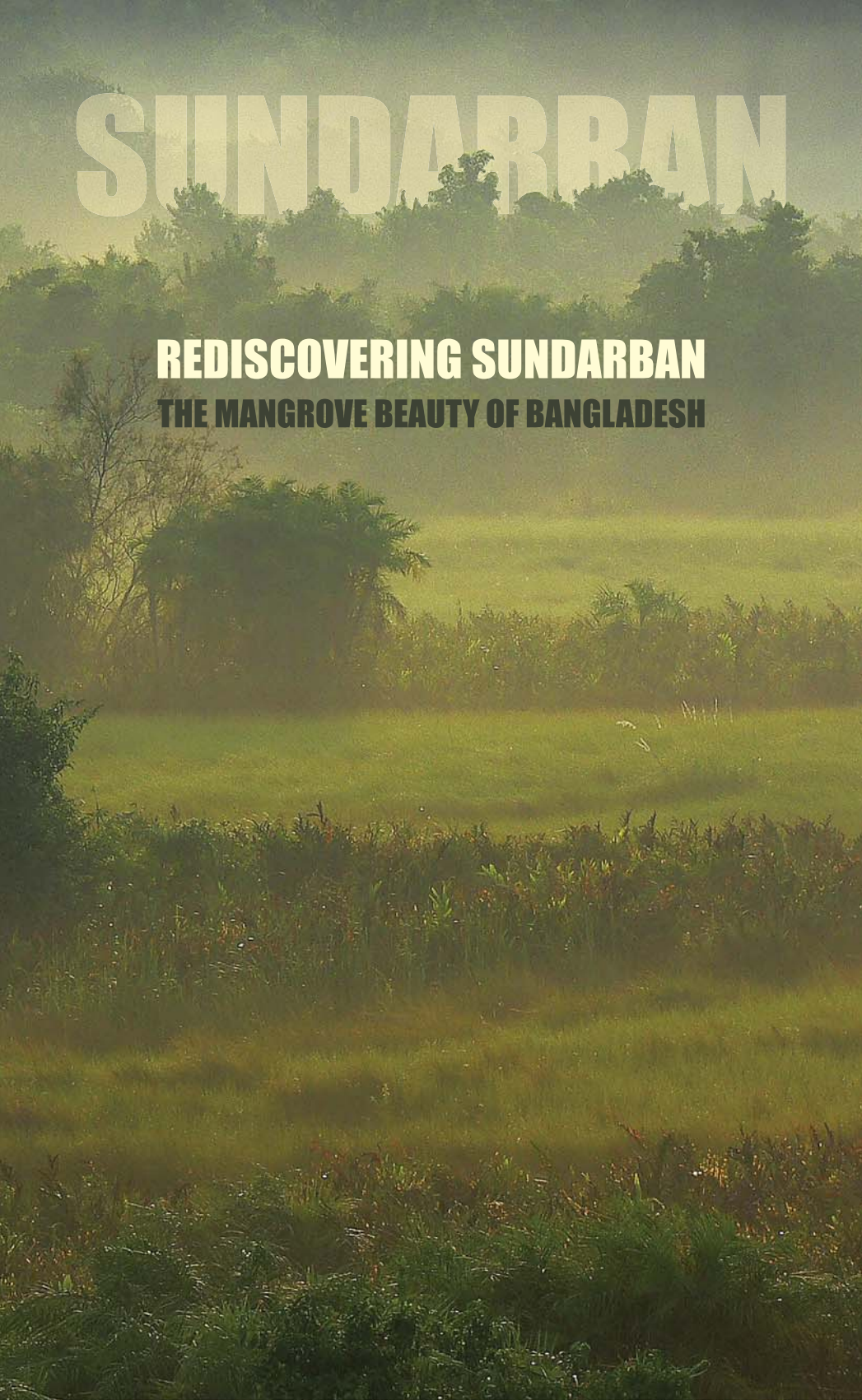

SUNDARBAN
REDISCOVERING SUNDARBAN
THE MANGROVE BEAUTY OF BANGLADESH

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THE MANGROVE BEAUTY OF BANGLADESH

NYMPHEA PUBLICATION

SUNDARBAN

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Edited by

Reza Khan

Research & Compilation

Shimanto Dipu

Faruq Ahmed

SUNDARBAN
Rediscovering Sundarban
The Mangrove Beauty of Bangladesh

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Editor
Reza Khan

Research & Compilation
Shimanto Dipu
Faruq Ahmed

Creative Editor
Sabyasachi Hazra

Graphics
Hasib Ahmed
Kazi Sujan

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Foreword

If one looks at the satellite map of the world it becomes clear that at many sea faces, where land meets the ocean, oceanic islands, coral islands, some estuaries or brackish water zones there exists a kind of salt-tolerant vegetation. In most of these land-sea face areas regional river systems discharge huge quantities of seasonal rain water into the seas and oceans through those meeting points, thus making those river mouths and their immediate environs very nutrient rich spots.

Through the eons the river mouths, estuaries, coastal mudflats and sandflats have allowed luxuriant growth of vegetation ranging from microscopic phytoplankton species to 30 metre tall Genwa or Sundari trees or invisible zoo planktons to huge Great One Horned Rhinoceros and Asian Buffalo or top of the land carnivore- the Bengal Tiger.

The vegetation formation along sea fronts and associated sheltered bays, creeks, inlets, canals and estuaries are usually called mangrove or mangal, also variously termed as coastal forest, estuarine forest, tidal forest, mangrove swamp, etc.

Mangrove formation could be stand alone forest, associated with other less salt-tolerant plant formation or even at the edge of the freshwater vegetation. However, mangroves always include a few species of plants that can withstand certain low to high levels of salinity and daily inundation by tide water for an appreciable period of a day and possibly all year round.

It is believed that there are over 2,50,000 species of vascular plants present in the world. Of these, just 101 plants are actually typically salt-tolerant. Most mangrove forests of the world do not have more than three dozens of such plants and most are represented by just a handful of species. As for example in the Arabian Peninsula there

is only Avicennia marina in the Persian Gulf, and along with this, Rhizophora species in the Red Sea and nearby Indian Ocean areas.

Whether we call these sea facing forests, mangrove or by any other name Bangladesh has one such forest that we call the Sundarban or the Sundarban Mangrove Forest at the mouths of the mighty rivers such as Padma/Ganga, Brahmaputra and Meghna. It is known as such throughout the world, and also happens to be the only mangrove forest having an assemblage of more than 300 species of mangrove and non-mangrove species of plants that no other similar forest has.

On a special note it is to be mentioned that Sundarban is a great pride for Bangladesh because it is the largest mangrove forest in the world a part of which it shares with the West Bengal State of India.

The plant and animal diversity that occurs in the Bangladesh part of the Sundarban (about 6,000 square kilometres out of a total of 10,000 square kilometres), is considered much superior than the Indian part. This is because as one moves from the east of the Sundarban to the west the level of salinity increases that restricts the abundance of flora and fauna. Moreover, in the Bangladesh part still there is no human settlement although anywhere between 2,50,000 and 3,50,000 people enter into the Sundarban on a daily basis to work for their livelihoods ranging from collecting dead and living tree logs, firewood, thatching materials, shrimp larvae, crab larvae, honey, shells, crabs and fishes. Occasionally deer and an old tiger are killed as well.

Nearly a dozen or so books have so far been written covering some aspects of the Sundarban by authors and publishers at home and abroad.

The present book entitled *Rediscovering Sundarban* is going to be an exceptional one as it has covered almost all aspects of the Sundarban Mangrove Forest from its biota to cultural, ethical, philosophical, economical, ecotouristic, and conservation aspects, as well as the charismatic animal and plant species and the impact of climate change on its ecosystem. The book has 28 entries written by 30 well known writers, litterateurs, artists, environmentalists, wildlife biologists, botanists and enthusiasts from home and abroad. Barring

two contributors, all are from Bangladesh. The book is profusely illustrated by senior and renowned artists of the country.

This book will not only introduce the vast resources of the Sundarban, its culture, ecology, economics and livelihood but also provide an instant source of reference for many subjects. Being written by authors of repute it has been prepared more as a popular book than a pure scientific one.

I hope it would reach many new generation wildlife and nature enthusiasts, conservationists, lobbyists, stakeholders and members of the public at large.

Reza Khan
Specialist
Wildlife and Zoo Management
Public Parks and Horticulture Department
Dubai Municipality, United Arab Emirates

Preface

The Sundarban mangrove forest ecosystem, which is globally recognised as the largest mangrove forest formation in the world, is one of the most unique gifts from nature. It is diverse both in flora and fauna and supports the largest array of life forms among forest ecosystems of similar type.

The Sundarban has attracted global attention among conservationists, researchers and nature lovers and has also earned a place as a global natural wonder.

The Bangladesh part of the Sundarban extends over an area of about 6,000 km^2. The Sundarban is the single largest source of forest products in the country. The Sundarban is home to an estimated 505 species of wildlife, including 355 species of birds, 49 species of mammals, 87 species of reptiles, 14 species of amphibians as well as emblematic species such as the Bengal Tiger .

The Sundarban plays an important role in environmental and ecological processes including (1) trapping of sediment and land formation, (2) allowing for denitrification, working as a natural filter by removing toxicants from water and sediments, (3) protecting of human lives and habitation from regular cyclones, (4) acting as a nursery for fish and other aquatic life, (5) producing oxygen, (6) recycling waste, (7) producing timber, (8) supplying food and building materials, and (9) regulating local and global climate and (10) helping climate change mitigation and adaptation through carbon sequestration, storage and cycling.

There are many publications, research papers, popular articles and books on various aspects of the Sundarban. But the present one is a compilation of almost all themes of the Sundarban including Ecology, Biodiversity, Wildlife, Flora, Culture, Livelihood, Travel and Tourism, Climate Change, etc. Renowned academics, researchers, scientists,

writers, and journalists have written different articles which have enriched the content of the book.

I am glad to know that Nymphea Publication, Bangladesh took an initiative to publish *Sundarban: Rediscovering Sundarban, The Mangrove Beauty of Bangladesh*, which focuses on the immense diversity of the Sundarban. The book will surely fulfill the demand of the members of the public, researchers, academics, scientists, tourists and the international community as it incorporates present and past information about the Bangladesh Sundarban. I congratulate the publisher, Nymphea Publication, authors, its research and compilation team and the editor, Dr. Reza Khan.

Ishtiaq Uddin Ahmad
Country Representative
IUCN Bangladesh

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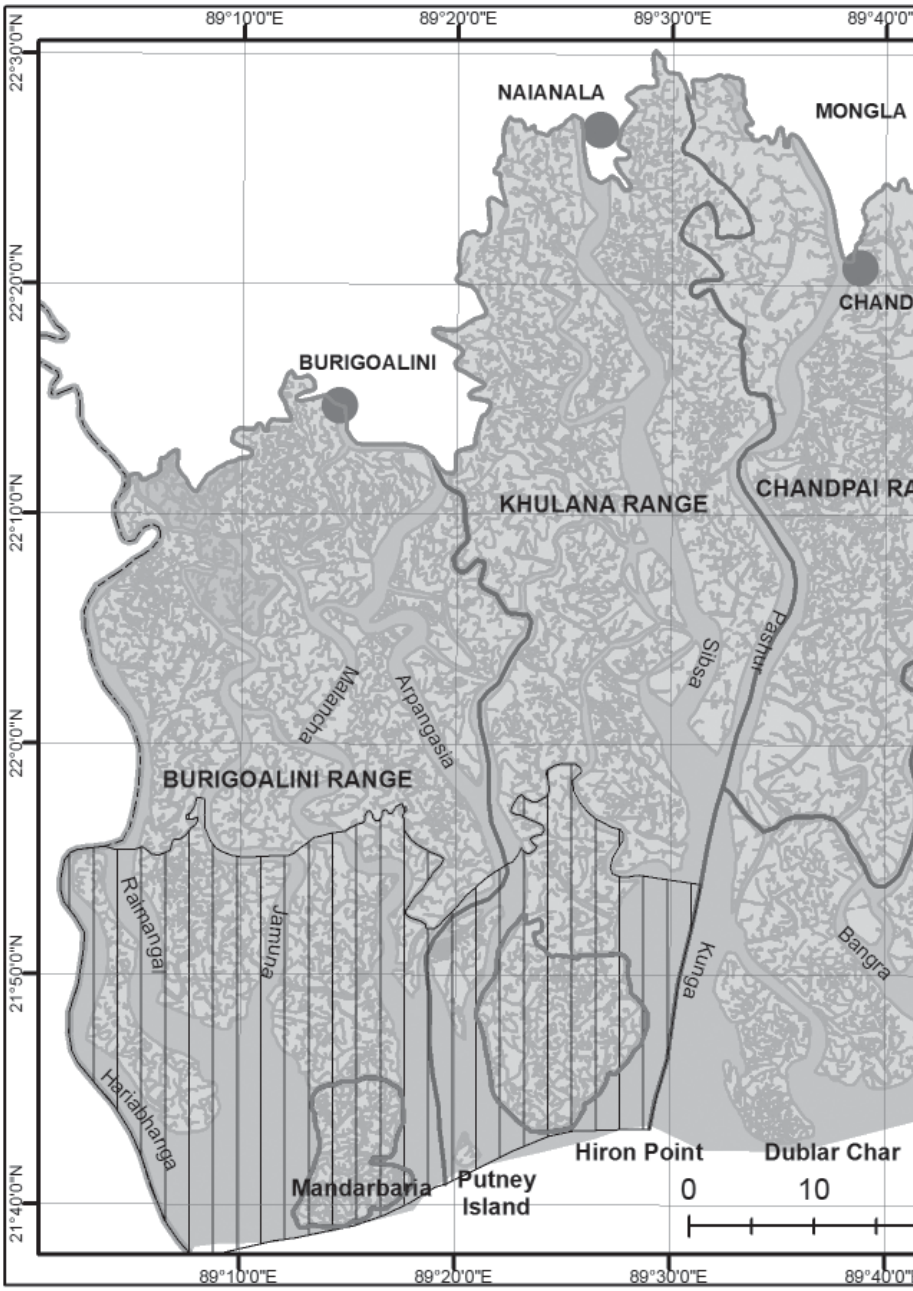
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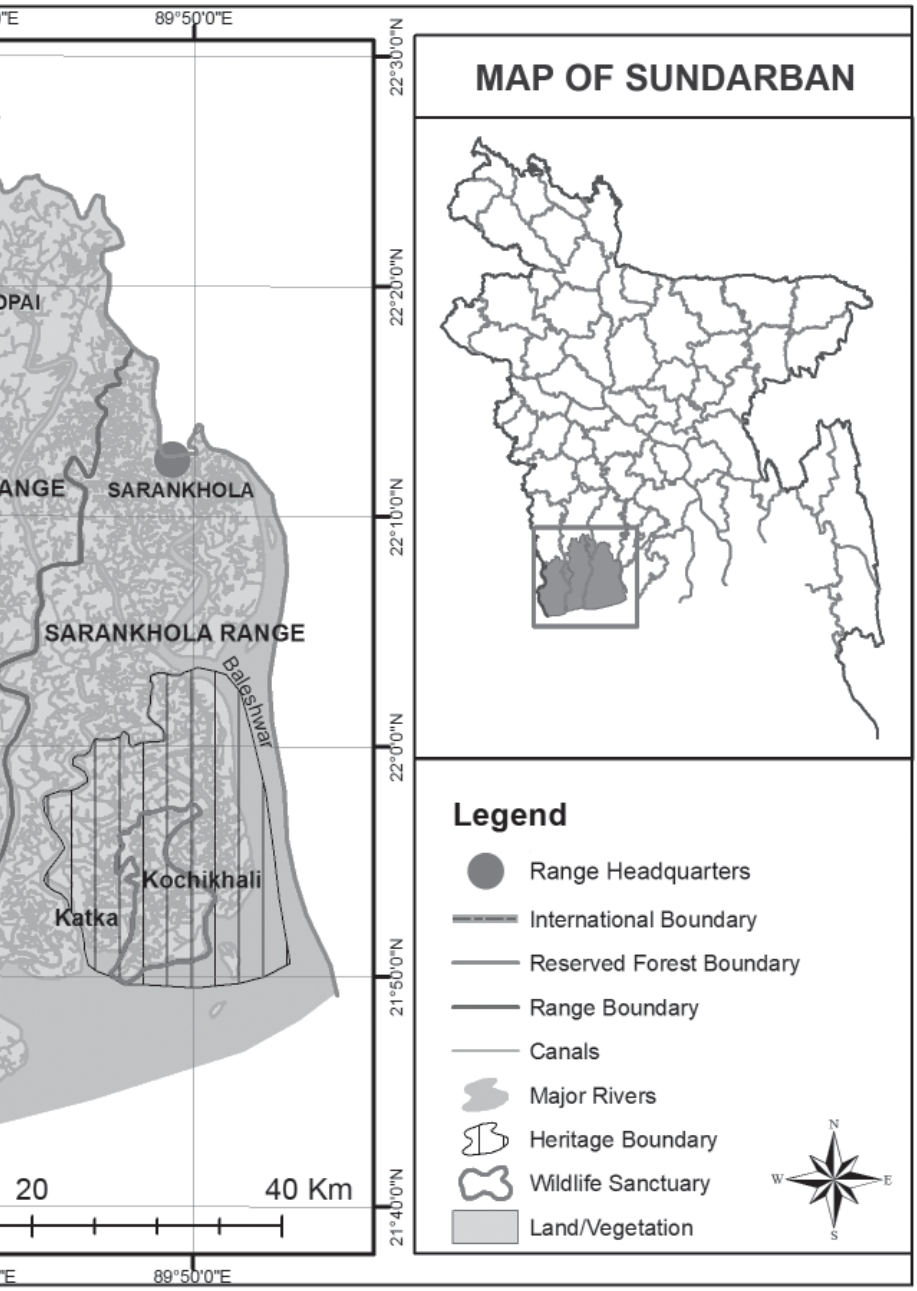
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SARANKHOLA
SARANKHOLA RANGE
Baleshwar
Kochikhali
Katka
20
40 Km
MAP OF SUNDARBAN
Legend
Range Headquarters
International Boundary
Reserved Forest Boundary
Range Boundary
Canals
Major Rivers
Heritage Boundary
Wildlife Sanctuary
Land/Vegetation
N
W
E
S

The Message of the Sundarban

No matter how spectacular and mute the construction of nature is it remains both welfare-oriented and enchanting. Bangladesh has the Himalayas to its north and the Bay of Bengal to its south and this unique embracing of the land makes its climate temperate and congenial for easy living and livelihood. The silence and sublimity of the Himalayas are balanced by the undulation and flamboyance of the Bay of Bengal and in order to encounter the audacity of nature there stands an impenetrable wall of green alongside the shore – the Sundarban. A large pat of the wall of the green has been eliminated because of human aggression. The Himalayas are also not in a good shape. The larger shares of the trees and shrubs have been plundered that has led to the drying up of rivers, and brought about

By **Dwijen Sharma**

a catastrophic scarcity of sweet water. In fine, the indiscriminate and greedy intervention of the humans have not yielded any benefit in the long run for the unfortunate natural greenbelt.

Mangrove forests grow on the coastal estuaries of the temperate zone and the Sundarban is the largest one in the world. In terms of providing a livelihood this forest is unique and totally different from other forests. The soil structure is formed with the sediments carried by the Ganges and the Bhrammaputra. Its land is composed of sand and alluvial soil, it has a mix of sweet and saline waters, high and low tides, adequate warmth, its own flora and fauna and its own animal kingdom most of which are not seen elsewhere. This kind of forest is not only the protector of bio-diversity; it is also its creator. As it happens in coral walls, different chambers of the forest have their unique arrangements of nurturing varieties of natural species.

The Sundarban came into existence two million years ago in the quaternary age long before human beings evolved. At the beginning of the British rule the forest was spread over an area of 43,252 square kilometers (km^2) or 16,700 square miles. In the next two hundred years that is at the time of division of Indian subcontinent, the forest cover had reduced to 37,813 km^2 (14,600 square miles). Currently two thirds of the forests occupy Bangladesh territory while the remaining one third is in West Bengal in India. Till now the Sundarban remains the largest mangrove forest in the world while the sanctuary spread over 32,400 hectares of land is a recognized world heritage. Apart from this it has a protected wetland and a huge area for the tiger project under the Ramsar Convention. The southern parts of Satkhira, Khulna and Bagerhat and parts of Barguna and Patuakhali join together to form the Bangladesh part of the Sundarban. It is an exotic place full of rivers, canals, islands and water-bodies.

The history of human occupation in the Sundarban dates back to olden days of the Moguls, the British and the Pakistani rules. Even today, the grabbing of forest land continues. The inaccessibility of the Sundarban gave the forest the strength to survive side by side with the human beings. The sticky clay of the forest land, steep branches and sharpened respiratory roots, crocodiles, tigers, venomous snakes and biting insects respond to the defense of the forest. But the increasing aggressions of the humans bolstered with instruments of modern

technology have gradually put the forest on the backfoot. Although national and international efforts to save the forests and greeneries are visible, forests find it increasingly difficult to survive in a densely populated country like Bangladesh. In recent years the survival of the forest has become more difficult with the addition of tourism which has resulted in further depletion of nature and environment. It requires a mention that the existing realities do not allow Bangladesh tourism to operate in an environment friendly way.

We know how forests less hazardous than the Sundarban had perished. Corruption of the forest department officials, imprudence of the political elites in power, misleading forest policies, needs of the poverty ridden masses join together to hasten the destruction of green forests. The most difficult of the issues to address would be the need of the poor. People dependent on forest resources and people living within the close proximity of the forest must have their alternative choices of living and without such provisions no project would ensure complimentary co-habitation of forest and people. It is more applicable to the meaningful existence of the Sundarban. The forests of the Sundarban provide not only wood, it supplies an abundance of fish and other aquatic resources, honey, wax, golpata and other resources. It works as the natural manufacturing house of nature. Making of such a manufacturing unit is beyond all human capability and even human efforts to develop and increase productivity might cause immense harm to the forest. But the fact remains that we feel accustomed to consider the great storehouses of natural resources to be just another factory and we make indiscriminate uses of the factory.

Although there is a crying need to preserve the forest it won't be an easy task to bring about changes in our outlook and evolve alternatives. Development and nature now face each other across a disastrous conflicting line. The outcome of such conflicts is yet unknown to us. The truth is now evident that with the greens destroyed the human race is not likely to be spared. This is what the Sundarban speaks about.

●

: Dwijen Sharma

The Sundarban: The Living Heritage of Bangladesh

The Sundarban is truly a unique ecosystem of global importance. It is a massive array of tidal mangrove forests, forming a fascinating labyrinth of ever-changing islands and twisting water channels that shape forming a fast River Delta. The Delta spans the coastline of Bangladesh and extends into West Bengal in India. The Bangladesh portion of the Sundarban alone covers an area of some 6000 km². It is considered by many to be perhaps the largest expanse of mangrove forests in the world and is home to a great diversity of species.

The Sundarban is formed by the outpouring of the Ganges, Brahmaputra and Meghna river basins as they make their way from the Himalayas to the ocean. Where these great river systems meet the sea, they join with salt water from the Bay of Bengal to create a vast

By **Aban M Kabraji, Ishtiaq U Ahmad & M Dougherty**

wetland of brackish estuaries. Herein thrive a great diversity of species. Out of the 35 true mangrove species in the world, the Sundarban host some 12 or 13. Mangroves are unique in that they thrive in intertidal zones such as the Sundarban. Mangroves are well known for providing a wide variety of ecosystem services. They are critical breeding grounds for a wide variety of fish, crabs and mollusks and therefore provide immense benefits to human food security as they grow and leave the forests for open water where they are caught by fishers. While mangroves are threatened by climate change and specifically, sea level rise, they are also well known to provide critical natural infrastructure. Through their important role as carbon sinks and in their ability to absorb the impact of large coastal storms they protect human communities further inland. The role of mangroves as a buffer in Bangladesh is especially important as every year surges hit the coasts, especially in the South and Southwest. It is well known that the area is prone to large violent cyclones which cause severe damage to the forest ecosystem and human settlements. Within this great mangrove ecosystem, a wide variety of wildlife thrive. Of course, the best known is the enigmatic Bengal Tiger. It is well known for its beauty, cunning and majestic grace. In local lore supernatural qualities are attributed to its strength, fierce stare and ability to seemingly vanish in the camouflage of the forest. There are however a number of other important wild animals which live in this unique ecosystem. The Chital and Barking Deer, wild boar, Rhesus Macaque, otter, a variety of lesser cats, tree shrews and rats, civets, mongooses and porcupines are joined by aquatic animals such as the Ganges river dolphin, the Irrawaddy dolphin, crocodiles, monitor lizards, King cobra and other venomous snakes and a variety of other reptiles and amphibians. There are huge numbers of birds with at least 226 species representing about 36% of the birds recorded in Bangladesh.

