leaves of these plants, the damage is usually minor and only temporary. It is estimated by experiments that, rather doing damage to the food-plants at the developmental stages, the butterfly adults do more benefit to the host plants by pollinating and gene-flowing activities leading to population increase of the plants. Caterpillars of some species feed on plants that are usually considered weeds.

Nectar plants are that by which butterflies can be attracted for their suitable flowers to nectar. Most butterflies can utilize a wide variety of flowers, these may be cultivated varieties or wild varieties, as nectar sources. But experiments showed that the butterflies are somewhat specific in selecting even the nectar plants as their family characters and many times as their generic characters. For the nectar-sac of the flower shall have to be within the range of proboscis capacity of the butterflies. All nectar-producing plants are not equally chosen / visited as they are not adaptable to the capability of all the butterflies equally. Butterflies seek nectar from many types of plants including ground covers, annuals, perennials, shrubs, trees etc.

Shade/ resting plants are mainly trees and hedges. It is revealed that, in the day time the butterflies take complete rest during afternoon 1:30 pm to 3.30-4.30 pm. The resting is not seen to occur on nectar plants or food plants. They take rest under/ on the leaves of hedges under a big shade tree. During this resting time butterflies do not move and do not feed on anything, but resting place need to be with high humidity and temperature comfortable for them. For this reason the butterfly park area especially the shade/resting area needs to be supported with water bodies.

Compared to the density of nectar plants and food plants area, the shade/ resting plant area must be more dense and with assemblage of high species composition. This means that species-richness of the plants (either related or not related to the butterflies) needs to be very high. Butterfly park directly and indirectly is very helpful for bio-diversity conservation and for establishment of species richness in an ecosystem.

Why butterflies are the best indicators?

Healthy presence of butterflies ensure the healthy status of a forest ecosystem. Butterflies have got reciprocal relations with the related plants. Because of that, they are distributed at all heights in the forest areas. The true/healthy forests provide three layers of vegetations in their status: vegetation at the ground level i.e. the grasses and the below man-height level vegetation; vegetation at man-height level i.e. the hedges and bushes; the canopy layers of vegetation i.e. the trees. The butterflies have got access to the plants of all heights at equal frequency. On the other hand, these plants are dependant on the butterflies for their pollination purposes and gene-flow activities.

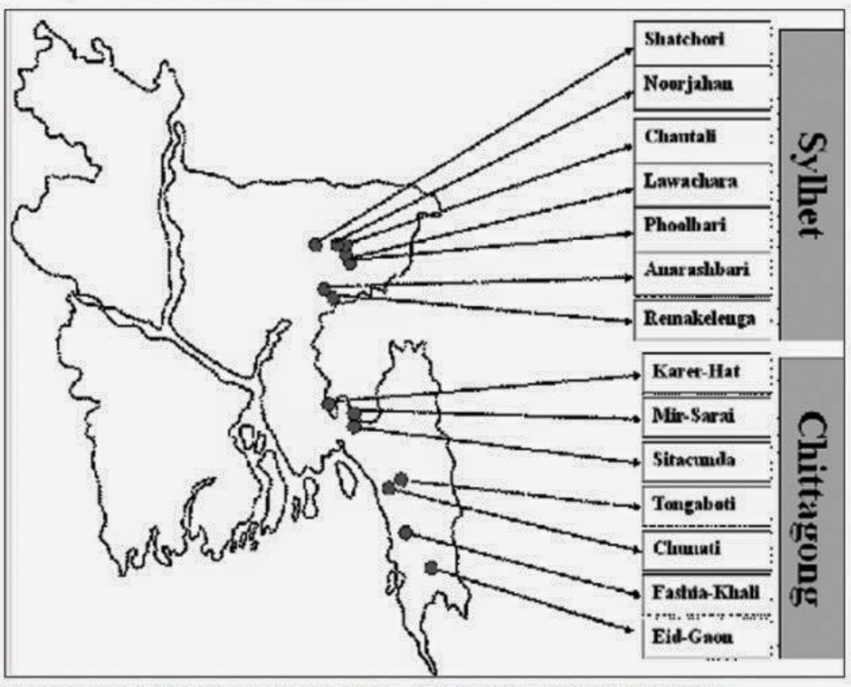
Life cycle changes in the butterflies are deeply related with phenology of the host plants and other related plants. Butterfly wings and its entire body is covered with billions of dust particles which capable of absorbing quantum of light coming from the solar system; and the photons received by the dust particles produce (by prismic system) the beautiful colourations (combination of colours) on the genetically characteristic basis for each of the species differently. At the same time, these (arrangements of dust particles on the body) are very much sensitive to the climatic changes i.e. the changes in photoperiodism and thermoperiodism of the habitat where they are living.