In respect to its unique biodiversity, a part of the Sundarban was designated as a world heritage site by UNESCO in 1997 and classified as a natural heritage under category (ii) and (iii) of the convention. Three wildlife sanctuaries over an area of 139,700 ha constitute this fascinating world heritage site. The Sundarban was declared as a Ramsar site wetland of international

importance in 1992. The department of forests in Bangladesh has also established the Chandpai, Dudmukhi and Dhangmari Wildlife Sanctuaries within the larger Sundarban Reserve Forests. Of course the Sundarban also plays an important role for humans, and provides a wide number of ecosystem services to them. People have lived in the area for many centuries. The immense resources of this the area are attractive and large areas of the forest have been turned into land for shrimp farming and agriculture. Besides, animals have been killed and habitats destroyed while rivers and creeks have been diverted or dyked. Still, it is estimated that over half a million people, especially in the north and northeastern areas adjoining the Sundarban depend directly on it for their livelihoods. A wide variety of non-timber forest products such as honey, wax, Nypa leaves and medicinal herbs are collected from the Sundarban. In the rivers and creeks large quantities of fish, shrimps, oysters and crabs thrive. And every year during the winter months fishers migrate to the coast to fish in the Bay of Bengal and retreat inland before the storms arrive. The coastal zone plays an important role in national development. Fisheries alone provide the second largest contribution to the national GDP. In addition there are two seaports, three export processing zones, three gas fields along the coast. Despite this, poverty in the coastal zone is very common with some 29% of the population living in extreme poverty. Coastal women are particularly disadvantaged both socially economically, although now national policies prioritize women in development activities and gender mainstreaming. There are a large number of environmental threats that the Sundarban falls. The area is repeatedly struck by extremely powerful cyclones which devastate human populations as well as the natural infrastructure. Changes in land use, due mainly to increased pressure of the population on limited resources, pose a serious threat to coastal ecosystems. In addition, land erosion and floods, congested drainage, salinity intrusion, drought, earthquakes, shortages of drinking water, arsenic contamination, pollution and climate change all contribute to the degradation of the ecosystem. Managing this vast and unique ecosystem has proved a challenge. While there is a wide network of government, nongovernment

organizations and research institutions highly active in the area, many have different mandates and coordination is often difficult. Currently there is no single agency responsible for overall coastal and marine zone management. Bangladesh does have a Coastal Zone Policy that addresses integrated coastal management and calls for integrated coastal development as a priority within the overall national development program. This policy is supported by a comprehensive framework of sectoral policies and a coastal development strategy. At the international level, Bangladesh is a party to a number of international conventions, treaties and protocols which relate to coastal development. These include agenda 21, Kyoto protocol of climate change, UN FCC, Basel convention, brands are convention, and the United Nations convention on the Law of Sea. Bangladesh is also a member of the South Asian Association for Regional Cooperation (SAARC), through which environmental ministers from the eight SAARC countries meet periodically to discuss issues concerning regional cooperation. Through this framework SAARC environmental action plan, the Dhaka declaration and SAARC action plan on climate change have been formulated. At the national level, Bangladesh has a five-year plan, which is an important starting point for understanding government objectives for the development of any area in the country, including the coastal zone. In addition, Bangladesh has a number of national plans relevant to the coastal zone, including the Poverty Reduction Strategic Plan, the National Adaptation Programs of Action, the Bangladesh Climate Change Strategic Action Plan, the National Biodiversity Strategic Action Plan, the National Water Management Plan and the Bangladesh Tiger Action Plan. These have been complemented by a wide variety of development initiatives in coastal areas, including work on integrated coastal management, coastal livelihoods, disaster risk reduction, forest resource development, environmental management, conservation of biodiversity and water resource management. Yet there are still a number of key issues and challenges that need to be addressed. Vulnerability to climate change is extremely important as Bangladesh is considered to be a high-risk country. The challenge of conserving coastal zone ecosystems in balance with economic needs and providing sustainable livelihoods for coastal communities is also

essential. Coordination among the wide variety of stakeholders in the area remains an important issue. As mentioned above, gender remains an important consideration due to the vulnerability of women in the coastal area. Finally, there is a large body of knowledge, which must be addressed, especially in terms of biodiversity and ecosystems. IUCN, the International Union for Conservation of Nature has been active in Bangladesh, for many years. IUCN helps the world find pragmatic solutions to our most pressing environment and development challenges. IUCN is the world's oldest and largest global environmental organization, with more than 1,200 government and NGO members and almost 11,000 volunteer experts in some 160 countries. IUCN's work is supported by over 1,000 staff in 45 offices and hundreds of partners in public, NGO and private sectors around the world. Currently IUCN is preparing to work through its Mangroves for the Future partnership initiative on coastal zone issues in Bangladesh. Mangroves for the Future (MFF) is a partnership-based initiative promoting investment in coastal ecosystems for sustainable development. MFF provides a collaborative platform to help countries, sectors and agencies in the MFF region tackle the growing challenges to coastal sustainability. The mission of MFF is to promote healthy coastal ecosystems through a partnership-based, people-focused, policy-relevant and investment-orientated approach, which builds and applies knowledge, empowers communities and other stakeholders, enhances governance, secures livelihoods, and increases resilience to natural hazards and climate change.

: Aban M Kabraji, Ishtiaq U Ahmad & M Dougherty

The Beauty and Vulnerability of the Sundarban

Bangladesh is a riverine country. It is more so for the Sundarban. Somewhere inside the country the rivers shrink like the waists of young girls and the more they go southward to the Bay of Bengal the more they are spread over and their stormy waves flow faster. On their way to the sea the rivers branch out in countless tributaries, canals and distributaries. Total number of rivers and canals of Bangladesh cannot even equal the number of rivers and canals in the Sundarban.

On the shores of the rivers and canals there grow bushes and hedges and trees like *Keora – Hental*, *Sundari – Garan – Genwa*. The trees bow down to the deep forest and create the charm of darkness. Somewhere on the two sides of the canals Gol trees huddle among

By **Bipradas Barua**

themselves and lean down to the trees on the other side which gives them the look of walls of a long tunnel. This wild beauty that can never be beaten is only reserved for the Sundarban. Unless one sees the spectacle of the wild one can hardly imagine how beautiful it might be. While enjoying this beauty if a visitor reaches a curve of a path or the confluence of three tributaries there awaits another wonder for him. Vast sheets of shoals lie ahead, neatly planted Keora trees have built green belts, behind the belts the forest remains hidden. We have not yet mentioned the beauty of birds and other animals. A huge body of water with no shores lies ahead revealing a rare beauty that never ends. The waves are tempestuous and wisps of vapours spew from them. When vapours go up they meet the falling rain on the way. The clouds touch the branches of trees and the touch of the Sundarban allows the clouds to open their song book and sing. It is not an easy task to part with the spell that the beauty casts. This spellbinding beauty is absolutely an affair of the Sundarban and no place.

The Sundarban is a magical name. Who knows when in the ancient time the largest delta of the world was created along with all these small islands infested with deep and dense forest at the estuary of the Ganges and the Padma? No one has recorded the history of the birth of this overwhelming beauty. The principal feature of the Sundarban is that of mangrove or tropical forests allowing their roots to crawl on soft clay and form the ribs of the chest of the Sundarban. It has dense bushes of herbs and creepers. On the green bed eyes are greeted with multicoloured flowers that at times bloom everywhere. What a view it gives with honey bees humming and flying around and sitting on the flowers. The deep forest accommodates majestic tigers, wild boars and venomous serpents.

Sharks, crocodiles and tortoise in the rivers, and deer and monkeys on the forest floor keep the forest vibrant. It has birds like Fish Eagles; and many Kingfishers, local and migratory birds fly around. In rivers and canals there are snails, dolphin, fish, tortoise and crab.

In the months of Ashar and Srabon one hears the roars of the massive waves coming from the Bay of Bengal. Local people also describe these as divine roars or mysterious sounds. During their reigns in India the British called it *Barisal Guns*. I have enjoyed many

times the unfathomable depth and riches of the sound that is not possible to listen elsewhere.

Many of the ancient pundits are of the opinion that there were 13 great forests in ancient India. The largest of the forests were the Angerio forest. It was spread over from the coastal area of the Bay of Bengal up to the Bhrammaputra river near Assam in Southeast India. A part of this forest is what is now known as the Sundarban. The forests of three hilly districts and Sylhet exist only nominally. On the Indian part it became evident from archeological excavation that similar Sundarban types of trees grew in Lucknow town near the river Ganges. It gives clear indication that once the Sundarban extended up to Lucknow. Then the Ganges flew to further south from this place. Even one hundred years ago the Sundarban occupied the tract between the west of the Meghna estuary to the eastern side of the Hugli river. From the east to west it covered a length of 160 miles (400 km) while the width from north to south in west was 70 miles (170 km) and at the narrow side in the east it was not more than 30 miles (75 km). With an average width of 50 miles (125 km) the area of the Sundarban was 8000 square miles. It means it extended from Barisal and Jessore in Bangladesh to Sagardwip in West Bengal. All this information speak of a Sundarban that existed one hundred years ago. Now there is no Sundarban in true sense to the south of the district of Barisal, Patuakhali and Barguna. The Haringhata River makes the eastern frontiers of the Sundarban. The forest of the Sundarban that occupies part of Bangladesh and part of India has an area of about 10000 km^2 – about 6000 km^2 in Bangladesh and 4000 km^2 in India. About 120 to 125 years ago the Sundarban was there in true sense of forest. Now what we see is a skeleton or we see its decomposed body. Then it drew the attention of the British.

The British well understood that clearing the dense forest of the islands would add to their land to be put under cultivation and thus add more to the land revenue they earned. This greed drove them to lease out the islands. Rich people from different parts of Bengal came forward to take lease of this land never tilled before and they extended their claws of greed in the forest. The industrial revolution in Europe had similar intervention on forest lands. Then began the worst onslaught of human beings on nature and environment. People

encroached mercilessly into natural territories of forests and thus the unholy and mindless steps of expansionism were followed without realizing the disastrous consequences.

Human beings got engaged in a demonic war against the large animals of the forests and also against aquatic animals of the Sundarban. The extent of human intervention resulted in the annihilation the green and dense forest of Barisal, Patuakhali and Barguna. In West Bengal they did not wipe out the forests on land rather developed habitats on 54 islands. The part of the forest that accommodates 4 million people has become denuded of its green but the rest of the forest areas remained intact due to intensive natural forestation. But in the Bangladesh part of the Sundarban the greedy claws of people cause fatal injuries to the dense forest due to lack of comprehensive planning and supervision. However, there exists no human settlement in Bangladesh Sundarban compared to the rampant in the northern parts of the Indian Sundarban.

As Bangladesh did not allow human habitation to grow inside the Sundarban, it somehow saved the forest. But the forest in the eastern part of the Sundarban closer to human dwellings in Barisal, Patuakhali and Barguna lost itself to human greed. Not to speak of these districts alone, the Sundarban once extended to the east up to Bhola, Hatia, Sandwip and even got Chokoria and Bashkhali within its range. Sporadic attempts are being taken there to plant the Sundarban type of mangrove forests.

When the Sundarban spread over the huge area starting from Lucknow to North Bengal and Assam, Bengal Tigers found their sanctuary in this forest. The Sundarban reached the estuary of the Ganges and the Padma and over time human greed shrunk the forest to its present state. Who knows where it ends up bearing the increasing pressure of 160 million people in the near future? If human interventions of need and greed continue to denude the forest and annihilate endowments of nature its worst effect will ultimately fall on the descendents of this 160 million people. The severe consequences will equally affect the people of the world.

The price of the Sundarban cannot be monetized. With the annihilation of the Sundarban the first disaster will be revealed in the change in climate, in weather and rainfall. In the second stage

calamities like Aila – with cyclones and tidal surges will bring about horrifying disaster and utterly mess up the southern Bengal. The worst crisis will be created in the kingdom of animals and plants severely affecting the biodiversity. None of the animals, birds, fish and insects will be spared. All visible and invisible resources of the Sundarban would be inseparably linked to the disaster. As the economy of Bangladesh is also closely tied to it the catastrophic consequence is obvious.

The greed of the British to extract more land revenue made them lease out the islands with deep forests. The owners of the leased lands tempted the poor people to become the prey of the fierce animals. Those people cleared the forest, particularly the western part and made it cultivable.

In 1929 a Britisher who travelled through the bushes and waterways wading through knee-deep mud and clays of the vast forest drew the map of the Sundarban. He gathered information on nature, environment, forest resources and wild animals. What he produced out of his hard labour was a map which is now our property, a resource of the government. Our knowledge of the Sundarban is based on it and the state also relies on it to chalk out its programmes. Planners and experts perhaps are oblivious of the fact that lots of changes have taken place during the last one hundred years. There were changes in the climate, navigability of the Ganges and the Padma has reduced and on the top of it the Sundarban has to bear the pressure of ever increasing population, live with the greedy eyes of government officers and employees, tolerate the dirty games of politics and yield to the directions of so called foreign donors. Along with our Bengal Tigers, if dolphins, crocodiles, tortoises, and crabs become extinct it will hardly matter for others. But it affects us and we cannot ignore it.

The Sundarban is our glory and honour and it is our pride too. We have serious lack of resources to hand over to the generations to come – natural forests, reserve of fuel and gas as they are lovingly called liquid gold. We have serious dearth of transferable resources. That is why all eyes are on the Sundarban. It is evident why the foreigners are serious about it. First of all we need an extensive study; we need detailed maps of rivers and canals networking the islands and deltas.

: Bipradas Barua

We need the right information and true portrayal of the forest, of its resources, of the animals living in it, and of the people dependent on it. A development plan can only be formulated on information drawn from a scientific survey. A beautiful city can never be built ignoring marginal people and dwellers of slums and shanties. A beautiful Sundarban needs to take everyone and everything into account. Affluent people discard poor and needy people. They put the blame that the poor are the plunderer of the forest. But are they not the politically blessed people of the party in power and the powerful forest department officials? Who are then the owners of the Sundarban? Whose forest is it? A national Sundarban fair was organized in Khulna in 2001 with the slogan 'Save Sundarban' protesting efforts of fuel and gas search in the forest. The grand occasion was supported directly and indirectly by 84 government, non government, socio-cultural, professional and voluntary organizations. The then President of the country inaugurated the function.

There was a Khulna Declaration at the end of the conference with 18 recommendations. The third recommendation was to stop initiative to search for fuel and gas in the Sundarban to preserve its environment. If there is gas in the whole of Bangladesh and even in the Bay of Bengal and if primary surveys are over can we not leave the Sundarban for now? Because intensive forest and forest resources in Bangladesh are synonymous with the Sundarban. Can we not protect our dream forest from any such intervention?

Attention is drawn to a recent contract of building a power station at Ramal bilaterally with Indian assistance. It is likely to be a death trap for us. The contract as such is not a devastating deal, rather the problem lies in selecting the site of the power station at Rampal in Bagerhat. The contract was signed on 29 January 2012. Bangladesh consented to build the power station as a joint venture on the basis of equal partnership. The electricity will be produced using coal and naturally the coal will be imported from India. Again if there is coal underneath our soil, we cannot extract on mere wishes. We know the problem of coal extraction from Barapukuria. We have problems of extraction of coal that remains much beneath the soil. The extraction of coal that remains underneath the forest or habitat poses no less a challenge. Foreign coal or hydroelectricity or atomic reactor are not

the solutions. The problem lies in the selection of site. The pollution that is created through emissions of coal driven power plant cannot be allowed to reign over the sky of the Sundarban, the only natural forest of the country. The forest itself is in a war and tired of fighting against various odds and oddities. Producing electricity on coal driven plants near the Sundarban would be a merciless blow on it. I apprehend the Sundarban does not have the power to withstand this blow. My logic fails to appreciate the justification of power plant at the close proximity of the forest and my heart does not give a nod to it.

The Sundarban is the last of our nature's storehouse. No one can create such a forest. Nature has created it. Human efforts can create forest with garjan, chapalish, champa, teak or neem. Such forests were available in the Hill Tracts. Then the forest gradually disappeared. Century old trees are hard to come by, at least I did not find any. The gazari forest of Madhupur and Bhawal is also disappearing.

For destruction of the Sundarban natural disasters are no less responsible. On the 29th year of Emperor Akbar in the throne in 1585 the water level at the sea rose up. Uninterrupted storms and rain continued for five hours. The unbridled surge of the sea damaged habitation, boats and sheep and the calamity claimed two hundred thousand lives. Then there was a cyclone and tidal surge again in 1688. It killed more than sixty thousand people of Sagardwip.

There was another deluge after the reign Protapaditya. People who survived the cyclone and surge of 1707 fled to the north for fear of life. The earthquake of 1737 was accompanied by severe cyclonic storm. It caused immense harm to the factories of The British in Calcutta and Hugli. After this storm people living in the forest absolutely deserted their dwellings and left the forest.

Then a series of major cyclones and storms followed - the first one on 14 May 1862, then on 5 October 1864, then on 1 November 1867 and again on 31 October 1876. The 1876 cyclone not only caused huge number of death of humans and animals, it also uprooted all the trees of the eastern part of the great forest. Thus the Sundarban and its adjacent districts continued to tolerate and live with the cyclones and tidal surges of the Bay of Bengal. Another cyclone on 17 October 1909 shattered the district of Khulna. In history this ravage was known to

be an act of the 'devastating cyclone of Ashwin'. During this cyclone almost all of the old trees of the forest were uprooted or broken. It is not all as there were earthquake to follow and ravage the forest occasionally. The inhuman tortures of the Maghs and the Feringhi also contributed to the destruction of the Sundarban. The 'History of Jessore and Khulna' suggests that during this period people used to live in this forest fighting calamities and outside invasions.

But the loss that the Sundarban incurred due to cyclones like Aila and tidal surges was also recovered following its natural course. But the torture that is inflicted in the name of development intervention, construction of commercial establishments, and extraction of resources under the soil, cannot be mended and the loss never recovered.

In order to protect the Sundarban what is needed first is an accurate and detailed survey. It will give a true scenario of the forest. An analysis of the situation revealed in the survey will help prepare a plan and strategy for the Sundarban. In the southern part of the Bay of Bengal new shoals are peeping up.

Alluvial siltation make rivers and canals dysfunctional. The marine resources of fish have lost their breeding grounds and got confused. This is why in 2012 the catch of Hilsa and other marine fish was so small. It has been observed for last few years that Hilsa fish are being outcast and leaving their natural habitat. Indiscriminate and rude intervention of human beings will compel the Sundarban to be cruel. It knows the mechanism as to how to cope with pains of natural calamities and get compensated by nature. But the strategy of getting rid of human cruelty is not known to the forest. This truth is irrefutable.

Wildlife of the Sundarban

Bangladesh is possibly the most blessed country in South Asia to have one of the biodiversity hotspots, the Sundarban Mangrove Forest, the largest such entity in the world as mentioned by world bodies like the WWF (World Wildlife Fund) and UNESCO (United Nations Educational, Scientific and Cultural Organization). In an overpopulated country like Bangladesh where there is an acute shortage of land even for human settlements it is noteworthy for it to have a single stretch of 6,000 square kilometres (sq. km.), out of a total of c. 10,000 sq. km., of natural forest shared by Bangladesh and the West Bengal State of India. The beauty of Bangladesh part of the Sundarban is that there exist no human habitations or permanent settlements whereas nearly half of Indian side of it is supposedly

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under such settlements. It deserves some recognition in the world arena of environment and wildlife conservation. As such Bangladesh has already declared three areas covering some 400 sq. km. of the Sundarban as two wildlife sanctuaries and one as UNESCO's Ramsar Site cum wildlife sanctuary.

The Sundarban occupies the head of one of the largest deltas of the world formed at the confluence of three mighty South Asian rivers- the Padma, Jamuna and Meghna flowing down from the Himalayas to the Bay of Bengal. These rivers not only push freshwater to the Bay but also carry the nutrient rich top soil from hills and foot hills of the Himalayas. In the process of the downhill journey of this river water the alluvial soil and sand washed from the upstream hill country get deposited at the delta mouth forming the basis for the mangrove, tidal, coastal or estuarine vegetation as the Sundarban Mangrove Forest. Ultimately over the millennia the delta mouth has given rise to a unique array of plants forming the present Sundarban. This in turn has made the Sundarban a congenial place for the survival of hundreds of species of nano, micro, macro and mega- sized animals from microscopic zooplankton to huge buffalo or Bengal Tiger.

In the Bangladesh context the Sundarban is possibly the last hope for the survival of any unique and great population of wildlife in the wild because all the other types of forests such as the Sal in the central and northern parts, and Mixed or Semi-evergreen forests in the hill country have virtually become barren or devoid of wildlife. The reasons for such depletion are excessive deforestation or forested lands being brought under monoculture of indigenous and exotic plants or plantation forests comprising commercially viable species and shifting cultivations followed by land grabbing which has changed the composition of local vegetation which in turn has wiped out major forest-dwelling wildlife species from the country (Anon. 2006; Khan 1982, 1985, 1987, 1996, 2003, 2008 and 2010; Khan,2007; Kibria *et al*, 2010; Kibria *et al*, 2011; Mukul *et al*, 2008).

Considering the declining and disappearing status of most wildlife in the country we need to ponder managing or preserving the vast wildlife wealth we still have in the Sundarban Mangrove Forest in a sustainable manner.

By gross definition, all life forms in wild state are considered

wildlife of a country or region. Most animals and plants which are not nurtured and nourished by human beings come under this category. There is a fundamental difference between the currently used popular biodiversity and wildlife as both are sometimes used interchangeably to mean wild animals and plants. However, biodiversity has much broader connotation than wildlife because the former not only includes all wildlife but also all life forms and genetic materials derived from them that exist in the world be that in the wild, laboratory, as chryo-preserved specimens such as fertilized or unfertilized sperms, ova, seeds or domesticated animals and plants.

In this literature animals and plants are to be addressed by different authors at various levels. I am just trying to put an overview of the wildlife of the Sundarban and general comments on their preservation. This will also include a historical background of the wildlife, their disappearance and present constraints posed by some natural phenomena and man-made ones for the sustainable growth and management of the existing wildlife of the Sundarban.

Wildlife Background

Existence of the Sundarban was known to historians and olden day travellers from the time of Chinese Hiuen-Tsang, Moroccan Ibn Battuta and others. Hiuen-Tsang visited India between 629-645 AD. His memoir gives extensive information on the distribution of forests at that time. He recorded deep forests in Sravasti, Kapilabastu, and nearby regions including Ramgram. From Ramgram 'he went north-east through a great forest road which was a narrow dangerous path with wild oxen and wild elephants, and robbers and hunters always in wait to kill travellers. Emerging from forests he reached the country of Krishnagara. The great traveller crossed PUN-NA-FA-TAN or Pundrabardhana (Pabna according to Cunningham, and Rangpur according to Ferguson). He mentioned that Pundrabardhana was a low country with moist, prosperous, fertile soil and jackfruit trees. Then Hiuen-Tsang came to Samatata i.e. present day Jessore, Dhaka and Faridpur districts, where the climate was moist and the land was low, and full of trees and wild animals (Anon, 2006, Sundarban).

Abul Fazal mentions the presence of forests in Jannatabad, Khalifabad and Bazuha. In Khalifabad he mentions an abundance

of wild elephants; while in Bazuha thick long timbers suitable for masts. Jannatabad was grassy and full of wild buffaloes. The present Sundarban, according to the description, extended further north up to northern Nadia and northern Jessore, and or as full of crocodiles and tigers (Anon, *ibid*).

Possibly the first ruler-cum-naturalist of the old Indian Empire Emperor Babur was the first to specifically mention any particular animal of the Sundarban. His notes mention that the "Lesser Rhinoceros or Javan Rhinoceros was found in the Bengal Sundarban, and a very few individuals were stated to occur in the forest tract along the Mahanuddy river, and extending northwards towards Midnapore"[1].

During the Mughal period (1203-1538), the local kings leased the forests of the Sundarban out. In the British colonial time, the area was mapped by the Surveyer General as early as 1764 and the proprietary rights were obtained from the Mughal Emperor, Alamgir II, by the East India Company in 1757. Systematic management of the forest started in 1869 after the establishment of a Forest Management Division in the Province of Bengal, in British India.

The Sundarban was declared a reserved forest in 1875-76, under the Forest Act, 1865. A Forest Division was created in 1879 with headquarters in Khulna. The first management plan was written for the period 1893-98. In 1911, it then stretched for about 266 km from the mouth of the Hugli (in West Bengal) to the mouth of the Meghna (in present Bangladesh), and was bordered inland by three districts: Twenty-four Parganas (of West Bengal), Khulna and Bakergunj (Greater Barisal, of present Bangladesh). The total area including water was estimated to be 16,902 sq. km.

However, this figure is now considered to be about 10,000 sq km, of which Bangladesh has 6000 and the Indian West Bengal has 4000 sq km.

Wildlife Richness in the Sundarban

There is no doubt that the Sundarban is possibly the most biodiversity rich area of the country. If we consider the wildlife species covering the major vertebrates, that is from the Amphibia to

1 http://www.indianetzone.com/39/indian natural_history_mughal_ period.htm

Mammalia and Fishes, both bony and cartilaginous, then we have 42 species of amphibians, 157 reptiles, 718 birds and 124 (125) mammals vide Khan (2010), and 442 species of marine fishes divided as 56 cartilaginous, 386 bony fish species when there are 266 of inland or freshwater and brackish water fish species vide Banglapedia, 2006[2]. Of these wildlife species, nearly 50 % are present in the Sundarban, barring the amphibians.

Back in 1986 I had for the first time prepared a comprehensive report on the wildlife of our mangrove ecosystem and reported 8 species of amphibians, 50 species of reptiles, 261 species – 180 species of non-passerine and 81 species, of passerine birds and 49 species of mammals. However, this report almost entirely consisted of the species records from the Sundarban, with the exception of some man-made and man-destroyed mangroves all along the coastal areas from the Sundarban in the west down to the St. Martin's Island in the east. One exception was the Parailla Bandar or Crab-eating or Long-tailed Macaque (*Macaca fascicularis*) that was only found in the mangroves along the bank of the River Naaf under Teknaf Upazila reported by me (Khan 1985, 1986b) and many later researchers. Prater (1971) considered Assamese Macaque (*Macaca assamensis*) to be present in the Sundarban. But I have refuted it in my papers and books (Khan 1979, 1981a, 1982, 1982c, 1985b and 1987b).

When I personally visited the Zoological Survey of India at Calcutta during the mid 1970s, from June 1974 to 1979, and talked to zoologists there they told me that one specimen of an Assamese Macaque was collected from Kolkata market which was wrongly labelled to have been procured from the 'Sunderbans' in the early 20th century and the mistake was carried in all literature prior to 1980s. I have never met any Bangladeshi zoologist who has worked in the Sundarban and has ever come across this macaque there. Assamese Macaque is one of the mammals that did not cross the River Jamuna and Padma in Bangladesh in the historical past thereby making Bangladesh as its westernmost limit in its range of world distribution.

Against my 1986 figures, now defunct Sundarban Biodiversity Conservation Project has reported some 40 species of mammals, 270 birds, 45 reptiles and 11 species of amphibians. It has reported 120

2 http://www.banglapedia.org/httpdocs/ HT/F_ 0088.HTM

species of fishes from the Sundarban.

The Sundarban hosts about 50 species of mammals, about 320 species of inland and migratory birds, about 50 species of reptiles, 8 species of amphibians, and about 400 species of fish (Anon, 2006) in Sundarban[3].

Shariar (2011), quoting various sources, noted 334 species of plants, 49 mammals, 320 birds, 53 reptiles, 11 amphibians, 400 fishes and 873 invertebrates, and 1 species of Hemichordate from the Sundarban.

A comparison of wildlife species in Bangladesh Sundarban, shown below, compared to that of the West Bengal in India and the world based on Anon (2006), Anon (2008), Khan (1986) and Shariar (2011).

Taxonomic group	World	Species described	West Bengal vide Mandal (2003)	Anon (2008)	Bangladesh Sundarban	
		subcontinent	Sundarban		1986/2006*	
Protozoa	31,250	2,577	106	175	Invertebrates 873 (Shariar, 2011**)	
Porifera	4,562	500	Invertebrate Species 1104	29		
Cnidaria	9,916	842		102		
Ctenophora	100	12		10		
Rotifera	2,500	330		76		
Gastrotricha	3,000	100		4		
Platyhelminthes	17,500	1,622		126		
Nematoda	30,000	2,850		176		
Mollusca	66,535	5,072		479		
Echinodermata	6,000	765		46+		
Arthopoda	987,949	68,389		5000+	24 *** shrimps	7 *** crabs
Fish	21,723	2,546	481	653	177 400 (**)	
Amphibians	5,150	248		34	8/8* (11**)	
Reptiles	5,817	460	55	154	50/50(53)*	
Birds	9,026	1,232	248	650	261/320*	
Mammals	4,629	397	58	121	49/50*	

* Figures are from 1986 (Khan 1986)/ 2006 (Banglapedia, 2006)

** Shariar (2011)

*** From IUCN, 1994

Islam (2008), based on Rashid *et al* (1994) and Siddiqi (2001) produced a table, below, showing the percentage of Bangladesh's major wildlife species living in the Sundarban compared to national total.

3 http://www.banglapedia.org/ httpdocs/HT/S_0602.HTM

Animal group	No of species in Bangladesh	Species in the Sundarban, Khan (1986)	% in Sundarban	No of species Extinct	No of species Endangered
Amphibians	22	8	36%	-	2
Reptiles	109	50	46%	1	16
Birds	624	261	42%	2	11
Mammals	110	49	45%	4	10
Total	865	368	42%	7	39

It has now been sufficiently established that the Sundarban is our wildlife hotspot. Sundarban is also home for species discovery or type locality of several vertebrates. The same could be true for some invertebrates that I did not try digging.

Wildlife Concentrations in the Sundarban

Anyone visiting the Sundarban would notice that not a single inch of it is free from wildlife. This could be represented by tiny crabs to mudskippers, barnacles to sea-squirts or toads to tigers. Among invertebrates the most dominant are the crabs and gastropods and bivalves on mud banks and intertidal zones, when some gastropods could be found on mangrove plants such the Baen, Genwa, Golpata, Bola, and Sundari trees. Butterflies, moths, dragonflies, honeybees, wasps, beetles, bumblebee, ants, bugs, spiders, flies, midges, mosquitoes, damsel flies, spiders, cicadas, scorpions and centipedes dominate the terrestrial habitats. There is no dearth of shrimps, prawns and crabs in the water.

Invertebrates

Zooplankton provides a lifeline for the fishes and other animals living in aquatic environment. This generally comprises the larvae of shrimps, crabs and other crustaceans, mollusks and echinoderms as well as fish fries.

Among invertebrates the most important commercial species are the shrimps and prawns and lobsters. Mud Crab *Scylla serrata* that are being harvested from nature and/or their larvae and juveniles are collected en masse from nature and then nurtured to an exploitable size in commercial mini and mega ponds and shrimp farms.

Major prawn and shrimp species used in commerce are *Macrobrachium rosenbergii*, *M. malcolmsonii*, *M. rude*; *Penaeus monodon*, *P. semisulcatus*, *P. indicus*, *P. japonicas*, *P. merguiensis*, *P. penicillatus*, *P.*

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orientalis and *Metapenaeus monoceros*. The commercially trawled lobsters include *Panulirus polyphagus*. *P. versicolor*, *P. homarus*, *P. ornatus*, and *Thenus orientalis* (Anon, 2006, Prawns and Lobsters).

Among insects the most important commercial ones are the honeybees – Giant Honeybee *Apis dorsata* and European Honeybee *Apis mellifera*. Basically honey is extracted from the large honeycombs during the peak of the season in mid-April and continues for two months or so. In addition wax from the hive is also collected by Mouals – the honey collectors. Woodcutters and most other people who enter into Sundarban for livelihood are generally called Bawals or Bawalis.

Non-commercial crabs that decorate the mudflats, mud banks, sandflats, overland, tree trunks and in the water of the Sundarban includes Red fiddler crab *Gelasimus annulipus*, Fiddler Crabs of *Uca* and *Gelasimus* species, *Metopograpsus* species, *Portunus pelagicus*, Three Spot Swimming Crab *Portunus sanguinolentus*, *Scopimera* species, Ghost Crab *Ocypode* species, Moon Crab *Matuta victor*, Smooth-shelled Swimming Crab *Charybdis affinis*, hermit crabs, soldier crab, etc.

Sand Bubbler Crab *Scopimera globosa* and its related genus *Dotilla* species are possibly the most numerous crabs on any sandy beach. They keep forming tiny balls of sand at ebb which are arranged in thousands of patterns but all radiate from a central hole. They are also the smallest of the crabs we encounter regularly in the Sundarban's southern face.

The Sundarban is heaven for butterflies. Most spectacular, colourful, immense varieties in colours define the hordes of species that we encounter regularly in the Sundarban, irrespective of seasons.

We have an endemic subspecies of Crow Butterfly called Sundarban Crow *Euploea crameri nicevillei* (Moore, 1890). The other crow that is commonly found in Sundarban and the rest of the country is Common Crow *Euploea core*.

Common Tiger *Danaus genutia*, White Tiger *Danaus melanippus* Blue Glassy Tiger *Ideopsis vulgaris*, Dark Brand Bushbrown *Mycalesis mineus*, Sergeant Butterflies of the genus *Athyma*; Common Rose *Atrophaneura (Pachliopta) aristolochiae*; many species of Swallow-tails, Mormons, under the genus *Papilio*, Lime Butterfly *Papilio demoleus*,

Commodore, Wanderer, Sailor, Leopard, etc. Smaller species include Skipper Butterflies, Cabbage White, Lineblue, Grassblue, etc.

Among moths we commonly see Hawk Moth, Death's-head Hawk Moth, Moon Moth, Tiger Moth *Asota* species, Atlas Moth, Day-flying Moth such as Marbled White and *Dysphania, Milionia* species, Paper Moth *Acropteris* species, Leaf Mimicking Moth *Oreta* species, Wasp Moth *Amata* species, etc.

Over a dozen species of dragonflies and Damselflies can be encountered during a day's trip through the Sundarban. Wasps, beetles, bugs, hornets, cicadas, crickets, midges, flies, grasshoppers, leafhoppers, aphids, ants and spiders are countless.

The most important mollusk item in commerce is the gastropod species *Telescopium telescopium* collected in a wholesale manner and exploited for the production of commercial lime or Calcium Carbonate used in buildings as a white water soluble paint and to a lesser extent as lime for use as an ingredient of betel leaf chewing as well as soil fertilizer and in poultry feed.

The bivalves identified as commercially important and found in the Sundarban to the St. Martin's Island are as follows: edible oysters *Crassostrea madrasonsis, Crassostrea belcher*i, *Crassostrea gruphoides*' and *Saccostrea cucullata*; Windowpane oysters *Placuna placenta*; Clams include *Anadara granosa*, *Anadara rhombea, Meretrix* sp., and Mussels *Mytilus edulis*[4].

Diversity of aquatic and semi-aquatic invertebrate species of Bangladesh is shown in the following table. The table below is based on Ahmed (1990) and Bangladesh Fisheries Research Forum (BFRF)[5]. Many of these species are found within the environs of the Sundarban.

Invertebrate Groups	Habitat	Species Number
Shrimps	Freshwater and marine	56
Crabs	Marine	11
	Freshwater	4
Lobsters	Marine	3
Mollusks	Freshwater	26
	Marine	301

4 http://www.fao.org/docrep/ field/003/AB710E/AB710E09.htm
5 http://www.bfrf.org/value-chain-mollusc.pdf

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Vertebrates

Fishes

The most important commercially important resource of the Sundarban is its fish biodiversity that is heavily exploited year round. Species that are commercially exploited include Bhetki, Asian Seabass *Lates calcarifer*, Ilish, Hilsa Shad *Tenualosa ilisha*, Bata, Gold-spot Mullet *Liza parsia*, Tade Mullet *Liza tade* or *Chelon planiceps*, Loitta, Bombay-duck *Harpodon nehereus*, Anchil Macch Greater Lizardfish *Saurida tumbil*, Kai Magur, Grey Eel-tail Catfish *Plotosus canius*, Rup Chanda, Silver Pomfret *Pampus argenteus*, Pangash, Fatty Catfish *Pangasius pangasius*, Lakkha, Indian salmon *Eleutheronema tetradactylum*, Indian Tassel Fish *Polynemus indicus*, Topshe Macch, Paradise *Threadfin Polynemus paradesius* and Poa Macch, Coraker's Pama *Pama pama*. Other fish groups include catfishes, mudskippers, herrings, bass, perches, flounders and sole fishes. In addition to these, there are at least half a dozen species of cartilaginous fishes such as sharks, sawfish, hammerheads, guitar fish, bat fish, skates and rays. Most endangered among the cartilaginous fish in the country is the Ganges river shark *Glyphis gangeticus* that IUCN considers as Critically Endangered (CR), which is found in the Sundarban.

Other than fishes the vertebrate fauna is dominated by an abundance of amphibians, reptiles, birds and mammals.

Amphibians

Notable among the amphibians are the Common Toad *Duttaphrynus melanostictus*, Marbled Toad *Bufo stomaticus*, Indus-valley Bullfrog *Hoplobatrachus tigerinus*; Jerdon's Bullfrog, *Hoplobatrachus crassus*, Kankra-bhunk Bang, Crab-eating or Mangrove Frog *Fejervarya cancrivora* Shabuj Bang, Cricket Frog, *Fejervarya limnocharis*, Green Pond Frog *Euphlyctis hexadactylus*, Skipper Frog *Euphlyctis cyanophlyctis*, Ornate Narrow-mouthed Frog *Microhyla ornata*, Common Tree Frog *Polypedates maculatus*, and a few species of *Fejervarya* yet to be identified.

Reptilians

Reptiles are dominated by turtles and tortoises, both freshwater and marine, monitor lizards, geckos, skinks, snakes and crocodile.

At least three species of marine turtles – Green, Olive Ridley and Hawksbill – inhabit the sea-facing parts of the Sundarban bordering many islands. Loggerhead has also been recorded but the Leatherback has never been noted. All four are endangered species both nationally and internationally. Some eggs and live specimens are used in local commerce.

Among the fresh and brackish water species the most endangered is the Northern River Terrapin *Batagur baska* that IUCN has categorised as Critically Endangered. It occurs nowhere else in Bangladesh but in the Sundarban although an NGO, CARINAM, with collaboration of the forest department has started a small captive breeding population in Bhawal national Park, Gazipur. Other freshwater terrapins and turtles live overland where there are freshwater pools nearby. None of these can be found inside the Sundarban where there is no permanent freshwater accumulation.

Visibly the reptile fauna is dominated by the two species of Varanus or monitor lizards. Bengal Monitor *Varanus bengalensis* and Ringed Monitor *Varanus salvator* can be seen crossing small canals or swimming past the rivers, sometimes basking ashore or on tree trunks and branches. The largest population of the Ringed Lizard lives in the Sundarban. Its distribution is partial to the coastal areas where the Bengal could live from the Sundarban to the St. Martin's Island or near the Sangu-Matamuhuri river banks in the hills. The third monitor, Yellow Monitor – *Varanus flavescens,* usually prefers freshwater belts bordering the Sundarban.

Two species of house gecko *Hemidactylus* species and Tokay Gecko *Gekko gecko*, Oriental Garden Lizard *Calotes versicolo*r and Many-keeled Grass Skink *Eutropis carinata*, dominate the lizard and skink fauna.

Sundarban is also the home not only for the largest diversity of snake species but also supports the highest density of most snakes. Notable among these are the King Cobra, 2 other species of Cobra Naja species, 2 species of Green Pit Vipers, 2 species of Vine Snakes *Dryophis/Ahaetulla* species, 2 species of Tree Snakes *Dendrelaphis* species, Copperhead Rat Snake *Elaphe radiata*, Dog-faced Water Snake, Checkered and Striped Keelbacks, Rat Snake, Kukri, Wolf, Golden Flying Snake, Bronzeback, water snakes, Indian Python

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and Common Sand Boa. Blind snakes are restricted to the villages bordering the Sundarban since they avoid the saltwater. Among kraits, Banded Krait and Common Krait seemed to be common. Russell's Viper lives only along the villages bordering the Sundarban. Of the 10 species of venomous sea snakes at least 7 are found in and around the Sundarban and its sea face. One species among these *Disteira nigrocincta* (Daudin, 1803) alternatively *Hydrophis nigrocincta* had its type locality marked as Sundarban.

Bangladesh's only population of the Estuarine/Salt Water Crocodile *Crocodylus porosus* is restricted to the Sundarban. Wild population of the crocodile may not be more than 200 specimens. However, the government forest department has been successful in captive breeding in a nursery in Karamjal area, near Mongla within the Sundarban's Chandpai Range. Also there are two private commercial farms trying to breed this crocodile specimens. No captive bred specimen has yet been released into the Sundarban. But, these are no doubt good attempts towards species conservation as in case of necessity such captive-bred crocodiles could be reintroduced into nature, I mean in its former place of existence, somewhere in the Sundarban itself. Also, commercial farm crocodiles cannot be released anywhere in the country.

Avifauna

Sundarban is a paradise for birds. Even if you do not see an amphibian, reptile or mammal you are not going to miss a bird or fail to listen to the call/song of one inside or along the periphery of the Sundarban.

The most notable among birds are the Masked Finfoot (Neumann-Denzau *et al*, 2008), Mangrove Whistler and Mangrove Pitta that occur nowhere else in the country outside the Sundarban. The same is true for the Ruddy Kingfisher and Brown-winged Kingfisher that do not occur anywhere beyond the Sundarban. Also the Great Thick-knee *Eascus recurvirostris* possibly do not occur anywhere beyond certain sandy islands in and around Sundarban.

The Sundarban is possibly the only place in the world where 9 species of kingfishers live almost allopatrically in the whole of the forest. These are Common Kingfisher *Alcedo atthis* and Blue-eared

Kingfisher *Alcedo meninting*. The latter has been reported in Kolkata birds by Sumit Sen[6] for the Indian part of the Sundarban. So, logically it is likely to be present in our Sundarban too. None of us has so far seen or reported it from Bangladesh Sundarban. The others are Brown-winged Kingfisher *Halcyon amauroptera*, Stork-billed Kingfisher *Halcyon capensis*, Ruddy Kingfisher *Halcyon coromandra*, White-throated Kingfisher *Halcyon smyrnensis*, Black-capped Kingfisher *Halcyon pileata* and Collared Kingfisher *Todiramphus chloris*; and Pied Kingfisher *Ceryle rudis*.

The Sundarban supports the largest concentrations of Red Junglefowl, half a dozen species of woodpeckers, barbets, Spotted Owl, Buffy and Brown Fish Owls, Collared Dove, Lesser Adjutant Stork, Little Green Heron, Pond Heron, Little Egret, Greater Egret, Night Heron, Green-billed Malkoha, Greater Coucal, Large and Black-headed Cuckoo-shrike, Chestnut-headed Bee-eater, White-bellied Sea Eagle, Grey-headed Fish Eagle, Crested Serpent Eagle, Shikra, Oriental Honey-Buzzard, Brahminy Kite, Rufous Treepie, Ashy Wood Swallow, Golden-fronted Leafbird, Black-hooded Oriole, Bronze Drongo, Greater Racket-tailed Drongo, Common Wood Shrike, Small Minivet, Scarlet Minivet, Bar-winged Flycatcher Shrike, Black-naped Monarch, Chestnut-tailed Starling, Asian Pied Starling, Jungle Myna, Velvet-fronted Nuthatch, Red-whiskered Bulbul, Yellow-bellied Prinia, Oriental White-eye, Thick-billed Flowerpecker, Orange-bellied Flowerpecker, Purple-rumped Sunbird, Purple Sunbird, and Crimson Sunbird.

None of us has so far seen or recorded the Alexandrine Parakeet *Psittacula eupatria* either from Bangladesh or the Indian part of the Sundarban (Khan, 1986; Khan, 2004, and Sumit Sen quoted above).

However, there is an interesting account of the breeding of this parakeet in the Bangladesh part of the Sundarban in the book *The nests and eggs of Indian birds* by Allan Octavian Hume. Hume guess Mr. H. James Rainey who writes: "Of the nidification and breeding habits of this exceedingly pretty species of Paroquet, the local name of which is Chandana, I made some notes several years ago, when residing in the Eastern Sundarbun, and those notes form the basis of

6 http://www.kolkatabirds.com/ sunderchecklist.htm

this paper.

" From the last half of the month of March up to the first half of the month of May, these birds are to be seen flocking to the interior of the forests of the Eastern Sundarbun, especially that portion of it situated between the Haringhata and Bhola rivers on the extreme eastern side of the Jessore district. They at once select suitable trees with convenient hollows in them, some 25 to 30 cubits above the surface of the ground, rather far apart from one another, and away from the banks of rivers and khals. The tree most preferred is, evidently, the Keura (*Sonneratia apetala*, Buchanan), a large tree, the wood of which is light, and the next in demand is, apparently, the Sundri (*Heritiera minor*, Roxburgh).

"They build their nests in the hollows, first scooping them down perpendicularly some two to two and a half feet, so that it requires a long arm to be able to remove the nestlings in them; and many go out on this quest annually at the proper season, as a pair of these birds readily fetch about a rupee or two shillings in the neighbouring hats or fairs, being in great demand by the natives on account of their beauty, and the facility with which they can be taught to imitate the human voice.

"The eggs are, usually, two or three, and sometimes four in number, slightly smaller in size than pigeon's eggs, and in colour like those of the domesticated fowl, only slightly more whitish. They are deposited in the end of the hollows, the scrapings of the wood being gathered below to form a soft bed for them and the young, when hatched. Both the parent birds perform, alternately, the duty of incubation. The eggs take, I have been told, about four weeks to hatch, but on this point I have no exact knowledge personally. During the month of June men go out bird-nesting into the interior of the forests of the Sundarbun, generally three or four of them together, and then the young birds are not quite fledged, and therefore unable to quit their nests. Great numbers of them are hauled out of their nests by the several parties who go out for them, and they find, as before stated, a ready sale for the nestlings.

"The young are able to leave their nests and fly away in the following month, July, and they then go to the cultivated tracts, roosting on the reed-jungle, known in the vernacular as Nal (*Arundo*

karka, Linnaeus), along the banks of streams ; and as vast flocks of them congregate in the same place every night, where they remain for about a month, if undisturbed, before dispersing themselves all over the surrounding country, they are easily caught in large numbers with bird-lime in the following manner. Slender sticks of split bamboo with their upper ends well smeared with bird-lime are placed in those parts of the Nal jungle where the birds are likely to settle for the night, and the next morning the flocks fly away, leaving those of their companions that have been caught, with the bird-lime, to captivity for life. Many are secured in this way, which is evidently profitable, for one patch of such jungle as they frequent (another may be miles away) is leased for this purpose for 20 rupees and upwards."[8] A version of the account with modernized spelling is available online.[9] Rainey originally published his paper in the ***Stray Feathers Journal*** published by the BNHS – Bombay Natural History Society that was edited by A. O. Hume).

Mammalians

Green (1990) states that "The Sundarban is the only remaining habitat in the lower Bengal Basin for a great variety of faunal species. The presence (or former presence) of at least 40 mammal species has been documented (Sarker, 1986). Of these, no less than five spectacular species, namely Javan rhinoceros *Rhinoceros sondaicus* (E [IUCN Endangered]),), water buffalo *Bubalus bubalis* (E), swamp deer *Cervus devauceli* (E), gaur *Bos gaurus* (V) and probably hog deer *Axis porcinus* have become locally extirpated since the beginning of this century (Salter, 1984). The only primate is rhesus macaque *Macaca mulatta*, considered by Blower (1985) to number in the region of 40,000 to 68,200, based on the surveys by Hendricks (1975) and Khan (1986, [here 1986b]), respectively, as compared to the much higher estimate of 126,220 derived by Gittins (1981)."

He also mentioned that "The Sundarban of Bangladesh and India support one of the largest populations of tiger *Panthera tigris* (with an estimated 350 in that of the former Hendrichs (1975). Again, Gittins' (1981) estimate of 430-450 tigers may be over-optimistic (see Blower, 1985). Spotted deer *Cervus axis*, estimates of which vary between 52,000 Khan (1986, [here 1986b]) and 80,000 (Hendrichs, 1975)

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and wild boar *Sus scrofa*, estimated at 20,000 (Hendrichs, 1975), are the principal prey of the tiger, which also has notorious reputation for man-eating. Of the three species of otter, smooth Indian otter *Lutra perspicillata*, estimated to number 20,000 (Hendrichs), is domesticated by fishermen and used to drive fish into their nets (Seidensticker and Hai, 1983). Other mammals include three species of wild cat, *Prionailurus bengalensis*, *F. chaus* and *Prionailurus viverrinus*, and Gangetic dolphin *Platanista gangetica*, which occur in some of the larger waterways."

The Sundarban is the only place in the whole country where we still have the Spotted Deer. It has disappeared from the rest of the country. Along with it we have the largest concentration of Rhesus Macaque and the Wild Boar in this forest. Same could be true for the Fishing Cat, Leopard Cat and Smooth Otter.

Sad Saga of Bengal Tiger

The most spectacular living mammal species not only in the Sundarban but also in the whole world is our National Animal, Banglar Bagh, the Bengal Tiger *Panthera tigris tigris* Linnaeus, 1758, whose number in both parts of the Sundarban is supposed to range from 400 to 500 or 600 to 800 heads only!

During the 18th century travellers passing through the Sundarban and the British Civil Servants have all declared the tiger a renegade and considered it a menace for civilization. As a result there was wholesale persecution of tiger not only in and around the Sundarban but the whole range from Myanmar to India and Nepal.

"Tigers are endangered because of the action of humans. In the past, tigers were hunted for sport. Thousands were killed and displayed as hunting trophies. Humans also killed tigers because they were considered pests. Beginning 1875, for the next 50 years, more than 57,000 tigers were killed in India. Tiger hunters received bounties for their kills. Today, humans continue to kill tigers for their fur and their body parts. Today, humans continue to destroy their homes and take their land away from them."[7]

Khan (2004) submitted and got his Ph.D. degree based on a thesis on Bengal Tiger in our Sundarban. He mentions "Based on the most

7 http://www.landofthetigers.co.uk/#!endangered

recent pugmark census, simultaneously done in both parts of the Sundarban, the rough estimates are 500 tigers for the Bangladesh Sundarban (Bangladesh Forest Department 2004) and 250-300 for the Indian Sundarban (Forest Department of West Bengal 2004).[8]

Barlow (2009), in his Ph. D. thesis based on a study of Bengal Tiger in Bangladesh Sundarban, has recorded the following: "A total of 3,615 human deaths were recorded, with data available from 84 years over a period of 126 years (1881-2006). Using only years where data were available for both the Indian and Bangladesh Sundarban gave an average of 51 human deaths/year (range 0-168). Taking into account missing data and a 33% error in recording efficiency, the estimated total number of people killed was 9,540, or 76 human deaths/year. A total of 1,259 tiger deaths were recorded for 81 years from 1881 to 2006, but some years had data for only the India or Bangladesh side. The mean number of tiger deaths was 6/year for Bangladesh and 1/year for India. The numbers of humans and tigers killed each year have dropped in recent decades, but current levels of conflict severely impacts local communities and may be a serious impediment to tiger conservation."

The population size for the Bangladesh Sundarban was estimated at 100-150 adult females or 335-500 tigers overall (Barlow, 2009). His highest population figure of 500 is similar to what Khan (2004) mentioned quoting Bangladesh Forest Department. Both these estimates ensure that Bangladesh Sundarban has the highest number of Bengal Tiger population in a single block of about 6000 sq. km. of the Sundarban. This must also be the largest single population of tiger anywhere in the world barring a population of 400-500 Sumatran Tiger in Sumatra, Indonesia[9]. When we add the tigers in the Indian part of the Sundarban (vide Khan, 2004, ibid) of 250-300 tigers the Sundarban is the only landmass in the world that supports the largest tiger population of maximum 800 with a density of one tiger per 12.50 sq. km.

For all practical purposes we need to consider that whatever may be the tiger population in our Sundarban or combined with Indian Sundarban we should not be complacent about the high density

8 http://www.carnivoreconservation.org/files /thesis/khan_2004_phd.pdf
9 http://en.wikipedia.org/ wiki/Tiger

or large tiger numbers. Our tigers have both natural enemies and human adversaries, since man himself is responsible for large number of deaths every year as mentioned by Barlow, above.

Biologically the Sundarban mangrove forest is the only tiger habitats of its kind in the whole world. Nowhere else does the tiger permanently live in a mangrove forest intersected and encircled by saline water, and where always there is a dearth of freshwater that tigers need to drink every now and then. Also, tigers of the Sundarban have become detached and isolated from all the other existing tiger populations in the Indian subcontinent. Moreover, the tiger has disappeared from the whole of Bangladesh, barring the Sundarban. So, Sundarban tiger cannot exchange its genetic material with any other tiger populations of the world.

As per the map below there is no living tiger population anywhere in Bangladesh or areas of India bordering Bangladesh where there is a viable population of Bengal Tiger within a 100 km radius of the Sundarban. The nearest one just over 100 km as a crow flies is in Simlipal in the Jharkhand State of India, beyond the border of West Bengal. Towards the north of Bangladesh, in the Jalpaiguri District of India, there are tigers in Jaldapara Wildlife Sanctuary and in Buxa Tiger Reserve. But the crow fly distance will be over 200 km from Sundarban. In all directions from Sundarban, barring the Bay of Bengal in the south, there are only human habitations and no contiguous forests through which tigers could migrate.

If a Sundarban tiger tries to get out of its jungle perimeter either members of the public will kill it or forest personnel will tranquilize and return it to the jungle provided they reach the tiger before the public do so.

In addition to killing by people, withdrawal of tiger cubs and poaching, and destruction of forest by people and calamities like the cyclone or tidal surge such as Aila and Sidr could have devastating effect on the prey species and tigers themselves.

Here we need to note that both nature and we ourselves were not kind to the wildlife of our country and the neighbouring countries during the past two centuries. This resulted not only in the loss of habitats but also large number of wildlife.

Of all the countries of the subcontinent Bangladesh is the greatest

loser. We have lost all the three species of Rhinoceroses, Buffalo, Barasingha, Hog Deer and Leopard from the Sundarban and rest of the country. Of these, only the Sumatran Rhino did not occur in the Sundarban. Also disappeared are the Marsh Crocodile, Gaur, Banteng, Pygmy Hog, Hispid Hare or Assam Rabbit, Wild Dog or Dhole, Striped Hyaena and Wolf from rest of the country as these did not occur in the Sundarban.

Aquatic Mammals

The Sundarban and its southern face up to the Swatch of No Ground in the Bay of Bengal is Bangladesh's dolphin-whale gold mine. Ganges River Dolphin or Susu (*Platanista gangetica*), Indo-Pacific hump-backed dolphin (*Sousa chinensis*), Irrawaddy dolphin (*Orcaella brevirostris*) and finless porpoise (*Neophocaena phocaenoides*) have made our Sundarban as their home. Bottle-nose Dolphin, Pantropical Spotted Dolphin, and Spinner Dolphin lives at the sea face of the Sundarban. Country's lone confirmed species of whale- the Bryde's Whale is also found in the Swatch of No Ground, some 60 km west of the Sundarban.