For designating the butterflies as "biotic-indicators", we have identified the research result in the way that, any climatic change is first perceived in the biosphere by plants and then by plant-phenology, but it does not appear visible to humans unless or until any organic damage is seen visually at drastic level. The butterflies have got serious sensitiveness to determine the phenological changes in the plants; and then in connection with the changes in plants, immediate changes in the life cycle and time-lag in butterflies are occurred. Then the population sustenance of butterflies gives them the "status of indicators" for forecasting impact of climatic changes and for the sustenance of biodiversity in an ecosystem.

Butterflies are very sensitive to the change of phenology of the plants in a forest ecosystem as they require plants of all heights for their life sustenance. Any climatic change affects phenological changes in plants. Any phenological, temporal and seasonal changes in plants affect the life cycle of the butterflies. Any abnormal change in the life cycle of buterflies affect the butterfly populations in an area. So, by seeing the population fluctuation visiually, 'climate change' forecasting can be measured.

The "Environmental Biology and Biodiversity Laboratory (EBBL)", department of zoology, University of Dhaka has been conducting researches on the butterfly conservation and conservation of forest biodiversity since 1999. The EBBL conducted researches in the forest biodiversity of Bangladesh and has found very significant result on the question of utilizing butterflies as "biotic indicators" for monitoring climatic change impacts on biodiversity of forest ecosystems. In summary, the EBBL reports that all the south-eastern forest areas have been facing the question of climatic changes, especially in the status of providing biodiversity . The working areas of the EBBL are Anarsbari, Chautali, Phulbari, NoorJahan and Lawasara under Srlmanagal forest area; Rama-Kalenga and Satsaree under Habigang forest area; Karerhat, Mirsarai, Padua, Chunati, and Tangabati under Chittagong area; Fashiakhali, Eidgaon, Eidgar and Teknaf under Cox's Bazar area.

Butterflies with their associated plant at man-height level of vegetation in Tangabati forest (Chittagong)



Forest areas in the south-eastern regions of Bangladesh taken under EBBL experimentations.

Of the experimenatl stations, the "butterfly indicators- experiments" showed that only Satsaree forest area has got less climatic change impacts on biodiversity and all other forests are affected. The most affected areas are under the Cox'sBazar forest region. In a study on the Fashiakhali forest it has been seen that the largest butterfly "bird wing" (Troides spp) are the most burning victim of the changes.

From 1999 to 2003 representative of the largest butterfly in the forest was found decreasing and from the year 2004 no trace of the "birdwing" in the forest is found. Reasons are accumulated in the EBBL lab. In abstract it could be said that the plants on which the "birdwings" depend (special vine: climbers) are very sensitive to climate change and human interference; their phenological changes have been occurred drastically and the dependant butterfly could not survive. But on the other hand, the same butterfly is still surviving in the Satsaree forset area. On the recorded data, the EBBL reports that biodiversity of all flora and fauna is in healthy condition in the Satsaree forest.

The EBBL has planned to extend its research areas as the following:

- Use butterflies as "biotic indicators" for monitoring/forecasting climatic change impacts on the biodiversity in the south-eastern forest ecosystems.
- Establishment of butterfly-colonization centres in experimental forest areas.
- Establishment of butterfly parks/ gardens for enhancing ecotourism and wildlife sanctuaries.

Establishment/materialization of the above programmes is the responsibility of the government. It is difficult for a lab. like the EBBL to materialize financially and administratively such large and national vital programmes. What the EBBL of Dhaka University can do is to do the scientific experiments and the researches to advance the programmes in perfect way. Though only the EBBL in the country has got vital experts in the line, but the laboratory intends to involve all other institutes like the forest department and other related organizations in the programmes.

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