Bangladesh Cetacean Diversity Project and its Bangladeshi zoologists and field biologists have done commendable works on the cetacean species in the Sundarban. They have discovered the largest world population of Irrawaddy Dolphin, some 6000 in number in the Sundarban. On the basis of their recommendations the Government has already decided to declare a large chunk of the Sundarban as dolphin-porpoise sanctuary in the late 2011.

Possibly the largest population of Gangetic Dolphin or Shishu lives in the Sundarban when its population in the rest of the country is dwindling. Also in no other place in the subcontinent we have so much concentration of dolphins, porpoise and river dolphins.

Records of major Sundarban animals in the historical Past

There are records of type localities for at least five species of bony fishes from the Sundarban although a few have later turned out to be synonymous with other valid names as shown below:

1. *Aplocheilus panchax* (Hamilton 1822) Synonym – *Aplocheilus*

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chrysostigmus McClelland 1839; Type Locality Sundarban and ponds about Calcutta, India[10].

2. *Danio rerio* (Hamilton 1822) Synonym-Danio striatus McClelland 1839; Type Locality Bengal, particularly Sundarban[11]; *Danio rerio* (Hamilton 1822), Synonym- *Perilampus striatus* McClelland 1839, Type Locality- Bengal, particularly Sundarban, India.

3. *Cynoglossus cynoglossus* (Hamilton 1822), Synonym – *Cynoglossus deltae* Jenkins 1910; type locality- Off Morelganj, Khulna dist., Sundarban, Bangladesh, 10 fms[12].

4. *Cynoglossus lingua* Hamilton 1822 Synonym – *Cynoglossus acinaces* Jenkins 1910 Sundarban, Khulna dist., Bangladesh, 10 fms[13].

5. *Puntius gelius* (Hamilton 1822), Synonym *Cyprinus gelius* Hamilton 1822 that M'Clelland (1838) said this fish to be common in and around Sundarban.

There appears no type locality for the amphibians from the Sundarban but *Kankra-bhunk Bang*, Crab-eating or Mangrove Frog *Fejervarya cancrivora* (Gravenhorst, 1829) is basically restricted to the Sundarban and its neighborhood in Bangladesh (Khan, 2009). Another species, the Green Pond Frog (*Euphlyctis hexadactylus*) is also found within the freshwater to slightly brackish water zones bordering the Sundarban (Khan, 1982, 1986, 2010).

Of the reptiles so far two species seemed to have been named based on type specimens collected from the Sundarban. A third one has been mentioned in the old text by Cantor a shown below:

6. World's largest and longest venomous snake is the *Raj Gokhra*, *Shankhachoor*, King Cobra *Ophiphagus Hannah* (*Ohiophagus hannah*), was first named in 1836 by Cantor based on specimen collected from the Sundarban vide "*Ophiophagus hannah* (Cantor, 1836) Synonym – *Hamadryas hannah* Cantor, 1836: 87; Type locality: "Sundarban" (Sundarban, West Bengal, E India, at that time there was no East Pakistan or Bangladesh and the Sundarban was a single unit under

10 http://www.fishwise.co.za/Default.aspx?TabID=110&GenusSpecies=Aplocheilus _chrysostigmus&SpecieConfigId=208068 Accessed on 17 July 2012

11 http://www.fishwise.co.za/Default.aspx? TabID=110&GenusSpecies=Danio_striatus&SpecieConfigId=258743

12 http://www.fishwise.co.za/Default.aspx?TabID=110&SpecieConfigId=211829&GenusSpecies=Cynoglossus_deltae

13 http://www.fishwise.co.za/Default. aspx?TabID=110&SpecieConfigId=194101&GenusSpecies=Cynoglossus_acinaces

the British Raj) and "jungle not far from Calcutta"[14].

Other than king cobra Daudin's Sea Snake has also been founded based on specimen collected from the Sundarban.

7. Daudin's Sea Snakes *Disteira nigrocincta* (Daudin, 1803) , Synonym – *Hydrophis nigrocincta* (Daudin, 1803) or *Hydrophis nigrocinctus* Daudin 1803: 380, Type locality: "salted waters of a river near Calcutta, Sundarban", Bengal[15].

8. Red-Tailed Bamboo Pit viper *Trimeresurus erythrurus* (Cantor, 1839), Synonym *Trigonocephalus erythrurus*, Cantor (young). Cantor (1886) says, "In Bengal I never observed but a single young one (T. erythrurus), captured in the Sundarban."

As per the literature no bird species has been named based on specimens collected from the Sundarban. But there are quite a few interesting notes in some of the 19th century literature.

9. *Podiceps cristatus*, Linnaeus , many killed in Sundarban and brought to Calcutta', noted by Jerdon (1864). This bird is our current *Jhuti/Shikhar-jukta Duburi*, Crested Grebe. He also mentions 'Gigantic Stork (or Adjutant Stork), to be breeding in the Sundarban. This stork is called Hargila, Greater Adjutant or simply Adjutant, *Leptoptilos dubius*. However, it has now virtually disappeared from the Sundarban although several pairs found breeding in the haor basins of the Greater Sylhet District. Its status in the country is a winter breeding migrant and an endangered species too.

10. Jerdon (1864) also mentioned that The Bengal Green Pigeon *Crocopus Phcenicopterus* Latham; (*Columba phoenicoptera* [as [Columba] Latham, 1790, Index Ornithologicus, 2, p.597,no.13; Synonym – Purple-shouldered Pigeon Latham,1787 (current name Botkol/ Haludpa Horial, Yellow-footed Green pigeon *Treron phoenicopterus* (Latham, 1790)), used to breed in Sundarban.

11. He also noted that our popular but fast disappearing *Kea/Jolar Titir* "The Kyah Partridge, *Ortygornis gularis,* (or current name Swamp Francolin, *Francolinus gularis* was common from Bengal, Sundarban to and extending eastwards into Assam, Sylhet, Cachar and Tipperah" (Jerdon, 1864).

12. E.C.S. Baker (1908) in his famous article "The Indian ducks

14 http://reptile-database.reptarium.cz/species?genus =Ophiophagus&species=hannah
15 http://reptile-database.reptarium.cz/species?genus=Hydrophis&species= nigrocincta

and their allies" published in the journal of Bombay Natural History Society gave a vivid account of our Buncha Hansh or Nukta. He mentions that "in Cachar it is by no means very rare. I have seen it in Sylhet and again have had notice of its occurrence sent me from the North Looshai Hills. As regards the Sundarban, Jessore was the district in which I first made the acquaintance of this species, a distant acquaintance only, it is true, but in the next district (Khoolna), we came into closer contact with one another. Here a pair of Nukhtas formed part of a bag of 140 couple of duck and teal got by my father, Mr. T. Wilcox, and myself in the Moolna (Khoolna, Khulna) bhil, a vast extent of swamp and water, covering fully 20 square miles of the country. This was in the cold weather, the end of January, I think, of 1882. In Cachar, Sylhet, and Looshai the-birds remain all the year round and breed, as they do in most of the other parts of their habitat, but in the Sundarban, I should think, they are, very probably, migrants, though I have no evidence on this point."

13. About the Greater Whistling-Teal (now called Large Whistling Teal, *Dendrocygna bicolor*), Baker (1908) mentions that he took a few nests of the teal in Rungpur, where, however, the bird was not common, one in Nadia, and a few in the Sundarban. This bird is now entirely a migratory species in the Sundarban and other parts of the country although a few may breed within the foothill country of Indian State of Meghalaya in Sylhet-Sunamganj Districts, bordering haors.

The most interesting information on the mammals of Sundarban appears in literature of the 19th and a few in late 18th centuries. Of these, important ones are the Frith's Tailless Bat *Coelops frithii* Blyth, 1848, and the Javan Rhinoceros *Rhinoceros sondaicus* Desmarest, 1822.

14. East Asian Tailless Leaf-nosed Bat *Coelops frithii* Blyth, 1848. Type Locality: Bangladesh, Sundarban. This is the only higher vertebrate species that has definitely been collected from Bangladesh Sundarban and the species was established in 1848 by Blyth on this basis.

"Colour dusky or blackish; the fur tipped with ashy brown above, paler and somewhat ashy beneath; membranes fuscous. This bat is

rare. The above description, given by Jerdon, is based on one specimen sent to Mr. Blyth by Mr. Frith, who obtained it in the Sundarban" (Sterndale, 1884).

15. Rookmaaker (1997) Notes that the "Javan Rhinoceros existed in the forests near the bay of Bengal, called the Sundarban, in southern Bangladesh and the state of West Bengal, India. It was first shot by F.V. Lamarepiquot in 1828, whose two specimens were described as a new species, *Rhinoceros inermis*, by Lesson in 1838. In total 11 specimens are now in different museums. The rhinos lived in small numbers in well-defined localities throughout the entire Sundarban. It must have become extinct before 1925."

Later on *Rhinoceros inermis* turned out to be a relict subspecies of Javan Rhinoceros. *Rhinoceros sondaicus inermis* Lesson, 138, known as the Indian Javan rhinoceros, once ranged from Bengal to Burma, but is presumed to have gone extinct before 1925. The term *inermis* means "unarmed", as the most distinctive characteristic of this subspecies is the small horns in males, and evident lack of horns in females. The original specimen of this species was a hornless female[16].

Jerdon (1867) mentioned that 'the Lesser Indian Rhinoceros, *Rhinoceros sondaicus*, Desmarest, 1822 (the Indo-Bangladesh subspecies 'inermis') "is found at present in the Bengal Sundarban, and a very few individuals are stated to occur in the forest tract along the Mahanuddy river, and extending northwards towards Midnapore; and also on the northern edge of the Rajmahal hills near the Ranges. It occurs also more abundantly in Burmah, and thence through the Malayan peninsula to Java and Borneo. Several have been killed quite recently within a few miles of Calcutta." One of these species formerly existed on the banks of the Indus, where it was hunted by the Emperor Baber."

According to Rookmaaker (1997) there "are three earlier reports of rhinos in the Sundarban. Around 1630; Sebastien Manrique passed the island Xavaspur (point 7 in his figure appended here), in the estuary of the Meghna River, and 'came across many Rhinos, whose horns, offensive in life, are after their death used in a defensive drug' (Manrique, 1927). On 16 January 1664, the Dutchman Wouter

16 http://en.wikipedia.org/wiki/ Javan_rhinoceros

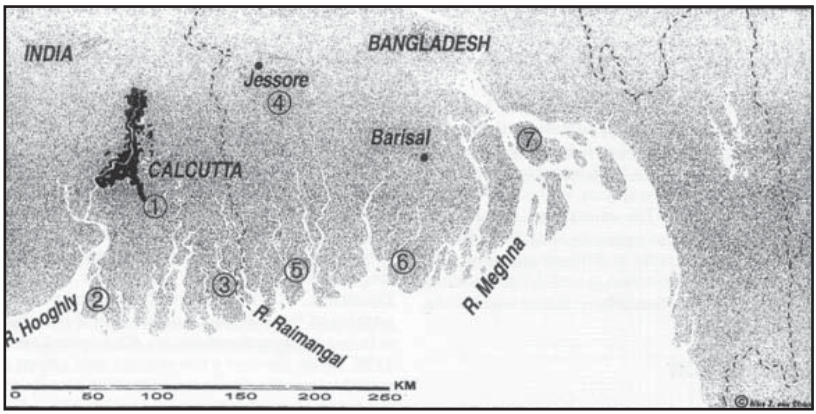


Figure 1. Map of Sundarban of India and Bangladesh. The numbers show locations where rhinos were sighted vide Roommaker, 1997

Schoutens (1676) passed the River Jillisar [?], where the shores of the Ganges are covered with bushes, inhabited by rhinos and other animals. Another traveler, Thomas Bowrey (1905) visited the 'creeks and rivolets at or about the entrance into the Ganges' around 1670 and mentioned the presence of 'rhinocerots' besides tigers and bears."

Figure 1 shows a map of the Sundarban of Bangladesh and India showing the locations of rhino sightings vide Rookmaaker (1997)

Of the 7 sightings of Javan Rhinoceros reported by Rookmaaker, 4 are in our part of the Sundarban and the nearby districts of Barisal and Jessore where the Sundarban existed about two centuries back. However, this rhino not only disappeared from the Sundarban but also from the whole of the Indian subcontinent.

Mallick (2011) mentions that the last rhino was killed around 1888 in the Sundarban. He further noted that its presence during the early 20th century is doubtful. Remains of this animal were collected from an excavated pond in upper layers (in the Sundarban) in 1870 and displayed in the Indian Museum, Kolkata. This museum has a few specimens of this rhino stuffed in its display and store. During a visit in 2003 I took pictures of a specimen collected from the Sundarban.

The board on the museum specimen of rhino in Kolkata clearly mentions the specimen was collected from the Sundarban.

16. *Felis bengalensis* (present *Chita Biral*, Leopard Cat *Prionailurus*

bengalensis) is found at the level of the sea in the Bengal Sundarban (Jerdon, 1867).

17. Jerdon, above, also considered that Buffalo to be very common in the Sundarban.

18. *Rhinoceros unicornis* Linnaeus, 1758 Great Indian one-horned Rhinoceros. Changing landscape and loss of freshwater mangroves led to extinction of this species (Mallick, 2011). Blyth (1862) mentions that "the Rhinoceros are still common" in the eastern Sundarban, and also of the Rajmahal hills in Bengal (where fast verging on extirpation), being identical with that of Java and Borneo, in the great oriental archipelago.

19. According to Mallick (2011) Asiatic wild water buffalo *Bubalus bubalis* Linnaeus, 1758 was found till 1885; by the end of 19th century it died out. A specimen of hip bone found from a pond (in the Sundarban) excavation during 1980 was identified by Zoological Survey of India to belong to this species.

20. *Rucervus duvaucelii* Cuvier, 1823 Swamp deer or *Barasingha* existed till the earlier part of the 20th Century in the West Bengal part of the Sundarban (Mallick, 2011). A team from the Wildlife Trust of Bangladesh collected an antler from the Sundarban during the 2000s confirming it was present there in the historical past (Samiul Mohsanin, WTB, pers comm.).

21. *Axis porcinus* Zimmermann, 1780 Hog deer Extinct at the end of 19th century (Mallick, 2011).

Achievements

In the past three decades or so Bangladeshi scientists and environmentalists and their supporting national and international NGOs have done commendable works on various aspects of the Sundarban, its wildlife and the parties involved, the stakeholders and international interest groups, each for saving each ones interests or motifs in the Sundarban.

The outcome has been varied – a couple of doctorate and postgraduate theses that gave their producers university degrees and later on promotions in their jobs; 100s of published newspaper reports and scientific articles at home and abroad; emergence of many experts on Sundarban; dozens of Sundarban stakeholders killed by tigers when stakeholders killed almost a reciprocal number of tigers

through revenge killing, in addition to gathering of some baseline data missing before.

At the end Sundarban has attracted more stakeholders, made some international bodies like the money lenders such as ADB and World Bank, UN bodies, donor agencies or countries over interested in the Sundarban vis-à-vis tiger conservation or its decimation (!) through massive investments in which grassroots stakeholders have very little to do or achieve, loss of more forests from the Sundarban and land grabbing and encroachment of certain areas progressed smoothly.

All these have compromised the basic need of conserving the Sundarban in its entirety, not piece meal, as is being done today, simply because our government machinery is divided in our national goals of saving the Sundarban from our national and international perspectives and not on donors and agencies or bankers' whims and wishes.

One net outcome of the works of the past three decades proved beyond doubt that we need to undertake a thorough in-depth study of the Sundarban by our own people with a view to inventorying of every resource living in every square kilometre of land towards a very long term planning for sustainable management for getting maximum benefits for the Sundarban itself and for those who depend on it for their livelihoods.

However, so far the Sundarban wildlife is concerned, we need to know that we have not done justice to the study of invertebrate fauna of the Sundarban as there are too many gaps in our knowledge about the species listings and relative abundance of major groups like the intertidal and benthic fauna, especially arthropods and mollusks, platyhelminthes, nemathelminthes, annelid and echinoderms.

It is noteworthy that scientists in the Indian part of the Sundarban have already done commendable studies on these animal groups (Mukherjee, 1975; Mandal and Nandi, 1989; Naskar and Mandal, 1999; Gopal and Junk, 2000; Chaudhuri and Choudhury, 1994; Nandi *et al*, 1993). This shows that we are lagging behind in these aspects.

Potentials in all the invertebrate are resources for conservation and enhancing the national wealth through sustainable resource utilization and management, and injecting more life to the existing

conditions need to be searched out.

Deductions

The last retired World Bank president has made tiger country heads, environment and wildlife ministers and ministries and some scientists to believe that if WB pours money and stakeholder countries plan the world population of tigers would be doubled in nature, possibly in two decades! This is far from the truth. The tiger or large cat population could only be doubled or tripled and appreciably increased in any zoo or captive breeding condition but not in nature simply because nature has its own intrinsic force or value that stops it from overpopulating an area with super abundance of a particular species or species groups, especially the carnivore and among them the larger carnivores like the lion, tiger, leopard and cheetah.

During 1975 Hendrichs (1975) conjectured that there are 350 tigers in Bangladesh Sundarban, Bangladesh Forest department and Dhaka University Zoology department in 1982 considered the population to be 450; Seidensticker (1987) put the figure as 150 adults in our Sundarban and 100 in West Bengal Sundarban. Forest department claimed the figure to be 359 in 1992 and Tamang (1993) considered the population to be 362 when Reza (2000) put the figure as 720 tigers in the Sundarban. All these information are from Khan (2004).

Sunquist (1981) mentioned that on an average a tigress needs about 5 to 6 kg of food per day and tiger needs 6 to 7 kg per day. He also found that a tigress without having young would go hunting every 8 to 8.5 days averaging 42 to 45 kills per year. A tigress with cubs of 6 to 10 months old killed prey every 5 to 6 days that means 61 to 73 kills per year.

Karanth (2001) reported that to sustain a tiger, where Spotted Deer is the main food, a situation similar to our Sundarban, 500 deer are needed. Khan (2004) has quoted this figure in his thesis too.

Khan (2004) estimated, rather conjectured, to have nearly 21 spotted deer per square kilometre of the Sundarban. Consider that we have 6000 sq. km. of Sundarban that has 4000 sq. km. of land and 2000 sq. km. of water. Deer lives on land. That means we have 84, 000 deer in Sundarban that should support at least 168 Tigers.

However, Karanth's (2001) study mostly concerns tigers in evergreen and deciduous forests of Himalayan foothills, central and southern India where habitat types are completely different than the Sundarban.

Khan (2004) himself believes and considered in his thesis that there could be 200 tigers in Bangladesh Sundarban. So, the number of tigers in the Sundarban may sensibly range between 200 and 500 and superfluously up to 720 vide Reza (2000). Considering the density of Spotted Deer I will be satisfied with a figure ranging from 150 to 300 tigers in our Sundarban. If this level can be maintained for the coming century it will still represent the largest single population of the Bengal Tiger anywhere in the world.

However, it appears that we do not have a definite figure for our Sundarban tigers. This does not matter.

Why tiger numbers cannot be doubled in the Sundarban in the next two decades may be considered in the light of the utter failure of the tiger project in India after spending billions of Indian rupees over the past 40 years as the first tiger project was launched in 1973.

The Project Tiger people in India claimed that it was "able to bring the population of tigers from 1,200 in 1970s to 3500 in 1990s." However, when the Government of India did a survey in 2008 the tiger population was estimated to be only 1,411[17].

Details of this latest 2008 survey reveals the following: "The methodology used during the tiger census of 2008 extrapolates site-specific densities of tigers, their co-predators and prey derived from camera trap and sign surveys using GIS. Based on the result of these surveys, the total tiger population has been estimated at 1,411 individuals ranging from 1,165 to 1,657 adult and sub-adult tigers of more than 1.5 years of age."[18]

This Indian instance sufficiently proved that the tiger number cannot be doubled whether we spend billions of rupees or dollars because largely nature and to some extent the erratic actions of humans control the environment and healthy growth of any animal population in a major forest or ecosystem.

We have no need to go beyond our country to get an example of

17 http://tech02.hubpages.com/hub/ different-ways-to-save-the-tiger-population-in-india-tiger-conservation

18 http://projecttiger.nic.in/whtsnew/status_of_tigers_in_india_2008.pdf.

such human atrocities towards forests and wildlife therein. An example is the total destruction of naturally growing Sal forest from the Dhaka, Gazipur, Mymensingh, Tangail, Jamalpur and Sherpur districts, and wholesale destruction and conversion of mixed-evergreen forests of the Chittagong and Sylhet revenue divisions into man-made forests or plantations as well as slash and burn cultivation and settlements of indigenous and plain-dwelling people that ultimately wiped out major wildlife species such as Tiger, Gaur, Leopard, all three species of Rhinoceros, Pygmy Hog, Hispid Hare, Spotted Deer, Indian and Green Peafowl, White-winged Duck, etc., (Khan, 1987, 2003, 2010) and Khan (2008).

When we want to discuss any issue regarding the Sundarban of Bangladesh we try to revolve it round the tiger or become tiger-centric! We shall have to come out of this exclusivity and consider the Sundarban in its entirety.

For a Scientific Management of the Sundarban we need to highlight on:

A detailed survey of all wildlife species occurring in the Sundarban.

1.1. This is to be done by dividing the Sundarban into at least 500 one square kilometre block/plot or 2 such plots in each of the existing Forest Management Blocks, based on GPS, each marked on a map, over an initial 5-year plan extendable to another two such terms.

1.2. All biodiversity of each 1 sq. km. block to be physically surveyed, identified and ones that cannot be identified in the field or microscopic ones are to be preserved and transported to laboratory facilities for species level identification.

1.3. Make inventory of the wildlife vis-à-vis the biodiversity.

Determine a priority list of pioneering species that are to be studied in detail from the point of biology and sustainable utilization. These could be:

2.1 Bengal Tiger, its prey species and competitors
2.2 Smooth-Clawed Otter
2.3 Irrawaddy Dolphin
2.4 Finless Porpoise
2.5 Ganges River Dolphin
2.6 White-bellied Sea-eagle
2.7 Mangrove Whistler and Mangrove Pitta
2.8 Larger Kingfishers- 3-4 species

: Reza Khan

2.9 Larger owls
2.11 Saltwater Crocodile
2.12 Northern Batagur
2.13 Ring and Bengal Lizard
2.14 King Cobra
2.15 Green Pond frog
2.16 Crab-eating Frog
2.17 Mudskippers
2.18 River Shark and other Cartilaginous fishes
2.19 Non-commercial fishes
2.20 Non-commercial crabs
2.21 Non-commercial Mollusks
2.22 Butterflies
2.23 Bugs, Beetles, Wasps
2.24 Grasshoppers
2.25 Moths
2.26 Spiders
2.27 Annelids
2.28 Microbenthos
2.29 Macrobenthos
3 Assessment of the total exploitable resource that can be extracted on yearly basis
4 Surveying the total number of Obligate and Facultative Bawalis.
5 Determine the needs of the Obligate Bawalis
6 Find out alternative livelihood for the Bawalis
7 Develop means of diversification of resource-base
8 Long term monitoring programme for biodiversity
9 Long term monitoring programme for the weather pattern
10 Long term monitoring programme for Salinity study
11 Long term monitoring programme for Water Quality and Pollution
12 Long term monitoring programme for the role of Bawalis and stakeholders in the Sundarban

The Sundarban is still the best forest in Bangladesh because the forest department used some common sense in not removing all plants of block or neighbouring blocks of the Sundarban when they extracted timber on commercial basis as they did in the Sal and Mixed-evergreen Forests. So, past process of selected logging kept both flora and fauna more or less intact but it did not allow century old trees to remain in place. Even then there is the chance of natural regeneration as no monoculture or exotic tree has been introduced into the system.

During the last Cyclone Sidr I made a public appeal to the government through newspaper that parts of the Sundarban destroyed by Sidr must not be disturbed, or uprooted trees or broken branches

be removed. Rather if left untouched the forest would regenerate on its own. Additionally, if government wanted to expedite the process of regeneration it can transplant saplings of local plants to those areas where regeneration process is slow.

Government did respond to my call and it is for the first time that our forest department did not jump into action of removing cyclone hit areas of a reserved forest. The Sidr was in November. When I visited the Sidr-hit area in January the regeneration process had already begun and if one visits those spot they may not find the 'burnt-out' trees. Of course the logs that had been trampled to the ground are still there and decaying slowly and in the process adding manure to the soil.

Why Sundarban needs to be conserved in its entirety?

1. It is the only naturally formed mangrove forest of the country.
2. The Sundarban is the largest piece of natural forest that is still intact.
3. It has the highest largest biomass per kilometre of land anywhere in the country in terms of both flora and fauna.
4. The Sundarban of ours and that of Indians together formed the largest single block of mangrove forest in the world.
5. The Sundarban of Bangladesh has no human settlements-a rare phenomenon in a country which has the highest human population per square kilometre of land in the world.
6. This forest supports the largest single population of Bengal Tiger in the whole world.
7. No other mangrove forest in the world has so much of plant and animal diversities as we have in our Sundarban.
8. It is the only place where we still have our national animal-The Bengal Tiger, the Chital or Spotted Deer and Saltwater or Estuarine Crocodile.
9. Possibly the largest world population of Irrawaddy Dolphin lives in the Sundarban.
10. The Sundarban is the single largest source of natural honey production, crabs, prawns and some fishes.
11. Highest snake, monitor lizard, crab-eating frog, wild cats, otter, macaques, wild boar and bird biodiversity of the country live in the Sundarban.
12. Nowhere else in the country 350,000 to 400,000 people enter

into a forest for their livelihood almost on daily basis.

13. This is the only place where wild animals kill at least 100 people on a yearly basis.
14. The Sundarban works as the natural supplier of mangrove seeds and propagules to the whole of the coastal areas of the country.
15. It is the largest nursery for fin fish and shell fish in the country.
16. It is the hottest biodiversity spot in the country.

The Sundarban is our national pride and we must save and protect it for our future generations and for the biodiversity to flourish unhindered in the centuries to come.

REFERENCES

Ahmed, A. T. A. 1990. *Studies on the identification and abundance of Molluscan fauna of the Bay of Bengal*. Bangladesh Agricultural Research Council.

Ali, S. and K.M.S. Aziz 1976. *A systematic account of Molluscan fauna of St. Martin's island*. Bangladesh Journal of Zoology. 4 (2): 23-33.

Anon (Anonymous). 1995. *Integrated Resource Management Plan of the Sundarban Reserved Forest*, Vol. 1, Draft Final Report of FAO/UNDP Project BGD/84/056-Integrated Resource Development of the Sundarban Reserve Forest, Khulna, Bangladesh.

Anon. 2006. *Banglapedia*. 10 volumes. Asiatic Society of Bangladesh, Dhaka. Entries consulted- the Sundarban, Deforestation, Fish, Forests and Forestry, and Wildlife.

Anon. 2010. *CBD* Fourth National Report -*_Bangladesh* (Part II, English version) Fourth National Report to the Convention on Biological Diversity: Fourth National Report (Biodiversity National Assessment and Programme of Action 2020)-Department of Environment, Ministry of Environment and Forests, Govt of Bangladesh. January 2010 (www.cbd.int/doc/world/bd/bd-nr-04-p2-en.pdf Accessed on 16 July2012.

Baker, E. C. S. 1908. *The Indian ducks and their allies*. Published by the Bombay Natural History Society. Bombay: Thacker and co., limited.

Barlow, A. C. D. 2009. *The Sundarban Tiger Adaptation, Population Status, and Conflict Management*. A thesis submitted to the faculty of the Graduate School of the University of Minnesota, Minnesota, USA. xii+191 pp. Available at http://www.carnivoreconservation.org/files/thesis/barlow_2009_phd.pdf .

Blower, J. 1985. *Sunderbans Forest Inventory Project*, Bangladesh. Wildlife Conservation in the Sundarban. Project Report 151. Overseas Development Administration, Land Resources Development Centre, Surbiton, U.K. 39 pp.

Blyth, E. 1862. *A memoir on the living Asiatic species of rhinoceros*. Jour. Asiat. Soc. Bengal. 31 (2):151-175.

Cantor, T. 1886. *Catalogue of reptiles inhabiting the Malayan Peninsula and Islands. In: Miscellaneous papers relating to Indo-China and the Indian archipelago*. Vol-II, pp 112-257. Trübner & Co., Ludgate Hill.

Chaudhuri, A. B. and A. Choudhury, 1994. *Mangroves of the Sundarban*. Volume 1: India. World Conservation Union, Gland, 247 pp.

Das, A.K. and Nandi, N.C. 1999. *Fauna of Indian Sundarban Mangal and Their Role in the Ecosystem*. Sundarban Mangal. Guha Bakshi, D.N. (Ed.). Naya Prakash. Kolkata.

Fazl, A. 1897. *Akbarnama* (translated from Persian to English by H.Beveridge). Vol. I, Asiatic Society, Calcutta, India.

Gittins, S. 1981. *A Survey of the Primates of Bangladesh*... Fauna Preservation Society, London. 64 pp. (Unpublished).

Gopal, B. and Chauhan, M. 2006. *Biodiversity and its conservation in the Sundarban Mangrove Ecosystem*. Aquatic Sciences. 68 (2006): 338–354.

Green, Michael J.B. 1990 IUCN *Directory of South Asian Protected Areas*. IUCN, Gland. Xvii+294 pp.

Hendrichs, H. 1975. *The status of the tiger Panthera tigris* (Linne, 1758) in the Sundarban mangrove forest (Bay of Bengal). Saugetierkundliche Mitteilungen 23:161-199.

Hume, A. O. and Oates, E. W. 1989. *The nests and eggs of Indian birds*. 2nd edition. Vol.3. London, R. H. Porter. [First edition was published in 1883 by Hume alone. Oates has actually edited the 2nd edition.]

Hunter, W.W. 1875. *A Statistical Account of Bengal*, Vol. I, District of 24 Parganas and Sundarban, Truebner & Company, London.

Hussain, Z., and Acharya, G., (eds.), 1994. *Mangrove of the Sundarban*, Volume Two: Bangladesh. IUCN – Bangkok, Dyna Print, Thailand.

Islam, M. S. N. 2008. *Cultural Landscape Changing due to Anthropogenic Influences on Surface Water and Threats to Mangrove Wetland Ecosystems: A Case Study on the Sundarban*, Bangladesh. Ph. D. Thesis. Brandenburg University of Technology at Cottbus, Germany. (Available at: opus.kobv.de/btu/volltexte/2009/588/pdf/PhD_Thesis_07_PDf.pdf Accessed on 16 July2012).

Jerdon, T. C. 1864. *The birds of India : being a natural history of all the birds known to inhabit continental India, with descriptions of the species, genera, families, tribes, and orders, and a brief notice of such families as are not found in India, making it a manual of ornithology specially adapted for Indi*a. Vol. III.George Wyman and Co., publishers, Hare Street, Calcutta.

Jerdon, T. C . 1867. *The mammals of India: a natural history of all the animals known to inhabit continental India*. Rookie: Printed for the author by the Thomason college press.

Jhala, Y.V. Gopal, R. and Qureshi, Q. (eds.).2008. *Status of the Tigers, Co-predators, and Prey in India*. National Tiger Conservation Authority, Govt. of India, New Delhi, and Wildlife Institute of India, Dehradun. TR 08/001 pp-151. Available at http://projecttiger.nic.in/whtsnew/status_of_tigers_in_india_2008.pdf.

Karanth, K. U. 2001. Tigers. Colin Baxter Photography, Scotland.

Khan, M.A.R. 1979. *The distribution and population status of primates of Bangladesh*. Abstract 7th Congress of the International Primatological Society, Bangalore.

Khan, M. A. R. 1981a. *The non-human primates of Bangladesh*. Tigerpaper 8 (1): 12.15.

Khan, M. A. R. 1981b. *The endangered birds of Bangladesh*. Newsletter for Birdwatchers, 21(12): 4-7.

Khan, M. A. R. 1981c. Note on a Slow Loris (Nycticebus coucang) in captivity. Bangladesh J. Zool. 9(1): 77-79.

Khan, M. A. R. 1982. *On the distribution of the mammalian fauna of Bangladesh*. Proceedings 2nd Bangladesh National Conf. on Forestry. Dacca. 560-575 Pp.

Khan, M.A.R. 1982a. *Present status and distribution of Crocodiles and Gharial of Bangladesh*. Crocodiles. IUCN, Gland, Switzerland. 229-236 Pp.

Khan, M. A. R. 1982b. *The endangered mammals of Bangladesh*. Oryx 18(3): 152-156

Khan, M. A. R. 1982c. Wildlife of Bangladesh- A Checklist. Bangladesh: Dhaka University. Pp iv + 174 with 48 black and white plates.

Khan, M. A. R. 1982d. *Chelonians of Bangladesh and their conservation*. J. Bombay Nat. Hist. Soc. 79(1): 110-116

Khan, M. A. R. 1983a. *Birds of prey of Bangladesh and their conservation*. Tigerpaper 10(4): 7-10.

Khan, M. A. R. 1983b. *Ecology and Conservation of the Common Langur Presbytis entellus in Bangladesh*. In: Roonwal, M. L. Mohnot, and S. .M. & Rathore, N. S. (Eds). Current Primate Researches. Jodhpur, India: S. K. Enterprise and Jodhpur University. 33-39 Pp.

Khan, M. A. R. 1983c. *Wildlife Conservation in Bangladesh*. In: Daniel, J. C. and Serrao, J. S. (eds.). Conservation in developing countries: Problems and prospects. Bombay: Bombay Natural History Society. 310-416 pp.

Khan, M. A. R. 1984a. *Conservation of Storks and Ibises in Bangladesh*. Tigerpaper 11(4): 2-4.

Khan, M. A. R. 1985a. *Future conservation directions for Banglades*h. In: Thorsell, J. W. Conserving Asia's Natural Heritage. Gland, Switzerland: IUCN. 114-122 Pp.

Khan, M. A. K. 1985b. *Mammals of Bangladesh- a field guide*. Dhaka: Nazma Khan. 92p.

Khan, M. A. R. 1985c. *St. Martin's – a vanishing coral Island of Bangladesh*.

Tigerpaper 12(4): 6-12.

Khan, M. A. R. 1986a. *The status and distribution of the cats in Bangladesh*. Cats of the world. National Wildlife Federation, USA. 43-49 pp.

Khan, M. A. R. 1986b. *Wildlife in Bangladesh mangrove ecosystem*. J. Bombay Nat. Hist Soc. 83 (1): 32-48.

Khan, M. A. R. 1986c. *Nature Conservation in Bangladesh*. In: Encyclopedia of Indian Natural History. Hawkins, R. E. (Ed.) India: Bombay Natural History Society, 404-405 Pp.

Khan, M. A. R. 1986d. *Threatened White-winged Wood Duck* Cairina scutulata in Bangladesh. Forktail 2:97-101.

Khan, M.A.R. 1987. Bangladesher Bonnyaprani ({in Bengali}: Wildlife of Bangladesh). Vol.1-3. Dhaka: Bangla Academy. Pp vol.-1:xvi + 169, vol.-2:xiii + 174 & vol.-3: x + 136.

Khan, M.A.R. 1987a. *Bangladesher Banar Norabana*r ({in Bengali}: Primates of Bangladesh). Dhaka: Muktadhara. Pp viii + 117 + 8 colour and 8 black and white plates.

Khan, M.A.R. 1987b. *The problem tiger of Bangladesh*. In: R. L.Tilson & Seal, U.S. (Editors). Tigers of the World. New Jersey, U.S.A.: Noyes Publications. 92-96 Pp.

Khan, M. A. R. 1988. The Grassland Avifauna of Bangladesh. In : ICBP Technical Publication No.7. 215-219.

Khan, M.A.R. 1992a. *Bangladesher Shap* ({in Bengali}:Snakes of Bangladesh). Bangla Academy, Dhaka. xi+227 with 54 black and white plates.

Khan, M.A.R. 2001. Status and Distribution of Bats in Bangladesh with notes on their ecology. Zoos' Print Journal. 16(5):479-483.

Khan, M.A.R. 2003. *Disappearance of the White-winged Duck Carinia scutulata from the Pablakhali Wildlife Sanctuary: A Saga of large-scale destruction of Mixed Evergreen Forest in Bangladesh*. Journ. Bombay Nat. Hist. Society. 100(2&3): 263-274 pp.

Khan, M.A.R. 2004. *Checklist of the Herpetofauna of Bangladesh*. Cobra. 54 (July-September): 1-32 pp.

Khan, M.A.R. 2008b (2010). *Bangladesher Pakhi* (Birds of Bangladesh). Dhaka: Bangla Academy. 354 Pp with 64 colour plates. Was actually released during April, 2010.

Khan, M. A. R. 2009. *Rare frog found in Sundarban*. The Daily Star, Dhaka. Front Page, Wednesday, September 2, 2009.

Khan, M. A. R. 2010. *Wildlife of Bangladesh- A Checklist* [from Amphibia to Mammalia] with Bengali names. Dhaka: Sahitya Prakash. 128Pp.

Khan, M. A. R. and Ahsan, M. F. 1981. *The population status of the non-human primates of Bangladesh*. Report to University Grants Commission, Dacca. 25 Pp. (Mimeographed).

Khan, M.A.R. and Ahsan, M.F. 1981. *The group structure, composition and age-sex relationship of primates of Bangladesh*. Proceedings 3rd National Zoological Conference, Dhaka, 1981. Pp. 287-302.

Khan, M. A. R. and Ahsan, M. F. 1981a. *The group-size, composition and age-sex relationship of primates of Bangladesh*. Proc. 3rd National Zool. Conf. Dacca. Bangladesh. 287-3O2 Pp.

Khan, M. A. R. and Ahsan, M. F. 1986. *The status of Primates in Bangladesh and a description of their forest habitats*. Primate Conservation 7 (2): 102-109.

Khan, M. M. H. 2004. Food habit of the Leopard Cat Prionailurus Bengalensis (Kerr, 1792) in the Sundarban East Wildlife Sanctuary of Bangladesh. Zoos' Print Journal 19(5): 1,475-1,476.

Khan, M. M. H. 2004. *Ecology and conservation of the Bengal tiger in the Sundarban mangrove forest of Bangladesh*. Ph. D. Thesis. Wildlife Research Group, Selwyn College, Department of Anatomy Cambridge, Cambridge University: Available at www.carnivoreconservation.org/ files/thesis/khan_2004_phd.pdf Accessed on 15 July 2012. This thesis has included almost all his papers published up to 2004.

Khan, M. M. H. 2008. *Protected Areas of Bangladesh – A Guide to Wildlife*. Dhaka: Nishorgo Programme, Forest Dept.- Govt of Bangladesh and USAID. 304pp.

Kibria, M.G.; Rahman, S. A.; Imtiaj, A.; Sunderland, T.C.H. 2011. *Extent and consequences of tropical forest degradation-Successive policy options for Bangladesh. Journal of Agricultural Science and Technology*. 2001(1): 29-37. Available at- http://www.cifor.org/online-library/browse/view-publication/publication/3460.html

Kibria, M.G., Sarker, D.C., Hossain, M.A.T., Manna, M.A., Motaleb, M.A. and Islam, S.S. 2000. *Forest Statistics of Bangladesh*, Bulletin 4, Forest Economics Division, Bangladesh Forest Research Institute, Chittagong, Bangladesh. 119p.

Mandal, A. K. 2003. T*he Sundarban of India: A Development Analysis*. Indus Publishing, New Delhi, India. 260 pp.

Mandal A.K. and Nandi, N.C. 1989. *Fauna of Sundarban Mangrove Ecosyste*m, West Bengal, India. ZSI. Calcutta.

M'Clelland, J.. 1838. *Indian Cyprinidae***.** Bishop's College Press, Calcutta, India. Mallick, J. K. 2011. *Status of the Mammal Fauna*. In: Sundarban Tiger Reserve,

West Bengal – India. TAPROBANICA. 03(02) : 52-68.

Mukherjee, A. K., 1975. *The Sundarban of India and its biota*. Journal of the Bombay Natural History Society. 72 (1): 1–20.

Mukul, S. A., Uddin M. B., Uddin, M. S., Khan, M. A. S. A. and Marzan, B.2008. *Protected areas of Bangladesh: current status and efficacy for biodiversity conservation*. Proc. Pakistan Acad. Sci. 45(2): 59-68.

Nandi, N.C., Das, S.R., Bhuinya, S. and Dasgupta, J.M. 1993. *Wetland Faunal Resources of West Bengal 1. North and South 24-Parganas Districts*. Records of the Zoological Survey of India, Occasional Paper No. 150: 10. Zoological Survey

of India, Kolkata. 50pp.

Naskar, K. R. and Mandal, R. N. 1999. *Ecology and Biodiversity of Indian Mangroves*. Day Publishing House, Delhi. 754 pp.

Neumann-Denzau, G., Mansur E. F., and Mansur, R. 2008. *Nests, eggs, hatchlings and behaviour of the Masked Finfoot Heliopais personatus from the Sundarban in Bangladesh, with first nesting observations*. Forktail 24 (2008): 92–99.

Prater, S. H. 1971. The book of Indian animals. Bombay Natural History Society, Bombay. 324 pp.

Rahman, A. K. A., Kabir, S. M. H., Ahmed, M., Ahmed, A. T. A., Ahmed, Z. U., Begum, Z. N. T., Hassan, M. A. and Khondker, M. eds. 2009. Encyclopedia of Flora and Fauna of Bangladesh,Vol-24. *Marine Fishes*. Dhaka:Asiatic Society of Bangladesh, Dhaka. 485 pp.

Rahman, S. 2011. *Impacts of Climate Change on Ecological Composition & Biodiversity of Sundarban*, Bangladesh. Paper presented at a conference in the Philippines that is available at http://www.ched.gov.ph/chedwww/index.php/eng/content/download/ 1792/9300/file/Impacts_CC_Sundarban_Shahriar_Rahman.pdf (Accessed on 15 July 2012).

Rashid, S. M. A., Khan, A., and Akanda, A, W. 1994. Fauna. In: Hussain, Z. Acharya, G. (eds.). *Mangrove of the Sundarban*, Volume Two: Bangladesh. IUCN – Bangkok, Dyna Print, Thailand. pp 115-132.

Rainey, H. J. 1875. *Nidification and breeding habits of the large Rose-ringed Paroquet in the eastern Sundurbun*. Stray Feathers 3: 382–384.

Reza, A.H.M.A. 2000. *Ecology of Bengal tiger*, Panthera tigris tigris (Linn. 1758) in the Sundarban. MSc thesis, Jahangirnagar University, Dhaka.

Reza, A.H.M.A., Feeroz, M.M. and Islam, M.A. 2001a. *Food habits of the Bengal tiger (Panthera tigris tigris) in the Sundarban*. Bangladesh J. Zool. 29(2): 173-179.

Reza, A.H.M.A., Feeroz, M.M. and Islam, M.A. 2001b. *Habitat preference of the Bengal tiger, Panthera tigris tigris, in the Sundarban*. Bangladesh J. Life Sci. 13(1&2): 215-217.

Reza, A.H.M.A., Feeroz, M.M. and Islam, M.A. 2002a. Prey species density of Bengal tiger in the Sundarban. J. Asiatic Soc. Bangladesh, Sci. 28(1): 35-42.

Rookmaaker, Kees. 1997. *Records of the Sundarban Rhinoceros (Rhinoceros sondaicus inermis) in India and Bangladesh*. Pachyderm 24: 37–45. http://www.rhinoresourcecenter.

Salter, R. 1984. Integrated Development of the Sundarban, Bangladesh: Status and Utilization of Wildlife. Report No. W/R0034. FAO, Rome. 59 pp.

Sanderson, E., Forrest, J., Loucks, C., Ginsberg, J., Dinerstein, E., Seidensticker, J., Leimgruber, P., Songer, M., Heydlauff, A., O'Brien, T., Bryja, G., Klenzendorf, S. and Wikramanayake, E.. 2006. Setting Priorities for the Conservation and Recovery of Wild Tigers: 2005–2015. The Technical Assessment. Washington (DC): WCS, WWF, Smithsonian, NFWF-STF.

Sarker, S. U. 1986. *Management of the wildlife of the Sundarban, Bangladesh*. Paper presented at the First International Seminar Cum Workshop for Conservation of Wildlife in Bangladesh, Dhaka, 1-4 December 1986.

Sarker, M. S. U. and Sarker, N. J. eds. 1988. *Wildlife of Bangladesh*- (a systematic list with status, distribution and habitat). Dhaka: The Rico Printers, 69 pp.

Seidensticker, J and Hai, M. A.. 1983. *The Sundarban Wildlife Management Plan : conservation in the Bangladesh coastal zone : a World Wildlife Fund Report*. WWF ; Bangladesh, Ministry of Environment and Forest ; Smithsonian Institution, National Zoological Park ; IUCN, Gland : IUCN, 1983. 120pp.

Siddiqi, N. A. 2001. *Mangrove Forestry in Bangladesh*. IFES, Univ. of Chittagong, 2001.

Siddiqui, K. U., Islam, M. A., Kabir, S. M. H., Ahmed, M., Ahmed, A. T. A., Rahman, A. K. A., Haque, E. U., Ahmed, Z. U., Begum, Z. N. T., Hassan, M.A., Khondker M. and Rahman, M. M. eds. 2007. *Encyclopedia of Flora and Fauna of Bangladesh*, Vol-23. Freshwater Fishes. Dhaka: Asiatic Society of Bangladesh. 330 pp.

Siddiqui, K. U., Islam, M. A., Kabir, S. M. H., Ahmed, M., Ahmed, A. T. A., Rahman, A. K. A., Haque, E. U., Ahmed, Z. U., Begum, Z. N. T., Hassan, M. A., Khondker, M. and Rahman, M. M. eds. 2007. *Encyclopedia of Flora and Fauna of Bangladesh*, Vol-17. Molluscs. Dhaka: Asiatic Society of Bangladesh. 415 pp.

Siddiqui, K. U., Islam, M. A., Kabir, S. M. H., Ahmed, M., Ahmed, A. T. A., Rahman, A. K. A., Haque, E. U., Ahmed, Z. U., Begum, Z. N. T., Hassan, M. A., Khondker, M. and Rahman, M. M. eds. 2008. *Encyclopedia of Flora and Fauna of Bangladesh*, Vol-26. Birds. Dhaka: Asiatic Society of Bangladesh. 662 pp. (From http://www.cbd.int/doc/ world/bd/bd-nr-04-p4-en.pdf Accessed on 16 July2012).

Sterndale, R. A. 1884. *Natural history of the Mammalia of India and Ceylon*. Calcutta: Thacker, Spink, and Co.; Bombay: Thacker and Co., Limited.

Sunquist, M. E. 1981. *The Social Organization of Tigers (Panthera tigris) in Royal Chitawan National Park, Nepal*. Smithsonian Contributions to Zoology Number 336. Washington DC: Smithsonian Institution Press.

Tamang, K.M. 1993. *Wildlife management plan for the Sundarban reserved forest*. Report of the FAO/UNDP project (no. BGD/84/056) entitled 'Integrated Resource Development of the Sundarban Reserved Forest'. 113 pp.

Bengal Tiger – The Wild Heritage of Bangladesh

In my childhood I was fascinated by my father's stories of close encounters with wild tigers in the deciduous forest of Madhupur in early 1940s. At his young age he got his first job in a hospital in Madhupur and spent a few years on the edge of the forest. At that time Madhupur forest covered a vast area, with very few ethnic Garo people living around, and the tiger was rather abundant. My father had a US-made Stevens's shotgun, so it is no wonder that he made use of it.

The stories were alive in my mind and I felt sad to understand how such a dominant creature like the tiger has been cornered to the Sundarban where it is extremely difficult to see. I thought I should do something to help tigers survive in Bangladesh. When the opportunity

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came in the year 2000, I took my Ph.D. project on tigers of the Sundarban at the University of Cambridge, UK. After the completion of my degree I continued working on tigers under the umbrella of Carnivores and People Conservation Programme of the Zoological Society of London. I spent many days and nights in the Sundarban and was fortunate (many people might think 'unfortunate') to have close encounters with tigers for many times. I was amazed to see how such a formidable predator has adapted to the inhospitable swampy habitat of the Sundarban. I saw them skillfully swimming across wide rivers, silently stalking the deer in the grassy meadows, and also watching me from behind the bush. I was overwhelmed when the forest shook with tiger's loud roar late at night. My understanding is that the tiger is thriving in the Sundarban. Every Bangladeshi should be proud that we have wild tigers in Bangladesh, and every Bangladeshi should take responsibility to ensure its survival. We must stop the trend of tiger's decline that started a hundred years ago.

Bengal, which is now Bangladesh and part of northeast India, used to be the prime land of the tiger. Therefore, the tiger sub-species that occurs in the Indian Subcontinent has got its common name 'Bengal tiger'. During the Colonial Era, one George Yule of the Bengal Civil Service had killed four hundred tigers in twenty five years, after which, although he continued to shoot, but did not think it worthwhile to continue recording them. He was just one of the many sport hunters of that time who had hunted hundreds of tigers. In the book 'Banglar Shikar Prani', published in 1957, Sri Shachindra Nath Mitra mentions the occurrence of tigers in eleven of the seventeen civil districts of the eastern Bengal (now Bangladesh) until the 1930s. This large predator was so abundant and widespread that it was treated as a menace and the Government used to pay a bounty for killing tigers. The merciless killing, together with the rapid decline of large prey animals and natural forests crucial for the survival of wild tigers, has brought the species at the brink of extinction. Today, the tiger is a globally threatened species. In Bangladesh only population of tiger occurs in the Sundarban.

Thankfully, the area of the Sundarban, together with the tiger population, is more or less stable over the last two decades, but two

hundred years ago the Sundarban was at its original extent which was double the size of the present Sundarban. At that time the Sundarban had stretched from Meghna river estuary up to Hooghly river estuary, covering an area of about 20,000 km^2. Notably, the present Sundarban is about 10,000 km^2, of which 60% lies in Bangladesh and the rest in the Indian state of West Bengal. Today, it sounds unbelievable to many people that Javan rhinoceros, wild water buffalo and swamp deer that have gone extinct from Bangladesh, had roamed in the Sundarban a hundred years ago. In 1908, the Bengal District Gazetteer mentions "…… the one-horned rhinoceros (Javan rhinoceros) has become rare and is only found within the southern portion of the reserved forests (Sundarban). Buffaloes are also fast disappearing and at present are only found in the waste lands of the Backergunge (Greater Barisal) of the Sundarban. Tigers and crocodiles, however, are still as numerous as ever. In the last hundred years the rhinoceros and buffaloes have gone extinct and the numerous tigers and crocodiles are now threatened with extinction. If we do not take strong conservation measures tigers and crocodiles might become history in the near future.

Based on remote camera-trapping, tiger track counts and prey abundance, I estimated that there are about two hundred tigers in the Bangladesh Sundarban along with another one hundred and fifty or so tigers in the Indian Sundarban, making the total one of the largest single populations of tigers on earth. With a total population of about 71,500, spotted deer is the commonest prey of the tiger in the Bangladesh Sundarban. Other prey species include wild boar, barking deer, rhesus macaque, Indian crested porcupine, lesser adjutant and other smaller animals. Other than in the Sundarban, we might have some tigers in the Chittagong Hill Tracts, particularly in Kassalong Reserved Forest and Sangu Wildlife Sanctuary, but these are vagrant tigers that do not form any stable population and often wander between Bangladesh, Myanmar and Northeast India. I have personally visited these remote areas of the Chittagong Hill Tracts and some local inhabitants of ethnic communities have told me their first-hand experiences of encounter with wild tigers in recent years. In the deciduous forests of the Madhupur Tract, the last tiger was seen by a local Garo in 1963. The last tiger of Greater Rangpur was hunted in

Banglabandha, Tetulia, in 1962. In Greater Sylhet, the last tiger was seen in Patharia Hill (Lathitila forest) in 2008. In Chittagong, the last tiger was hunted in Ramgarh in 1960.

It is clear that the tiger has lost 95 percent of its former range in Bangladesh, so the tiger population in the Sundarban is the last in Bangladesh that requires strong conservation action. But why do we care about the tiger? What difference would it make if we lose our last tigers? It is not that instead of the tiger we will just have to find another animal to declare our National Animal, but it will lead to an ecological, economic and cultural disaster. The tiger is an indicator of healthy environment and undisturbed natural forest. Since the tiger is at the apex of the food chain, absence of the tiger will lead to excessive growth of the prey population, which will lead to overgrazing (so there will be no regeneration of the forest) and malnutrition of the prey. Ultimately, the imbalance will lead to a disaster to the prey population and the forest. The number of foreign and local tourists who visit the Sundarban in the hope of seeing the tiger, or at least its pugmarks, and pay a large amount of revenue to the Government, will no longer be interested to visit if there is no tiger. Studies have proved that sheer presence of the tiger in a forest attracts a large number of tourists, no matter how many of them actually see a tiger. Not only that, the tiger is deeply rooted in our history and culture. Image of the tiger was found in the terracotta of two old temples in Madaripur (Razaram Roy's Temple, 17th century) and Rajshahi (Pancharatna Govinda Temple, 18th century). The tiger replica is worshipped by the Hindu people living around the Sundarban, and Muslims also respect the tiger due to its connection with Gazi and Kalu – the two mythical Muslim leaders of the region. We have the watermark of the tiger in our bank notes. Our cricket team uses the tiger in its logo and tiger stripes on the uniform. Above all, the tiger has its intrinsic right to survive, same as we do.

The biggest threat to tigers in the Sundarban is prey depletion due to poaching. Eighty percent of tiger diet is composed of only one species – the spotted deer. Hence, the future of the tiger depends on the status of the deer population. Deer poaching is common in the Sundarban, because it is relatively easy to poach (by using snares)

and there is a good demand of venison (deer meat) in the locality. Venison is more expensive than beef, mutton or chicken and it is treated as a delicacy. At least a few thousand deer are poached every year for meat and skin.

Tiger poaching incidence is rare, because it is difficult to locate and poach a tiger that is thinly distributed over the vast and inaccessible tract of the Sundarban. However, on an average, five tigers are killed every year by poachers or by angry villagers in and around the Bangladesh Sundarban. Tiger poaching takes place in rather opportunistic manner. Deer poachers sometimes bring liquid poison with them. If they find fresh tiger pugmarks, they kill the deer or wild boar trapped by them, pour the poison on it and leave it for tiger to eat and get poisoned and killed. If they find any half-eaten kill of the tiger they do the same. Later on, the poachers find the dead tiger to collect the skin, teeth and other body parts. Gun-traps are also used occasionally. In this case the poachers set a gun beside the tiger trail and a thread, with one end attached to the trigger for triggering and the other across the trail. The trigger is pulled by the tiger itself when it walks along the trail. Late Pochabdi Gazi, the well-known tiger hunter of the Sundarban who had hunted 57 tigers in his lifetime, had hunted most of the tigers by using gun-traps. He inherited the skill from his ancestors.

Stray tigers often visit the villages around the Sundarban and occasionally get killed by people. It is true that some of these stray tigers start killing cattle, but it has become a bad trend to kill the tiger whenever it is found in a village, whether or not it had attacked any cattle or people at all. The stray tigers, however, do not normally turn into man-killers. The man-killers live in the forest and deliberately kill people when they go to the Sundarban for fishing, woodcutting or honey hunting. On an average 27 people are killed every year in tiger attacks in the Bangladesh Sundarban. The rate is the highest of all the tiger range countries. Since there are more man-killing incidences in the western Sundarban, people of the west are more hostile towards the tiger than those in the east.

The last tiger habitat, i.e. the Sundarban, is rather inaccessible to people and the area is not suitable for permanent human settlement.

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That is why such a huge forest has remained unfragmented in a densely populated country like Bangladesh. The Sundarban, however, is threatened by the diversion of freshwater flow in the upstream, sea-level rise due to global warming, poaching of hard-wood trees (viz. *Sundari* and *Passur)*, and pollution from Mongla Port and from tourists.

Threats to tigers of the Sundarban can be eliminated or controlled by implementing the national laws and policies. Scientific research and monitoring are also necessary to ensure informed management of tigers, while public awareness and public participation in conservation and management is vital.

The highest density of the tiger was found in the southern Sundarban where the spotted deer density was higher and human disturbance was lower, therefore, poaching of spotted deer and human disturbance in other areas of the Sundarban must be better controlled in order to ensure the survival of the tiger.

Since the bulk of the tiger diet is the spotted deer, more emphasis should be given to the management of the spotted deer to maintain the tiger population. Scientific study of the wild boar population is further required to know the reason for its relatively low density, despite apparently suitable habitats being available, so that initiatives to increase the wild boar population can also be taken so that it can provide an alternative food source for tigers. Re-introduction of the wild buffalo (which became extinct in the Sundarban by 1925-1930) could also be considered to form an alternative prey population, but this would be very expensive and if the causes of extinction are not resolved, the re-introduction will not be successful. Introduction of domestic buffalo as a feral buffalo population, which already freely graze in the northern Sundarban for about six months and are probably already familiar to the tiger (since tigers sometimes prey on them), would be relatively cheap and easy.

Habitat diversity in the Sundarban should be maintained since it is crucial for the maintenance of some activities of the tiger and initiatives should be taken to increase the habitat diversity wherever possible. While mangrove woodlands and transitional areas are popular for tigers, so are other habitats especially grasslands. It was

observed that the grassland pockets in the southern Sundarban are good for the spotted deer, and so for the tiger. Therefore, sungrass cutting should be allowed, as otherwise the sungrass will die and the areas will be gradually encroached by woodlands and bushes, but the sungrass cutters should be allowed to stay and work in the Sundarban for only two to three months as a large number of sungrass cutters for a long period of time disturbs wildlife.

Since the breeding peak of tigers is probably in winter, this season should remain undisturbed but unfortunately, winter is also the main harvest and tourist season when the disturbance is more intense. Presently tourists can go anywhere in the Sundarban after taking an ordinary entry permit and paying revenue, but it is recommended that some tourist zones should be demarcated (which will exclude the important areas for tigers) and tourists should be allowed only in these areas, while controlled ecotourism should be developed so that both the Government and the local people benefit financially.

In order to reduce the conflict between tigers and humans, local people should be motivated and educated, alternative livelihoods should be made available (e.g. local ecotourism organisations, cottage industries, agroforestry, honey-bee rearing, etc.) and existing anti-poaching regulations should be implemented properly. In order to strengthen local support for conservation, compensation should also be given to the families of victims of tiger attack for the loss of their relatives, serious injuries and the loss of cattle to tigers but the compensation should be strictly controlled, so that there is no fraud.

In the Sundarban, local people should always work in groups, each individual should carry a big stick (mainly to show the tiger a 'weapon') and each group should keep a domestic dog on leash (so that it gives a signal to people when a tiger is around and people get some time to climb up a tree or get together). Dangerous professions like honey hunting (honey hunters are more vulnerable to man-eating tigers) should be allowed only under certain conditions so that the risk is minimised. Since winter is the main conflict season, work permits should be reduced in winter as much as possible.

Groups of trained dogs and handlers should patrol along the forest-village boundary so that tigers are discouraged to stray into

villages. The groups will also be able to drive the stray tigers from the village to the forest with a plenty of noise and light. This will teach the tiger not to stray into the village. Domestic dogs have smelling and hearing abilities that are much higher than in human beings. Therefore, if the dogs (must be leashed) are kept in frontline, the location of stray tiger will be correctly identified and if the tiger attacks, the dogs will be able to save humans. Notably, dogs are afraid of the tiger when they are alone, but when they are in groups and with their handlers they become very courageous. Additionally, some traditional practices can be helpful such as: fencing, watchposts with guards having fire-crackers and lights, and excavation/restoration of canals along the forest-village boundary (this will not stop the tiger, but will reduce the trespassing of cattle and people into the forest).

The forest department should strengthen its capacity (by recruiting people with proper training and motivation, and adding modern equipment and vehicles) and develop local intelligence networks to collect information to aid detection and prevention of poaching. Some community services like hospitals and schools should also be provided by the forest department in order to reduce the stress between the forest department and the local people, and more local people should be employed in the forest department and in the tourism industry so that the local community realises the benefits of conservation.

The tiger is legally protected under the Bangladesh Wildlife Act 1974 (2012), and the use and export of tiger parts is banned under the provisions of the Conservation on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (from 1982). Three Wildlife Sanctuaries of the Sundarban has been declared a UNESCO World Heritage Site in December 1997. The Government of Bangladesh has published the first Tiger Action Plan 2009-2017 with the vision to ensure protected tiger landscapes where wild tigers will thrive at optimum carrying capacities and which will continue to provide essential ecological services to mankind. This policy-level document will guide an integrated and focused tiger conservation programme.

Practical conservation of Sundarban tigers, however, still remains

undeveloped. The Sundarban is the only mangrove habitat in the world where wild tigers exist and this impenetrable swamp offers natural protection to healthy populations of tigers and their prey. Therefore, the Sundarban tiger population is one of the very few that may survive in the long-term, provided that threats are controlled and the natural processes of the ecosystem are allowed to function. Tiger is the icon of the natural heritage of Bangladesh. We simply cannot let it go extinct.

: M. Monirul H. Khan

Man Killing Tendency of Sundarban Tigers

Man Killing tendency is one of the major problems of tiger conservancy in the Sundarban, the country's only tiger land. The remaining thirteen countries in East, South and Southeast Asia still sustain tiger in their forests. But other than India and Sumatra of Indonesia, they are less prone to problem tigers. However, the Sundarban tigers, from both parts of Bangladesh and India, are responsible for killing or injuring a considerable number of people entering into the Sundarban for their livelihoods.

It has been a puzzle to tiger ecologists why these tigers are aggressive to humans. German biologist Hubert Hendrichs conducted a scientific expedition (in 1970 and 1971) to the Bangladesh Sundarban to uncover the mystery of behavioural patterns of tigers, especially

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focusing, on their man-killing tendency. Hendrichs suggested that Sundarban tigers drink saline water, which may cause considerable damage to their livers and ultimately trigger an unusual behaviour in the animals.

Hendrichs categorised the Sundarban tigers into four types. A-type tigers – shy of human intruders will leave the forest area if they sense human presence there. B-type tigers are circumstantial man killers and do not return to the kill. C-type tigers are opportunistic man killers, eat human flesh but mainly depend on natural preys. D-type tigers are compulsive man killers and grab every opportunity of securing a human victim. Hendrichs said that 30 percent of Sundarban tigers of B, C and D categories are responsible for human killing. I am not a scientist, nor a tiger ecologist, but I have been long associated with the Sundarban forest.

To check how far Hendrichs hypothesis is correct, I went to the forest department and paid a one-and-a-half-month visit to the mangrove forest. I selected Katka-Kachikhali sanctuary areas, where a lot of people live and tiger density is very high. Before reaching Katka area, I visited the northern border of Chandpai range where predatory tigers come out of the forest after dark into the adjacent human settlement and occasionally attack livestock.

Along the 22 km forest fringe, from different points, five tigers (two males and two females; and one female cub) prowled into the village. The male and female tigers were killed by the villagers inside the locality. When I visited the adjacent forest after the incidents, I found that the forest in that area did not have any natural prey for tigers.

Local hunters had set off the depletion of game animals, which was ultimately accomplished by the local villagers by introducing their livestock into the forest. It is easy for ungulates to change their territory, but tigers, very sensitive to their territory, jealously guard their turf area. So the tigers that stayed in their areas started preying upon the introduced livestock. As Sundarban tigers are small animals compared to their northern cousins, it became a difficult task for the local tigers to bring down an introduced buffalo, while they can kill a cow with ease.

The problem started a year prior to my visit. As tigers killed

two hundred heads of cattle including buffalos, villagers stopped introducing cows into the Sundarban. Cattle pens were built close to the forest fringe. A narrow muddy creek marks out the forest from villages, which was no big barrier to the tigers that can get close to the flimsy cow pens easily. So a natural game killing tiger took on a life of cattle lifter.

After my visit I came to know that some tigers had been killed by the villagers. A big tiger was wounded by bullet in its right forepaw which became a notorious man killer, setting a reign of terror for four years before being killed by a wood cutter who plunged the blade of his axe into the leaping tiger's skull. The tiger killed fifty-four people before being killed.

During my visit to the Katka-Kachikhali area, I found more than 1,000 fisherfolk built 120 huts to live along the western bank of Supati river. Along with them, 150 grass cutters worked on the meadows. Forest officials and fisherfolk said that other than one incident, this area was free from man-tiger conflict. A prowling tiger was surprised by a fisherman who came to fetch drinking water from the pond near the forest office at night. The animal mauled the man but did not kill him. The man survived with only scratch marks on his back. We have estimated that about six tigers live peacefully with forest dwellers and officials[1].

The area was densely populated with chital deer and pig population. These two species of animals constituted 90 percent of tigers' diet in the Sundarban. The remaining 10 percent came from fish, crustaceans, birds, monitor lizards, monkeys, snakes, lesser cats, turtles, and any dead animal the tigers could secure.

From the Katka-Kachikhali experience, it appeared to me that if the tigers get adequate prey species in their territory they do not consider humans to be their natural prey. But the forest quality of Katka-Kachikhali hardly represents the true terrain of the Sundarban. While the Katka-Kachikhali area is more of a grass land meadow where prey species can flourish easily, most of the other parts are densely wooded forests with thick undergrowth.

The forest floor is muddy and laden with breathing roots. Each

1 Editor's note: No fisherfolk or non-forest personnel are present in this area soon after this has been declared as a part of a sanctuary

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kilometer of it had been divided by rivers or creeks. Most of the land mass gets submerged by tide twice a day. Prey species are sparsely and unevenly distributed. Tigers live a hard life, especially in squaring prey and nursing cubs. Tigers of this area show aggressiveness toward man.

Hendrichs hypothesis seems paradoxical. It is true that most human killings occur in the western part and the frequency of occurrence is less in the eastern part, but it is not totally immune to killings, nor uncommon. So I started travelling the western areas. Forest offices in the western area used to keep record of human killings only of the permit holders. I reviewed them and talked to the different forest dwelling professionals and tiger victim families. I came to the following conclusions:

(a) It is not the rate of salinity in water but forest quality, especially vegetation quantity, that is responsible for making a game killing tiger into a human-killer.

(b) There are similarities in vegetation qualities in those areas where the emergence of fishermen is very frequent. In those areas, landmass is old, undergrowth is dense, prey species population is thin.

Some areas of the Sundarban have sustained frequent man killing tigers over the last 100 years. These areas are compartment Nos. 55, 20, 37, 38, 41, 42, 47, 50A, 51A and 52B. But the most sensitive areas are Atharobenki compartment Nos. 48, 49 and Talpatti compartment No. 55. There are also some areas in the forest where a human-killer emerges every ten years. These areas are Chandeswar, Dubla, Mara Pasur, Bhomorkhali, Hathdora, Khalishabunia, and Dobenki areas.

Although most of the man killing tigers are old animals but young animals acquiring man-killing habit is not uncommon. The sex ratio is mostly even, but the percentage of tigresses may be higher. Tigresses are opportunistic killers and active mostly after dark. They take a chance on individuals or a small group of forest dwellers. Male tigers are bold creatures and usually do not bother about the number of forest dwellers. They kill

people mainly in daytime and haul the victims long distances from the scene of hunting. But the most menacing creatures are young and inexperienced man-killers. They attack very frequently without any design; inside the forest or in open places they even jump on the passing boats. In most cases they fail to secure a victim but terrorise the area by injuring forest dwellers.

(e) A good percentage of human-killers are mangy: gum-infected, limb-injured, one-eyed and scabies- infected. But healthy and occasionally youthful animals also turn into human-killers.

(f) In choosing human preys, man-killing tigers do not care for the age, sex and physical condition of their victims.

(g) The vulnerability of the forest dwellers depends on the nature of their job. Honey collectors and goran woodcutters are more vulnerable to the tigers than others.

(h) Tiger attacks increase in January, when the salinity level in water is very high and the highest number of people enter the forest to fetch their livelihood.

(i) No human-killer can live only on human flesh. They have to prey upon natural prey to supplement their diet.

(j) If a tiger or tigress becomes a human-killer, it never enters the village in a predatory manner.

It is difficult to single out any particular cause of a game-killing tiger turning into a human-killer. There are several causes, the most acute may be the scarcity of substantial natural preys. Compared to other tiger-infested forests, the main prey species of Sundarban tigers (deer and pig) can be termed medium-sized, and they are not equally distributed across each territory. So the Sundarban tiger has to prey upon more animals than their cousins elsewhere and has to work harder.

Tigers from other countries are active only two to three hours a day. They spend the rest of the time sleeping and resting. But the Sundarban tigers have to be active five to six hours a day to secure a prey. When the animal becomes a human-killer it has to be active longer in daytime. Tigers are designed for work in dark hours. When a nocturnal creature has to adopt the habit of a diurnal creature, it

causes a serious trouble in its motor function. These animals are said to behave like 'drug addicts'.

A nursing tigress is sensitive to its nursery territory. If a group of unwary forest dwellers enters its nursery it will surely attack them. During the mating period, tigresses do not tolerate any creature around the mating areas. They do not tolerate forest felling as well.

Like humans, their temperament varies according to age, sex and physical condition. They are instinctive animals. In their domain, they are the supreme predators and fearless. Humans are the most defenseless and slow-footed animals. Tigers do not think much to add human flesh to their diet.

Sidr and a Mysterious Temple in the Forest

Night crept up on us with the stealthy feet of a tiger. And before we knew it, it was murky dark. An owlet hooted from one bank of the river and it was answred by another from the other side. A little later, a crescent moon appeared on the sky and cast a mesmerising glow on the forests around. The forest silhouetted against a dark sky and looked like a huge ancient animal breathing in deep slumber by the riverbank.

Soon the insects started buzzing around the hot filament of bulbs, like disoriented ideas in a head. It seemed the night was trying to suffocate us with a duvet of humidity, which stretched over the stooping treetops before touching the water. Our ship changed positions quite a few times and even crossed a whole channel in the

By **Inam Ahmed**

dark to blow some wind onto the deck.

We lay down against the cool steel of the deck, listening to the generators rumbling away continuously in the bowels of the ship. We switched off the ship's lights to enjoy the darkness. Now we knew night has its own brilliance as a zillion stars blinked back at us -- they were mingled with the forest in a secret intimacy. Like they shared stories every night.

The bright celestial pinheads reflected all around us in the rippling water. And the sky's face was occasionally streaked by a sudden shooting star, which glowed for a few evanescent seconds, carrying the wishes of so many people. The smell of the night mingled with the salty green smell of the river.

Ideas were exchanged and stories were swapped over steaming cups of tea on the deck. Siraj talked about the man-eating behavour of the Sundarban tigers. For some strange reasons, 90 percent of the man-eaters exist in the west Sundarban where we are now. He told us amazing stories of courageous men who had fought tigers barehanded and survived. He saw a man half of whose skull was crushed by the powerful punch of a tiger and yet he held the dislodged bone in place with his hand and swam a river to a rescue boat. The man survived but many of his senses have dimmed. All amazing stories. Then there was this man whose face the tiger tried to bite off. He survived by poking his fingers into the eyes of the tiger. The man recalls how his face was wet with the tiger's saliva.

As the darkness deepened, the heat subsided, and tiny drops of dew landed with their soft feet on our bodies. The cushions we were lying on got damp and started giving off a musty dank smell. It dawned on us like a surreal, Dali-ish dream – we were in the middle of nowhere, out of the clutches of network, and the grasps of the web. There were nocturnal beasts that lurked in the forests, just out of sight. Or maybe there were pirates, some way up the river, quite unlike anything we had seen in Pirates of the Caribbean.

We were lying there, spotting satellites and constellations, when we noticed the Milky Way, our own galaxy. It stretched like a very long and winding, misty road all across the sky, pressing close to the earth. It seemed we could just reach out and touch it. All this time, I had known Milky Way to be one single stretch of whitish

streak. But here, to my wonder, I discovered that it has two almost parallel stretches, one a little shorter. Then an aircraft crossed over the Sundarban from a great height and we watched its blinking lights until they vanished. We listened to the forest song as thousands of crickets chirped, chirped and fell silent as if to make us know the difference between absolute silence and the forest's own noise. We heard the night birds that flitted above. And then we fell asleep.

Morning brought a cooling relief as a cloud smudged the sky. But the humidity still hung in the air. As I climbed onto the deck for breakfast, the ship was already moving down the Shibshah River. Clusters of golpata-thatched huts came into view. Each of these clusters had a red flag flying from long bamboo poles a clear sign of distress, a sign of people in want of relief even after so many months of cycloe Alia lashing the coasts. People lined up by the bank waiting for any succour. We talked to some of them and they told us they needed shelter and food, but they needed water the most. We later learnt how terrible the situation was there with almost all ponds – the only sources of sweet water – spoiled by salt water. We visited some shelters at Angtihara where we were stranded for a long time because of engine trouble. These people were living almost an inhuman life. They had spread pieces of polythene sheets over their hut roofs and placed pitchers below. Then they used long wicks to channel rainwater all the way to the pitchers. That was all they had – rainwater – to survive. And if rain did not come – as it had not in the last few days – the situation turned desperate. They have to travel up to 25 miles on boats to bring water. These people were living a pale existence of poverty ravaged by a cyclone. All through the day the only relief operation we witnessed was two relief-laden launches run by Medicine Sans Frontier, the French organization. The Frenchmen sitting under the sun with lifejackets on waved at us. They could still smile in this heat.

We got stranded at Nalian Bazar with a broken engine before it was noon. We had our lunch and watched the launch terminal, the last point of the Sundarban which people can reach by a regular launch service. We watched the launches approach and moor by the pontoon. A few people got down and a few boarded; then the launch lazily beeped and went back towards Chalna where it came from.

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After lunch we lay on the front deck downstairs and did practically nothing. We just lazily watched the mechanics work on the engine, taking it apart bit by bit and putting in new spares. Someone took a boat to the shore and brought some horrible tasting biscuits which we ate with tea. And still the engine did not start. At last when we heard the rumble again, it was afternoon.

The ship moved fast now through the Shibshah because we wanted to reach Ada Chai forest office before dusk. The scene was changing from here already – the trees looking taller and greener and the forest even lonelier. We knew we were in deep forest now. Fishing boats were fewer and far between too.

An ominous black cloud gathered in the south and it slowly spread northward, like a giant squid, like a leaden heart over the magical emerald forest. The light changed: instead of the intense light that made everything look burned out with deep shadows, it was now a soft glow, a golden glow mixed with a strange green, almost translucent like some green amber. The mysterious forest looked glorious, almost smiling and still somehow sombre. The river was turning choppy. The rain came down first in drizzled and then in torrents obliterating everything from our sight. We could only make out the distant outlines of trees if we squinted hard. And they looked like washed away paints in monochrome water colours.

When we reached Ada Chai, the rain had stopped. And a piece of the sun had broken through the black cloud in its last effort to bid us goodbye. Our ship had slowed down and was moving at an idling speed. The river looked wide here, very wide indeed. There appeared a beautiful small patch of forest on an island just in the middle of the river. We circled it slowly and approached the blackish wooden structure on the shore of the Ada Chai forest office. Then we stopped and the anchor was dropped in the clanging of the running chain. We would spend the night here. Up along the right bank we could see the Shibsha channel where we would go tomorrow in the morning in search of the Temple Tiger the magical beast that stays there and dodges every eye. We felt a strange anticipation in our heart. We had come all the way to here in search of this majestic tiger; and would we find it? But for now, we decided to make a quick visit to the Ada Chai forest office. The engine boat was already throbbing for us to board.

We set off for the shore before it was too dark.

Chai forest station looked forlorn in this deep forest – an outstation with a pale existence. We walked down a long wooden pier that had developed gaping holes through its rotten wood planks. At the end of it was the wooden station its planks blackened by continuous rain. A damp, musty smell hung in the air. The lanterns could hardly beat the gloom of the gathering dusk as we entered the ramshackle station. The dampness enters your inside and you feel dizzy. I was taken aback by the unbelievably sorry living condition of the foresters.

What surprised me more was the backyard of the station. A long pier about ten feet above the ground ran to the toilets. And it was protected with tightly knit golpata partition all the way. The floor was also made with solid wood.

"The man-eaters," one of the foresters smiled. "This is a tiger infested area. Only a few days ago, a tiger visited our station. We don't want to get dragged away at night while going out to the toilet."

We took a short walk at the back of the station. Thick thorny hetal bush spread all the way to the keora forest.

"Don't walk any further," a forester warned. "The tiger often sleeps in this forest. We should not take risk at this hour."

We felt bad for these people who were living in constant fear of the big cats. And worst still, their life had turned bleaker by the lack of drinking water. The only fresh water pond had become unusable after Aila had dumped salt water into it. Tonight they were left with only a jug of water and if fresh rain did not come tonight they would be left without any.

It was getting late and we had to leave the station in a sullen mood, leaving the poor souls to fend for themselves. As our boat crossed the river to the ship, we could see Shibsha forest on our left where that mysterious temple sits tight amidst thick forest and where that even more mysterious tiger lives. Tomorrow we are going to look for it.

The day began with a heavily overcast sky. It rained the whole time last night and it was now drizzling. Breakfast was quick and then the ship set out along the Shibsha River. But at the entry to the Shibshah canal we had to anchor again. It was now low tide and we waited for the high tide so that we could enter the serpentine canals in an engine boat.

From there, I looked out to the deep forest lying ahead and wondered what a daunting task it was for Raja Protapadittya to set up a township here to fight the pirates some 450 years ago. Who were those brave men and women who came to this wilderness and tried in vain to make this place liveable? We were here to get inside that deep forest to have a look at the remnants of the temple that was built by the Pratapadittya settlers.

The tide turned soon and we took the engine boat to cross the choppy stretch of the river to enter the channel that twisted through the deep forest and gradually became narrower. We saw a huge white-bellied sea eagle slowly winging above us to the other side of the forest. What a majestic bird it was! We saw a honey buzzard and a grey-headed eagle too.

The journey was becoming mysterious now and we felt a kind of adrenaline rush thinking about the temple tiger. We were slowly rowing and a strange kind of silence had wrapped us tight. There were no songbirds singing. Only the crowing of an occasional red jungle fowl proved that it was not a dead forest.

Rows of golpata and hetal bushes frilled the blackish muddy banks. Beyond them stood the sundari and kewra and myriad other varieties in a tangle to form a dense forest. Reza Khan pointed out to the hetal fruits and said these are a variety of dates. They looked brilliant orange. Mudskippers and blue fiddler crabs crawled the banks among sharply pointed breathing shoots.

The canal had become so narrow here that the boatmen climbed down in the mud and pushed the boat as oars were of no use here. Khosru was looking intently ahead to locate the canal that would take us closest to the temple. The spiky hetal branches were brushing our faces and we had to be careful to save our eyes. It was drizzling again.

Suddenly Khosru signaled to stop. He was silently pointing to the bank. The pugmark was definitely imprinted a few minutes ago – a huge male tiger had jumped across the canal. The claw marks were sharp and fresh – the swampy mud had not blunted them yet. We silently watched the mark, a weird feeling descending upon us. We did not know whether the tiger was watching us from behind the bushes. What was he thinking?

From the boat we stepped right onto the bank and sank knee-

deep in the spongy mud. Very slowly we climbed up the steep slope and found ourselves into a hedo bush. Hedo is the ideal place for tigers in the Sundarban as the cats can use the reed like plants as mat to sleep on in the swamp forest.

"Everybody! Shout! Shout loudly!" Siraj yelled. "Not every forest is a good place to sight a tiger. Make noise as much as you can!" Siraj had seen some recent human victims of tiger attack and the memories were still fresh in his mind.

"Whaaaoooo," we hollered, almost in unison. And we started walking, trying to cross the hedo brushwood as quickly as possible. But however fast we tried, our progress was painfully slow. Every step saw us sinking deeper in the most sticky mud. And we almost lost balance with every step too. That posed a most perilous prospect as the sharp breathing shoots were everywhere around us in great numbers. One fall and at least ten of them would pierce you through.

But then there were two more dangers. Our shoes were getting stuck in the mud and we had to vigorously pull our legs to free them. This was really challenging. And then we had to first place our foot slowly and carefully to be sure that we were not stepping on any breathing shoots hidden in the mud.

Some of us were slowing down and Khosru shouted us to a halt.

"One guard in the front and the other in the rear," he ordered. "Everybody must be covered by the guards. No-one should fall behind!"

I very much doubted how much protection the two forest guards could provide in case of a tiger attack. Before they could aim their rifles, they would skid and roll over on the mud. But still they gave us a kind of mental protection -- by now a strange kind of fear had seeped into our mind and we did not want to meet this mysterious temple tiger any more.

Soon one by one we got rid of the shoes because with them on it was impossible to move any further. Barefooted, we were exposed to more danger though. Anytime a breathing shoot could nail through our soles. And a little later our situation was further jeopardised as Reza Khan dragged out a dog-faced water snake by its tail from the mud. Who knows how many of them are lying on our path. And I remembered Khosru warning us to be extremely careful at the temple

sight because it is teeming with cobras.

Thickets brushed against our faces and they stung like wasps. The drizzle, the danger, the crooked branches of the trees and the deep shadow of the forest created a ghoulish atmosphere. Suddenly Reza Khan stopped dead. He was the only guy still courting a boot.

"The tiger is close by," he whistled. "It is stalking us."

The words hit us like bullets and froze us for a moment. An icy wave trickled down my spine. We felt helpless in this terrible terrain. For the first time, I resented having come here. And I did not know whether I would have the energy left, if not life itself, to cross the same distance back. Worst of all, we had no idea how much path we had yet to cross to the temple.

"Shout louder!" Khosru ordered and we tried to best use our lungs. Someone suggested the guards shoot in the air. But the foresters looked unsure they have to explain to their officers for any bullet spent.

"It's useless," Ronald Haldar murmured beside me. "If it is a man-eater, no shouts can deter it."

"But we are twenty together. The tiger surely would not dare to attack such a large pack," I said hopingly.

"Ha! There you say," Ronald snorted. "I know of tiger attacks on bigger packs. Man-eaters are man-eaters."

We started walking faster now probably by the fear of the unseen tiger softly following us. And no-one wanted to be too far away from the guards. After sometime, I lost track of time. We were all walking mechanically like some haunted souls. Plop, plop, our feet rose and fell in the mud. I was no longer glancing at the reeds that almost sandwiched us from all sides. We just kept treading. In empty heads. In empty minds. And then finally came in view a bright brick structure through the bush.

Slowly the temple became clearer. It is about 30 feet high, a very old structure. The thin bricks had lost their sharpness of edge over the centuries. Plants had grown all over it, darkening its haunted look. There was an opening through which we tentatively stepped inside and held still for a few seconds. We did not want to be bitten by a cobra. Then as vision adjusted to the semi-darkness we panned our eyes around and then tilted up. It was a small place, about 350 square

feet. The ceiling had arched and showed some obscure designs. Some 450 years ago, people used to come here and place their offerings. Smell of incense would swirl in the air, mixing with the strange smell of the forest. The Sundarban would then become a magical existence. Some 450 years ago, these people – the kaguji or papermakers and molongi the salt producers – would find spirituality in the shadows of this temple.

Someone called out from outside and my spell was broken.

"Tiger marks!" a voice was heard.

Right beside the temple we saw the pugmarks of the temple tiger. So fresh that even the grasses were yet to lose their rumple. It looked like a tigress. Was the large canal-crossing male its mate? The tigress was probably resting on the high ground of the temple when its sleep was disturbed by our shouts. She got up and went down to see who the intruders were to enter her kingdom.

"We must get back fast," Khosru announced.

Headcounts were done and we lined up again -- one guard in the front, another in the rear. Then we plodded on through the mud, through the needles, through the same danger.

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: Inam Ahmed

Butterflies in the Sundarban

The Sundarban in Bangladesh is the largest mangrove forest in the world. It was given the status of 'World Heritage Site' by the World Heritage Committee of UNESCO in 1997. This mangrove structure is distinctive for its biodiversity which is characterized by a wide range of flora and fauna. The floristic composition includes trees, herbs, shrubs, climbers, grasses, algae, epiphytic ferns, and orchids. The faunal composition of the Sundarban consists of a variety of wild animals namely tigers, deer, wild fowls, wild boars, monkeys, otters, crocodiles, pythons and other varieties of snakes, lizards, birds, amphibians, mollusks and crabs. In addition, the Sundarban is rich in insects, including colorful butterflies.

By **Monwar Hossain**

Butterflies are the most beautiful and best-known of all the flying insects. This colorful insect is found ubiquitously in the world except for the continent of Antarctica. However, the highest number of butterflies lives in the tropical areas, including Bangladesh. The greatest economic importance of butterflies comes from their function as pollinators of plants and crops. They are used in food chains for other animals like birds, lizards, mammals, spiders, and other insects as well. The act of catching butterflies for trade is a big business today. Besides, butterflies are also used to study color vision as well as learning and memory. They are good indicators of environmental changes too. Their sensitivity to environmental changes makes them valuable indicators of people's health and the climate. From egg to adult, butterflies depend on various plants for their survival. Due to very host specificity they use only selective plants.

In the Sundarban, an abundance of butterfly is seen between March and June when plenty of flowers bloom. There are many trees which are considered to be typically honey-producing plants in this forest. Among these, *Goran* (*Ceriops decandra*), *Keora* (*Sonneratia apetala*), *Baen* (*Avicennia officinalis*), *Passur* (*Xylocarpus moluccensis*), *Kankra* (*Bruguiera gymnorrhiza*), *Genwa* (*Excoecaria agallocha*), and *Saila* (*Sonneratia caseolaris*) are remarkable. Besides, there are many herbs and shrubs which attract butterflies. These are *Khulsi* (*Aegiceras corniculatum*), *Hargoza* (*Acanthus illicifolius*), *Baoli lata* (*Sarcolobus globosus*), *Tylophora* (*Tylophora tenuis*) and *Wedelia* (*Wedelia biflora*). On the other hand, *Ipomoea* (*Ipomoea illustris*) which is a climber also attracts the butterflies living in this mangrove forest.

Most of the butterflies found in this mangrove forest are periodic visitors which come from the nearby places. They come here for nectar when flowers are in bloom and new twigs are found in the trees. They concentrate in the north-west and the northern parts of the mangrove forest. Butterflies like grassy land, especially the meadows that cover the wide areas from Katka to Kachikhali. They gather in the Sundarban just only to sip nectar. It is interesting to note that usually they do not breed here. A total number of 23 butterflies under 7 families, viz. Danaidae, Papilionidae, Pieridae, Nymphalidae, Lycaenidae, Hesperiidae and Satyridae are found in the Sundarban as shown in the table at the end of this article. Among them, only

4 species, viz. Sundarban crow, Common crow, White tiger, and Crimson rose, are found to be breeding inside the Sundarban.

The Sundarban crow (*Euploea crameri niceville*) is called *Sundarbaner kak* in Bangla; it belongs to the Danaidae family. In the whole world, this particular subspecies of butterfly is exclusively found in the Sundarban of Bangladesh, where it is a permanent resident. The male and female wing span of this butterfly is 85-95 mm. It performs leisurely flight. Though its larval food plants are not yet known it is likely to be the same as that of *Euploea* sp.

The common crow (*Euploea core*) is a common butterfly in the Sundarban. It has got tough and leathery wings; and its wingspan is 85-95 mm. It has easy flapping flight. It visits large variety of flowering plants in the forest. It has also got the habit of migrating from one place to another. It is due to the uptake of chemicals from the latex of the food plants like milkweed or fig plants, which is consumed in their caterpillar stage, that these butterflies become unpalatable to their predators.

The white tiger (*Danaus melanippus indicus*) is common in the Sundarban; it belongs to the Danaidae family. Its male and female wing span is 75-95 mm. Its flight is slow; however, it shows faster flight if disturbed. This butterfly is rather available at the scrub jungle.

The crimson rose (*Atrophaneura hector*) has got a red-bodied brilliantly coloured swallowtail; it is under the family Papilionidae. It usually flies up and basks at the top of the trees. Its wing span is 90-110 mm and has got white and red spots on its wings. It flies in a steady and straight-line manner. The male and female butterflies of this species are similar in this feature. This species has got the tendency of migrating from one place to another. It usually migrates during April and June from Sundarban to its neighboring areas. To complete a life cycle (egg to adult), it usually takes on an average 5-6 weeks. However, it very much depends on the weather. It breeds up to maximum of six times in a year. Its larval food plants are various species of Aristolochia.

Among the seven families mentioned above, the members of Pieridae are white, yellow or orange butterflies. Most of the members in this family are of medium size. Their flights are speedy and they fly usually unevenly amongst the plants in the mangrove forest. Their

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migration can be *seen* on a periodic basis. Nymphalids are brightly colored butterflies. They usually prefer nectar from flowers. However, some of them enjoy fermenting fruits, and even dung in the forest. They perform strong and fly fast and fly close to the ground. The members of Lycaenidae are seen in the new-accumulated sites of land where grasses grow. If people goes into the forest just along the river bank, they would find them fleeting about. The Hesperiids are small sized butterflies. They are called skipper because of their flying pattern, which is very rapid and of jerky style. Only one species has been recorded under this family in the Sundarban. These butterflies are mostly orange or brown color. The larval food plants are mainly grasses and palms. The members of Satyridae are dull brown butterflies and rather prefer shady areas. They prefer to sip rotten fruits. They usually fly at low elevation. Their larval food plants include grasses and palms. There are around 40 different types of grasses in the Sundarban. Among them, *Cyperus* sp., *Kyllinga* sp. *and Murdannia* sp. *are remarkable*.

Twenty three butterfly species in total have been recorded in the Sundarban. It appears that this list is not complete; more species of butterflies are yet to be discovered. Rigorous surveys are warranted to update the list of butterfly species in this mangrove forest. A butterfly depends on 3 types of plants, viz. resting plants, nectar plants, and larval host plants. A detailed survey of the plant species is also required to conserve this beautiful creature.

The 'Sundarban crow', a unique butterfly which is found only in the Sundarban, may become extinct soon because of the unavailability of larval host plants. Hence, necessary measures should immediately be taken to conserve the ecosystem of this mangrove forest.

Table 1. List of butterflies of the Sundarban

Sl. No.	Family	Common name	Scientific name
1	Danaidae	Common crow	*Euploea core*
2		Sundarban crow	*Euploea crameri nicevillei*
3		White tiger	*Danaus melanippus indicus*
4		Plain tiger	*Danaus chrysippus*
5		Striped tiger	*Danaus genutia*
6		Blue tiger	*Tirumala limniace*
7	Papilionidae	Common rose	*Pachliopta aristolochiae*
8		Crimson rose	*Pachliopta hector*
9		Lime butterfly	*Papilio demoleus*
10	Pieridae	Common grass yellow	*Eurema hecabe*
11		Common emigrant	*Catopsilia pomona*
12		Mottled emigrant	*Catopsilia pyranthe*
13		Common jezebel	*Delias eucharis*
14		Red spot jezebel	*Delias discombesi*
15	Nymphalidae	Grey pansy	*Junonia atlites*
16		Blue pansy	*Junonia orithya*
17		Peacock pansy	*Junonia almana*
18		Great eggfly	*Hypolimnas bolina*
19		Tree nymph	*Idea agamarschana*
20		Chestnut-streaked sailer	*Neptis jumbah*
21		Common leopard	*Phalanta phalantha*
22	Lycaenidae	Scarlet flash	*Rapala dieneces*
23		Common cerulean	*Jamides celeno*
24		Common pierrot	*Castalius rosimon*
25		Lesser grass blue	*Zizeeria otis*
26	Hesperiidae	Common banded awl	*Hasora chromus*
27	Satyridae	Common evening brown	*Melanitis leda*
28		Common palmfly	*Elymnias hypermnestra*
29		Dark-branded bushbrown	*Mycalesis mineus*
30		Common fourring	*Ypthima huebneri*

: Monwar Hossain

Invertebrates and their Ecosystem Services in Bangladesh Sundarban

An invertebrate is an animal that has no vertebral column or backbone to support its body.The invertebrates are the most diverse and important group of animals on our planet. Humans as well as all the vertebrates, animals having vertebral column or backbone, could rarely survive without invertebrates. But unfortunately, they are neglected in large part in the formulation of policies concerning conservation studies especially in Bangladesh. This statement is also true for the Bangladesh part of Sundarban, a treasured UNESCO World Heritage Site. Roles of invertebrates in this mangrove forest have never been considered seriously and as a result, our knowledge of this group of animals is poor. Accordingly, efforts are made to review the invertebrate diversity and their ecosystem services in Bangladesh

By **Bidhan Chandra Das**

part of the Sundarban. Altogether 358 invertebrate species under 271 genera of 131 families belonging to four Phyla, viz. Rotifera, Mollusca, Annelida and Arthropoda have so far been reported from Bangladesh part of Sundarban. Ecosystem services provided by some groups of invertebrates, viz. shrimps, crabs, mollusks and insects are also reviewed. Local people think that the ecosystem services provided by different groups of invertebrates in the Sundarban has decreased. The necessity of research works on invertebrates in the Bangladesh part of the Sundarban is discussed.

1. Introduction

Invertebrates are important components of the ecosystem (Ormerod *et al*., 2009; Graça, 2001; Kellert, 1993) and eclipse all other forms of life on Earth, not only in sheer numbers, diversity, and biomass, but also in their importance to functioning ecosystems (Black *et al*., 2001). They are the primary driving force in ecosystems function, and from the perspective of biodiversity, invertebrates make up 99% of animal species (Lunney, 1992). In ecosystem food chains, they constitute prey for higher trophic levels and acting also as herbivores, predators, and parasitoids (Jokimäki, 1998). Invertebrates participate actively in the interactions that develop in soil among physical, chemical and biological processes (Lavelle *et al*., 2006). Although invertebrates are vitally important, they are often overlooked (Black *et al*., 2001) and ignored (Lavelle *et al*., 2006). Invertebrates play important roles to wetlands biodiversity, food webs, and nutrient cycling (Batzer *et al*., 1999, Keiper *et al*., 2002) and they colonise newly constructed aquatic habitats quickly (Keiper and Walton, 2002; Wissinger *et al*., 2001). However, in spite of their great importance, until recently they have been very poorly studied, evaluated and understood especially in the mangrove forest of Bangladesh. Accordingly, an effort is made in this paper to evaluate them in relation to their diversity and ecosystem services in the Sundarban.

1.1. Mangrove Invertebrates

Mangrove invertebrates have traditionally been regarded as taxonomically diverse and numerically abundant (EPA, 2001; Wells,

1983). The complex matrices of mangrove result in very high habitat heterogeneity in the mangrove ecosystems (Brij and Chauhan, 2006). They typically demonstrate vertical and horizontal zonation within mangrove forest. Mangrove invertebrates are classified into four general trophic groups (Odum *et al*., 1982): (1) direct grazers such as insects and mangrove tree crabs; (2) filter feeders such as sessile invertebrates, which feed on phytoplankton and detritus; (3) deposit feeders such as mobile invertebrates that consume detritus, algae, and small organisms from the sediment surface; and (4) carnivores such as highly mobile invertebrates that feed upon all the other group.

1.2. Diversity

In spite of immense importance of invertebrates, unfortunately our knowledge of this group in the Sundarban, especially in the Bangladesh part, is very poor. Serious efforts to explore invertebrate fauna of the Sundarban have not yet been made. As a result it is really difficult to prepare any consolidated account of invertebrates for this part of the Sundarban.

The present account of invertebrates from Bangladesh part of Sundarban (Table 1) is prepared on the basis of insufficient information (Biswas and Raychaudhuri, 2012; Hossain, 2012; Magny *et al*., 2011; Baksha, 2008; Bernacsek *et al*., 2001; Biswas, 1997; Ahmed, 1990; Jahan *et al*., 1990, 1998; Chowdhury, 1995) and personal communications with relevant biologists. However, data on collection and observations from a series of field research trips by the present author are also included here.

Table1: Invertebrates of Bangladesh Sundarban

Phylum: Rotifera			Family	Genus	Species
	Class: Eurotatoria				
		Order: Ploima	4	6	6
		Order: Flosculariaceae	1	1	1
Total			5	7	7
Phylum: Mollusca					
	Class: Polyplacophora				
		Order: Neoloricata	1	1	1
	Class: Gastropoda		0	0	0
		Order: Neritopsina	1	3	9
		Order: Neotaenioglossa	6	8	11

Phylum: Rotifera		Family	Genus	Species
	Order: Neogastropoda	7	8	9
	Order: Archaeopulmonata	1	2	2
	Order: Architaenioglossa	1	1	1
	Order: Basommatophora	1	1	1
	Order: ystellommatophora	1	1	2
	Order: Archaeogastropoda	1	1	1
Class: Bivalvia		0	0	0
	Order: Myoida	3	4	4
	Order: Ostreoida	3	4	5
	Order: Unionoida	1	1	1
	Order: Mytiloida	1	3	3
	Order: Veneroida	6	8	9
	Order: Arcoida	1	1	1
Class: Cephalopoda		0	0	0
	Order: Sepiida	1	1	1
	Order: Teuthida	1	2	2
	Order: Nautilida	1	1	1
Total		38	51	64
Phylum: Annelida				
Class: Oligochaeta				
	Order: Opisthopora	1	2	2
Class: Polychaeta				
	Order: Aciculata	5	9	13
	Order: Canalipalpata	2	2	2
Total		8	13	17
Phylum: Arthropoda				
Class: Arachnida				
	Order: Araneae	3	4	6
Class: Merostomata		0	0	0
	Order: Xiphosura	1	1	1
Class: Malacostraca		0	0	0
	Order: Decapoda	10	17	30
	Order: Stomatopoda	1	1	1
Class: Branchiopoda		0	0	0
	Order: Diplostraca	1	3	5
Class: Maxillopoda		0	0	0
	Order: Cyclopoida	1	3	3
Class: Ostracoda		0	0	0
	Order: Podocopida	1	1	1
Class: Insecta		0	0	0
	Order: Odonata	3	10	14
	Order: Orthoptera	2	8	10
	Order: Isoptera	1	4	4

Phylum: Rotifera		Family	Genus	Species
	Order: Thysanoptera	1	1	1
	Order: Hemiptera	7	8	8
	Order: Coleoptera	13	61	88
	Order: Hymenoptera	4	6	8
	Order: Lepidoptera	26	65	81
	Order: Diptera	5	7	9
Total		80	200	270
Grand Total		131	271	358

Table 2. Invertebrates of Indian Sundarban (Brij and Chauhan, 2006)

Phylum	Class	Number of Species
Porifera		1
Cnidaria		33
Ctenophora		2
Platyhelminthes		41
	Turbellaria	1
	Monogenera	21
	Trematoda	13
	Cestoda	6
Nemathelminthes		68
Acanthocephala		3
Nemertinea		2
Rotifera		4
Mollusca		143
Sipuncula		2
Echiura		3
Annelida		78
	Polychaeta	69
	Oligochaeta	6
	Hirudinea	3
Arthropoda		476
	Crustacea	240
	Insecta	201
	Merostomata	2
Entoprocta		1
Bryozoa		3
Brachiopoda		1
Chaetognatha		4
Echinodermata		20
Grand Total		885

: Bidhan Chandra Das

So far only 358 invertebrate species under 271 genera of 131 families under four Phyla, viz. Rotifera, Mollusca, Annelida and Arthropoda have been reported from Bangladesh part of Sundarban (Table 1). However, from the Indian part of the Sundarban, altogether 885 invertebrate species under 18 Phyla, viz. Porifera, Cnidaria, Ctenophora, Platyhelminthes, Nemathelminthes, Acanthocephala, Nemertinea, Rotifera, Mollusca, Sipuncula, Echiura, Annelida, Arthropoda, Entoprocta, Bryozoa, Brachiopoda, Chaetognatha and Echinodermata are recorded (Table 2). This statistics is surprising since area of Bangladesh Sundarban (599,330 ha) is higher than that of Indian Sundarban (426,300 ha).

It is generally considered that the species composition of Indian and Bangladesh Sundarban are more or less similar, however; variation in salinity concentration as well as freshwater flow from west to east influence the distribution of biota (Gopal and Chauhan, 2006). Moreover, anthropogenic activities and management procedures are not the same in Indian and Bangladesh Sundarban. As a result diversity, abundance and distribution of biodiversity are likely to differ between the countries. For example, the Bangladesh Sundarban is dominated by Genwa (*Excoecaria agallocha*) and Sundori (*Heritiera fomes*), whereas the Indian side is dominated by *Genwa* and *Goran* (*Ceriops decandra*) (Gopal and Chauhan 2006; Iftekhar 2008). Bangladesh part of the Sundarban is still managed as a continuous block of mangrove forests with no human habitation inside, whereas out of 102 islands in the Indian part of the Sundarban, 54 are inhabited by 2.5 million people according to 1981 census (Rahman, 2003).

2. Ecosystem services

Ecosystem services are the set of ecological functions that are critical for human survival (Daily *et al.*, 2000) or, in other words, these are the benefits that people obtain from ecosystems (MA, 2003). The role of invertebrates as ecosystem service providers in the Sundarban has not yet been investigated. In fact, they are badly neglected in terms of exploration and evaluation. Ecosystem services of invertebrates in the Sundarban can be discussed under the following headings:

2.1. Provisioning Services – Produce goods

A number of groups of invertebrates can be recognized as very important sources of human food and minor forest produce, viz. beeswax and limes in the Sundarban.

2.1.1. Food

2.1.1.1 Shrimp/Prawn

Shrimp/prawn (many people use the words shrimp and prawn interchangeably) is one of the important groups of invertebrate that has high nutrition and is preferred by people throughout the world. For this reason it is commercially a very important group of invertebrates in the Sundarban. About 300 metric tons of shrimps/ prawns are harvested from the Sundarban each year (Banik, 2004). *Penaeus monodon* ***Fabricius***, the giant tiger shrimp is the most widely cultured shrimp species in the coastal region of Bangladesh, whose fries till early nineties of the last century used to come from the Sundarban. Today, quite a large number of inhabitants along the border lines of the Sundarban carry out their livelihoods by catching and selling fries of this shrimp.

However, nowadays shrimps harvesting from the Sundarban (especially tiger shrimp) has declined and fry catching is confined along the rivers outside the boundary of the Sundarban.

According to Holthuis (1980), the shrimps include about 2,500 species, of which less than 300 species are of economic interest throughout the world. However, in the Sundarban altogether 23 species of shrimps under 10 genera and 6 families are found. These are: Penaeidae [*Penaeus monodon* Fabricius; *Fenneropenaeus indicus* H. Milne Edwards; *Penaeus indicus* H. Milne Edwards; *F. merguiensis* De Man; *Penaeus merguiensis* De Man; *Metapenaeus affinis* H. Milne Edwards; *M. brevicornis* H. Milne Edwards; *M. lysianassa* De Man; *M. monoceros* Fabricius; *M. spinulatus* Kubo; *Parapenaeopsis hardwickii* Miers; *P. sculptilis* Heller; *P. stylifera* H. Milne Edwards; *P. uncta* Alcock; Solenoceridae [*Solenocera crassicornis* H. Milne Edwards]; Sergestidae [*Acetes indicus* H. Milne Edwards]; Squillidae [*Oratosquillina perpensa* Kemp]; Palaemonidae [*Exopalaemon styliferus* H. Milne-Edwards; *Macrobrachium birmanicum* Schenkel; *M. lamarrei* H. Milne-Edwards; *M. mirabile* Kemp; *M. rosenbergii* De Man; *M. rude* Heller and *M.*

villosimanus Tiwari] and Alpheidae [*Alpheus euphrosyne* De Man].

Shrimp species other than *P. monodon* in the Sundarban are also important both commercially and local consumption.

Table 3. Number of tiger shrimp fries caught from the Sundarban (1999-2000 to 2011- 2012; Source: Forest Department, Khulna Circle, Bangladesh).

Financial Year	Quantity (number)
1999-2000	–
2000-2001	–
2001-2002	3436940
2002-2003	9828200
2003-2004	54900
2004-2005	–
2005-2006	–
2006-2007	–
2007-2008	569560
2008-2009	1175020
2009-2010	434200
2010-2011	73200
2011-2012	–

2.1.1.2 Crab

Crabs are another important fisheries item in the Sundarban. A lot of people catch crabs using various types of traps in Sundarban. Banik (2004) reported that 312 tons of crabs are harvested from the Sundarban each year. *Scylla serrata* (Forskål), is the most important species of crab in Sundarban, which has high commercial value. Many people along the border side of Sundarban fattening this species collecting young crabs from Sundarban.

Altogether 12 species of crabs under 10 genera and 5 families are found in the Sundarban. These are:

Grapsidae [*Episesarma mederi* Edwards; *Varuna litterata* Fabricius; *Metaplax crenulata* Gerstaecker; *M. elegans* De Man], Limulidae [*Carcinoscorpius rotundicauda* Latreille], Matutidae [*Matuta victor* Fabricius], Ocypodidae [*Gelasimus annulipes* Latreille, *Macrophthalmus brevis* Herbst; *Uca dussumieri* Milne Edwards; *U. forcipata* Adams & White; Portunidae [*Scylla serrata* Forskål; *Portunus sanguinolentus* Herbst].

According to the local people, crab populations have decreased in the Sundarban.

Table 4. Amount of crabs caught from the Sundarban (1999-2000 to 2011- 2012; Source: Forest Department, Khulna Circle, Bangladesh).

Financial Year	Quantity (Metric Ton)
1999-2000	–
2000-2001	–
2001-2002	364.20
2002-2003	1384.0
2003-2004	2144.0
2004-2005	2924.0
2005-2006	2998.0
2006-2007	2135.0
2007-2008	4014.84
2008-2009	3625.19
2009-2010	15397.37
2010-2011	3106.93
2011-2012	1301.56

2.1.1.3 Mollusk

The Munda people along the borderline of the Sundarban eat shellfish. Head, foot, mantle and columellar muscle of the shellfish are consumed by them. *Telescopium telescopium* (L.) is a popular food among the Munda people and approximately 386.45 metric ton of meat of this snail collected from the Sundarban are consumed by them (Zaman, 2011).

Molluscan meat is also used as the food for prawn and crab, poultry and catfish, crab and as fishing baits. Shells are used in poultry and fish feeding, construction materials, ornamental and show peaces (Zaman, 2011).

Cattle fish and squids [Sepiidae (*Sepia* sp.), Loliginidae (*Loliolus hardwickei)* Gray, and Brachioteuthidae (*Brachioteuthis* sp.)] are also found in the Sundarban. However, they are not eaten by the local people, although they have demand in overseas sea food markets.

Processed shell lime is used for human consumption along with betel leaf.

2.1.1.4 Honey producing Insects – *Apis dorsata* Fabricius, *A. cerana* Fabricius and *A. florea* Fabricius produce honey in the Sundarban, however; honey is collected only from the comb of A. dorsata. The people, who collect/harvest honey from the Sundarban, are locally called 'Mowali'. They usually collect honey from mid

March to mid June. However, it is conjectured that the quantity of honey production has decreased in the Sundarban, which suggests that abundance and distribution of A. dorsata has also declined.

Table 5. Quantity of honey harvested from Sundarban (1999-2000 to 2011- 2012; Source: Forest Department, Khulna Circle, Bangladesh).

Financial Year	Quantity (Metric Ton)
1999-2000	555.20
2000-2001	346.50
2001-2002	234.10
2002-2003	279.60
2003-2004	337.80
2004-2005	396.20
2005-2006	321.80
2006-2007	599.40
2007-2008	374.00
2008-2009	304.22
2009-2010	175.65
2010-2011	361.50
2011-2012	165.45

2.1.2. Non-food Items

2.1.2.1. Shell lime

For lime production, molluscan shells are traditionally collected from the Sundarban. Mainly nine molluscan species, viz. *Telescopium telescopium* (L.), *Crassostrea madrasensis* (Preston), *Meretrix meretrix* (L.), *Cerithidea cingulata* (Gmelin), *C. obtusa* (Lamarck), *Pugilina cochlidium* (L.), Polymesoda bengalensis (Lamarck), *Neritina* sp. and *Anadara* sp. of Sundarban are used in lime production. Lime is prepared by the local people following indigenous method by heating them to high temperature. Shell collectors and lime producers are locally known as *Jongrakhota* and *Chunary* respectively (Zaman, 2011). Other than human consumption, shell lime is used for water purification, calcimining, curing materials, and masonry works. However, *Jongrakhota* and *Chunary* people think that the abundance and distribution of different types of mollusks are declining in the Sundarban.

In Sundarban, there are as many as 60 species of mollusks including snails, oysters, mussels and clams under 44 genera of 33 families from which lime can be produced. Nonetheless, local people

think that most of these, except the above-mentioned nine species, are not commercially viable. These species are as follows:

Anomiidae [*Enigmonia aenigmatica* Holten]; Arcidae [*Anadara* sp.]; Babyloniidae [*Babylonia spirata* Linnaeus]; Bursidae [*Bufonaria rana* Linnaeus]; Cassidae [*Phalium granulatum* Born, 1778]; Corbiculidae [*Polymesoda bengalensis* Lamarck]; Costellariidae [*Zierliana* sp.]; Donacidae, *Donax* sp.; Ellobiidae [*Cassidula aurisfellis* Bruguière, *C. nucleus* Gmelin; *C. multiplicata* Von Martens; *Ellobium gangetica* Benson; *Pythia plicata* Férussac]; Fasciolariidae [*Latrius* sp.]; Littorinidae [*Littoraria melanostoma* Gray; *L. scabra* Linnaeus]; Mactridae [*Spisula solidissima* Dillwyn]; Melongenidae [*Pugilina cochlidium* Linnaeus; Muricidae [*Cymia lacera* Born, *C. tissoti Thais blanfordi* Melvill]; Myidae [*Sphenia* sp.]; Mytilidae [*Perna viridis* Linnaeus; *Modiolus striatulus* Hanley; *Brachiodontes* sp.]; Nacellidae [*Cellana radiate* Born]; Nassariidae [*Nassarius nodiferus* Powys; *Nassarius* sp.]; Naticidae [*Polinices didyma* Roding]; Nautilidae [*Nautilus pompilius* Linnaeus]; Neritidae; *Nerita articulata* Gould; *N. balteata* Reeve; *N. fulgurans* Gmelin; *N. polita* Linnaeus; *Neritina cornucopia* Benson; *N. smithi* Wood; *N. violacca* Gmelim; *Neritina* sp.; Onchidiidae [*Onchidium tigrinum* Stoliczka; *O. Tenerum* Stoliczka]; Ostreidae [*Crassostrea belcheri* Sowerby; *C. Gryphoides* Schlotheim; *Crassostrea madrasensis* Preston; *Dendostrea folium* Linnaeus]; Pectinidae [*Pecten* sp.]; Pholadidae [*Pholas* sp.]; Planorbidae [*Indoplanorbis exustus* Deshayes]; Potamididae [*Cerithidea alata* Philippi; *C. cingulata* Gmelim; *C. obtusa* Lamarck; *Telescopium telescopium* Linnaeus]; Psammobiidae [*Gari* sp.]; Tellinidae [*Macoma birmanica* Philippi]; Thiaridae [*Thiara tuberculata* Mueller]; Unionidae [*Lamellidens marginalis* Lamarck]; Veneridae [*Bassina calophylla* Philippi; *Meretrix meretrix* Linnaeus; *Marcia opima* Gmelin; *Periglypta* sp.]; Viviparidae [*Bellamya bengalensis* Lamarck]

Table 6. Quantity of snails caught from Sundarban (1999-2000 to 2011- 2012; Source: Forest Department, Khulna Circle, Bangladesh).

Financial Year	Quantity (Metric Ton)
1999-2000	6089.80
2000-2001	6007.90
2001-2002	3250.30
2002-2003	774.60
2003-2004	1531.00

Financial Year	Quantity (Metric Ton)
2004-2005	2362.90
2005-2006	3230.30
2006-2007	203.60
2007-2008	134.60
2008-2009	01.10
2009-2010	00.30
2010-2011	1028.90
2011-2012	1036.58

2.1.2.2. Beeswax

Beeswax is a natural ***wax*** produced by the bees. In the Sundarban beeswax are also harvested during the honey collecting by the '*Mowali*'. Although *Apis dorsata* Fabricius, *A. cerana* Fabricius and *A. florea* Fabricius make combs in the Sundarban, however; beeswax is collected mainly from the comb of A. dorsata since other two species are not commercially viable.

Table 7. Quantity of beeswax harvested from Sundarban (1999-2000 to 2011- 2012; Source: Forest Department, Khulna Circle, Bangladesh).

Financial Year	Quantity (Metric Ton)
1999-2000	138.90
2000-2001	86.60
2001-2002	61.90
2002-2003	64.20
2003-2004	84.44
2004-2005	98.92
2005-2006	80.00
2006-2007	141.50
2007-2008	93.51
2008-2009	68.02
2009-2010	69.69
2010-2011	81.29
2011-2012	41.74

2.2. Regulating Services – Eliminate climate regulation

2.2.1. Pollination

Insects play an important role in pollination biology of the Sundarban. Honeybees regularly visit and pollinate different mangrove species in the Sundarban. Generally, honeybees produce honey by gathering nectar from flowers of *Avicennia*, *Ceriops* and *Sonneratia* in the Sundarban that has high commercial value.

Information on pollinating insects in Sundarban is almost nil except for these three honeybees. However, the present author observed other insects as flower visitors under the Orders, Lepidoptera, Hymenoptera, Diptera and Coleoptera during his repeated research tours in the Sundarban.

2.2.2. Pest and disease control

Information on invertebrates, which act as predators, parasites or parasitoids is really nil for Sundarban mangrove forest. Anyway, there could be a good number of invertebrate species that regulate other species in the Sundarban. For example, 14 odonate species recorded from the Sundarban act as predators since all members under this order are carnivorous throughout their life, mostly feeding on smaller insects and crustacean larvae and thus regulate other animals' numbers. The odonate species are: Coenagrionidae – *Ceriagrion cerinorubellum* Brauer; *Ceriagrion coromandelianum* Fabricius; *Pseudagrion decorum* Rambur; *Ischnura aurora aurora* Brauer; *Onychargia atrocyana* Selys;

Libellulidae – *Brachythemis contaminata* Fabricius; *Brachydiplax sobrina* Rambur; *Crocothemis servilia servilia* Drury: *Diplacodes trivialis* Rambur; *Neurothemis tullia tullia* Drury; *Orthetrum sabina sabina* Drury; *Pantala flavescens* Fabricius; *Tramea virginia* Rambur; *Tholymis tillarga* Fabricius; *Rhyothemis variegata variegata* Linnaeus; and *Urothemis signata signata* Rambur.

Fireflies (Coleoptera- Lampyridae) population is high in the Sundarban and their larvae are carnivorous, living off smaller insects, snails and slugs. Ants (Formicidae: Hymenoptera) are also important predators in the Sundarban forest. In fact, a wide range of predatory and parasitic insects with diverse hosts and habits occur in mangrove habitats. These include predatory larvae and adult insects, which prey on other organisms, parasitoids that feed within a single host and eventually kill it, hyperparasitoids that parasitize parasitoids, and blood-sucking parasites of vertebrates. They can be found throughout the mangroves, from the soil to the water surface and on mangrove plants, where they exert a restraining influence on populations of herbivorous and saprophagous organisms (Nagelkerken *et al*., 2008).

Other invertebrates especially members under the Phyla Platyhelminthes, Nemathelminthes and Arthropoda in the Sundarban also act as parasites or parasitoids or predators of other animals. But

unfortunately no work has yet been carried out in the Sundarban to explore these facts.

2.3. Supporting Services

2.3.1 Nutrient cycle and decomposition

The nutrient cycle of the Sundarban is mainly dependent on the invertebrates and leaf litters. Invertebrates play an important role in running the nutrient cycle in a balanced way in the Sundarban. Crabs and other invertebrates can modify the mangrove sediment have the potential to mediate mangrove vegetation structure and productivity (Ashton *et al.*, 2003). Crabs influence mangrove community dynamics by facilitating the conversion of organic nitrogen to ammonia (Alongi *et al.*, 1992), helping decomposition of organic matter (Robertson and Daniel, 1989; Micheli *et al.*, 1991; Lee, 1998), grazing on leaf material (Onuf *et al.*, 1977; Beever, 1979), aerating anoxic soils through burrowing (Smith *et al.*, 1991) and altering soil microtopography by producing mounds (Warren and Underwood, 1986; Minchinton, 2001). Moreover, predation of propagules and seeds by crabs can be highly important in controlling recruitment (Smith, 1987; Allen *et al.*, 2003). That is why crabs are called ecosystem engineers. However, the foundation for the idea of crabs as ecosystem engineers had just been laid when other invertebrate taxa, such as mollusks and insects, went on the stage much earlier (Cannicci *et al.*, 2008).

2.4. Cultural services

Invertebrates have great values in relation to aesthetic, recreational and ritual aspects. Honey is an essential item for worship of Hindu Community. Some molluscan shells are used in marriage and funeral events and also for worship in Hindu Community. Butterflies and coloured beetles give pleasure to the tourists of the Sundarban. In the dark night, the present author and his research team members were amazed several times by the beautiful light from millions of fireflies (Coleoptera- Lampyridae) in the Sundarban. Some molluscan shells and insects are used as decorative pieces. Shells are also used as ornaments. Diverse invertebrates in the Sundarban have also educational value.

3. Conclusion

Biodiversity related activities in the Sundarban as well as in Bangladesh are mainly centred on charismatic animals, e.g. tigers, monkeys, deer, snakes, frogs, crocodiles, birds, dolphins, fishes, etc. Non-charismatic or invertebrates animals viz. sponges, jellyfishes, helminths, earthworms, rotifers, insects, arachnids, molluscs, echinoderms, etc., are badly neglected in Bangladesh, as if they have no importance to the ecosystem. Statistics show that these neglected groups represent 77.19% of total explored organisms of the world followed by higher plants (14.49%), whereas the so called charismatic group of animals represent only 3.26%, almost close to fungi (2.91%). Most of the researchers, activists and media workers in Bangladesh are interested in this minor group (3.26%) of animals (charismatic). Almost 99% of funding goes to this minor group related works. As a result we do not have any idea regarding the exact animal diversity and their status in the Sundarban as well as in Bangladesh. Local people think that ecosystem services provided by the different groups of invertebrates in the Sundarban are decreasing. Moreover, we do not have any national collection of voucher specimens of our recorded animals. Many authorities (!) in Bangladesh have published animal names from time to time, whose authentication or their further study cannot be done due to this problem. We have to be careful about the consequences of this as McGuinness (2001) mentioned it clearly, "Invertebrates are extremely important components of the world's biota. They help maintain ecosystem functions through activities such as the cycling of nutrients, breaking down of pollutants, and production of soil. They are an important source of food for many animals and may also constitute a source of food for humans. Invertebrates are also vital to the fertilisation of a vast number of plants. In short, without invertebrates, much of the life on earth today would cease to exist…."

Accordingly, we have to do much research on these neglected groups of animals and funding opportunity should also be increased by the authorities towards these groups. In this connection establishment of a National Biodiversity Research Centre/Natural History Museum in Bangladesh is a crying need of the day. If we really mean to conserve

our natural resources, we must change our attitudes of neglecting small and minute animals, i.e. invertebrates that constitute the lion's share and integral part of the biota.

REFERENCES

Ahmed, A.T.A. 1990. *Studies on the identity and abundance of molluscan fauna of the Bay of Bengal*. Final Report, Contact Research Project, BARC: 1-85.

Allen, J.A., Krauss, K.W. and Hauff, R.D. 2003. *Factors limiting the intertidal distribution of the mangrove species Xylocarpus granatum*. Oecologia, 135: 110–121.

Alongi, D.M., Boto, K.G. and Robertson, A.I. 1992. *Nitrogen and phosphorus cycles. In: Tropical Mangrove Ecosystems* (eds. Robertson, A.I. and Alongi, D.M.), pp. 251–292. Coastal and Estuarine Studies 41, American Geophysical Union, Washington, D.C.

Ashton, E.C., Macintosh, D.J. and Hogartht, P.J. 2003. *A baseline study of the diversity and community ecology of crab and molluscan macrofauna in the Sematan mangrove forest*, Sarawak, Malaysia. Journal of Tropical Ecology, 19:127-142

Baksha, M.W. 2008. Insect pest of forest of Bangladesh. Bangladesh Forest Research Institute: 1-131.

Banik, H. 2004. *Bangladesher Sundarban (Bengali)*. Situtuni Book House, Comilla, Bangladesh. 1-300.

Batzer, D. P. and V. H. Resh. 1992. *Macroinvertebrates of a California seasonal wetland and responses to experimental habitat manipulation*. Wetlands, 12:1–7.

Beever, J.W., Simberloff, D. and King, L.L. (1979). Herbivory and predation by the mangrove tree crab Aratus pisonii. Oecologia, 43: 317–328.

Bernacsek, G.M. 2001. *Guide to the Shellfishes of the Bangladesh Sundarban*. Technical Reports TR No. 11, Sundarban Biodiversity Conservation Project, ADB: BAN 1643/3158. 1-111.

Biswas, V. and Raychaudhuri, D. 2012. ORB- *Weaving spiders of Bangladesh-II: Genus Larinia Simon (Araneae: Araneidae)*. Records Zoological Survey of India (in press).

Biswas, V. 1997. *Record of gynandromorphy spiders from Bangladesh: Genera Lycosa Latreille, Hippasa Simon and Oxyopes Latreille (Araneae : Arachnida)*. Journal of Bengal Natural History Society, New Series, 16: 25-34.

Black, S.H., Shepard, M., Allen, M.M. 2001. *Endangered Invertebrates: the case for greater attention to invertebrate conservation*. Endangered Species UPDATE,18 (2): 42-50.

Cannicci, S., Burrows, D., Fratini, S., Smith, T.J., Offenberg, J. and Dahdouh-Guebas, F. 2008. *Faunal impact on vegetation structure and ecosystem function*

in mangrove forests: A review. Aquatic Botany, 89:186–200.

Chowdhury, S.H. 1995. *Entomology of the Sundarban reserved forest* (Draft Report-. Integrated Resource Development of the Sundarban reserved forest, Bangladesh). FO: DP/BGD/84/056. UBDP-FAO: 1-34

Daily, G.C., Soderqvist; T., Aniyar, S., Arrow, K., Dasgupta, P., Ehrlich, P.R., Folke, C., Jansson, A., Jansson, B., Kautsky, N., Levin, S., Lubchenco, J., Maler, K., Simpson, D., Starrett, D., Tilman, D. and Walker, B. 2000. *The value of nature and the nature of value*. Science, 289: 395-396.

Gopal, B and Chauhan, M. 2006. *Biodiversity and its conservation in the Sundarban Mangrove Ecosystem*. Aquatic Sciences, 68: 338–354.

Graça, M.A.S., 2001: *The role of invertebrates on leaf litter decomposition in stream-a Review.* International Review of Hydrobiology, 86: 383–393.

Holthuis, L.B. 1980. FAO species catalogue. Vol.1. Shrimps and prawns of the world. *An annotated catalogue of species of interest to fisheries*. FAO Fisheries Synopsis (125), 1 : 1-261.

Hossain, M. 2012. *Butterflies and the Sundarban*. Bangladesh Nature Quest. September-November. 59-63.

Iftekhar, M. S. 2008. *An overview of mangrove management strategies in three South Asian countries: Bangladesh*, India and Sri Lanka. International Forestry Review, 10: 38-51.

Jahan, M.S., Islams, G.M.J and Rahman, M.R. 1998. Molluscan biodiversity of Sundarban, Bangladesh. *Proceedings of the National Seminar on 'Coastal Environment and Energy Resources in Bangladesh*; December 08-09,1998, Khulna. 35-44.

Jahan, M.S., Mannan, M.A., and Mandai, K.N. 1990. *Intertidial molluscs of Sundarban, Bangladesh*. Enuironment and Ecology, 8(2): 603-607.

Keiper, J. B. and W. E. Walton. 2002. *Effects of vegetation management strategies on shore-flies (Diptera: Ephydridae) associated with constructed treatment wetlands*. Annals of the Entomological Society of America, 95: 570–576.

Keiper, J. B., Walton, W.E. and Foote, B.A. 2002. *Biology and ecology of higher Diptera from freshwater wetlands*. Annual Review of Entomology, 47:207–232.

Kellert S. R. (1993). *Values and perceptions of invertebrates*. Conservation Biology, 7: 845–55.

Lavelle, P., Decaëns, T., Aubert, M., Barot, S., Blouin, M., Bureau, F., Margerie, P., Mora, P. and Rossi, J.P. 2006. *Soil invertebrates and ecosystem services. European Journal of Soil Biology*, 42: S3–S15.

Lee, S.Y. (1998). *Ecological role of grapsid crabs in mangrove ecosystems: a review*. Marine and Freshwater Research, 49: 335–343.

Lunney, D. 1992. *Communication skills and the debate on conserving biodiversity*. Australian Zoologist, 28(1-4): 1-2

MA (Millennium Ecosystem Assessment) 2003. *Ecosystems and Human Well-Being:*

A Framework for Assessment. Island Press, Washington, DC.

Magny,G.C.D, Mozumder, P.K., Grim, C.J., Hasan, N.A., Naser, M.N., Alam, M., Sack, R.B., Huq, A., 3 and Colwell, R.R. 2011. *Role of Zooplankton Diversity in Vibrio cholerae Population Dynamics and in the Incidence of Cholera in the Bangladesh Sundarban*. Applied and Environmental Microbiology, 77 (17): 6125-6132.

McGuinness, C.A.2001. *The conservation requirements of New Zealand's nationally threatened invertebrates*. Threatened species occasional publication, 20 Biodiversity Recovery Unit, Department of Conservation, Wellington, New Zealand: 1-658.

Micheli, F., Gherardi, F. and Vannini, M. 1991. *Feeding and burrowing ecology of two East African mangrove crabs*. Marine Biology, 111: 247–254.

Minchinton, T.E. (2001). *Canopy and substratum heterogeneity influence recruitment of the mangrove Avicennia marina*. Journal of Ecology, 89: 888–902.

Nagelkerken, I. and Blaber, S.J.M. and Bouillon, S. and Green, P. and Haywood, M. and Kirton, L.G. and Meynecke, J-O. and Pawlik, J. and Penrose, H.M. and Sasekumar, A. and Somerfield, P.J. 2008. *The habitat function of mangroves for terrestrial and marine fauna : A review*. Aquatic Botany, 89: 155-185.

Odum W.E., McIvor C.C., Smith T.J. 1982. *The ecology of the mangroves of South Florida: a community profile*. FWS/OBS-81/24. US Fish and Wildlife Service, Office of Biological Services, Washington, DC.

Onuf, C.P., Teal, T.M. & Valiela, I. 1977. *Interactions of nutrients, plant growth and herbivory in a mangrove ecosystem*. Ecology, 58: 514–526.

Purves, W.K., Orians, G.H. and Heller, H.C. (1992) *Life: The Science of Biology*, 3rd rev. edn, Sinauer Associates Inc, Massacheusus, USA.

Robertson, A.I. and Daniel, P.A. 1989. *The influence of crabs on litter processing in high intertidal mangrove forests in tropical Australia*. Oecologia 78, 191–198.

Robertson, A.I., Daniel, P.A., 1989. T*he influence of crabs on litter processing in high intertidal mangrove forests in tropical Australia*. Oecologia 78, 191–198.

Ormerod, S.J., Durance, I., Terrier, A. and Swanson, A.M. 2009. *Priority Wetland Invertebrates as Conservation Surrogates*. Conservation Biology, 24 (2): 573–582.

Rahman, M.A. 2003. The Sundarban: A world Heritage Site. In: Proceedings of the National Seminar on the Sundarban, the largest Mangrove forest on the earth: A world Heritage Site, held on 25-26 June 2003, Khulna University, pp. 168- 180.

Smith, T. J. 1987. *Seed predation in relation to dominance and distribution in mangrove forests*. Ecology, 68: 266–273.

Smith, T.J., Boto, K.G., Frusher, S.D. and Giddins, R.L. 1991. *Keystone species and mangrove forest dynamics: the influence of burrowing by crabs on soil nutrient status and forest productivity*. Estuarine, Coastal and Shelf Science, 33: 419–432.

Warren, J. H. and Underwood, A. 1986. *Effects of burrowing crabs on the topography of mangrove swamps in New South Wales*. Journal of Experimental Marine Biology and Ecology, 102: 223– 235.

Wells, F.E. 1983. *An analysis of marine invertebrate distributions in a mangrove swamp in Northwestern Australia*. Bulletin of Marine Science, 33(3): 736-744.

Wissinger, S. A., S. G. Ingmire, and J. L. Bogo. 2001. *Plant and invertebrate communities as indicators of success for wetlands restored for wildlife*. Pp. 207–236. In: Bioassessment and Management of North American Freshwater Wetlands (eds. Rader, R.B. Batzer, D.P. and Wissinger, S.A.) John Wiley and Sons, New York, NY, USA.

Zaman, M.B. 2011. *Ecology and economic status pf lime producing mangrove Gastropod, Telescopium telescopium (Linnaeus) in Bangladesh*. Ph.D. Thesis, IES, Rajshahi University: 1-197.

Crocodiles and Turtles of the Sundarban

The Sundarban mangrove forest supports diverse ecosystems due to differences in the salinity gradient along the north-south as well as east-west transect. These variations influence the availability and composition of species assemblage, including flora and fauna within the Sundarban mangrove ecosystem. The northern and northeastern portions comprise mostly freshwater/brackish water and as we move south and southwest the salinity increases. The ecosystem and the diverse habitats have been described in several chapters of this book.

Crocodiles

Bangladesh once had three species of crocodiles in the wild namely, marsh crocodile (*Crocodylus palustris*), saltwater crocodile (*Crocodylus porosus*), and gharial (*Gavialis gangeticus*) (Husain 1977, Khan 1982 a

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and b, 1987, Rashid *et al*, 1994) but now only two species - saltwater crocodile and gharial - survive in the wild (Khan 1987, Rashid 2003, 2012). According to the IUCN-Bangladesh Red Data Book (2000), marsh crocodile is extinct in the wild and the remaining two species are critically endangered with the gharials at the verge of extinction in Bangladesh. Both these species are listed in CITES-I.

Crocodiles are carnivorous reptiles and play the role of top-predators in an aquatic ecosystem. It is not only that they feed on the fish, which is the cause of contention with the fishermen or other large mammals but in return contribute to the 'health' of the aquatic ecosystem. So how do they do that? They often feed on the large carnivorous fish allowing other fish to grow. They also feed on weak and sick fish and so keep the fish population and water clean by scavenging on dead animal matter they keep the aquatic environment uncontaminated and contribute to the nutrient balance (of allochthonous origin) of aquatic environments. A medium-sized crocodile can eat between 0.6 and 0.8 percent of its body weight per day and excrete about 0.20 to 0.27 percent of its body weight of nitrogen, phosphorus, calcium, magnesium, sodium and potassium ions per day (Fittkau 1970, 1973). In places where crocodiles have been eliminated, declines in fish production have been noted, possibly because of a drop in the primary production based on the excreted nutrients that crocodiles help in dispersal in an aquatic environment. That's why crocodiles are also termed 'indicators' of a clean and healthy aquatic environment.

Understanding the biology of the crocodile will solve half the problem. Very often conservation projects are launched without proper understanding of the biology and the needs of the target species but instead revolve around the social perspectives of human beings that is already in chaos and the project is doomed. Each species or populations deserve to be treated separately in the habitat ecosystem they live in. The urgency in taking appropriate steps in protecting the species or addressing social issues is also often overlooked, which further pushes the viability of the target or endangered species to a state of no-recovery. The crocodile population in the Sundarban has never been studied. Similarly, no census has been made to estimate the population, neither have the threats to the crocodile population

in the Sundarban been addressed properly or exclusively.

Let's look at the present state of the crocodiles in the Sundarban. The saltwater crocodiles are under threat in the Sundarban, the population of which is declining at a frightening rate. No factual figures are available, as no scientific population estimation studies have been conducted yet (Rashid 2004). Based on my personal visits to the Sundarban since the 1980s it is estimated that between 1980 and 2000 there were about 250-300 adult crocodiles surviving in the largest single stretch of mangroves in the world, which is far below the carrying capacity of the Sundarban. But in 2012, the population went down further and the population may not exceed 100-150 adult individuals. One of the possible reasons of the decline of the wild saltwater crocodile population is that during the late 1950s, about 3000 crocodiles were killed under a government order for exporting their skin. Adding to this plight is the increase in the magnitude of human presence and human disturbance and fishing activities in the Sundarban whereby a lot of the crocodile hatchlings get caught in the fishing nets and are either mostly killed or traded by the fishermen. The crocodile population has not been able to recover from the 1950s killings and then with limited recruitment in the wild, the population is being further pushed to a point of no recovery. In a recent (16-18 January 2012) survey of crocodiles in the Indian Sundarban, 141 direct observations were made of which only 69 were adults, roughly estimated as 0.12 crocodiles/km (Choudhury et al. 2012).

Strong administrative and management decisions accompanied by pragmatic crocodile recovery plans are needed. The Forest Department (FD) is the only government agency managing natural resources in the Sundarban that makes it easier to implement administrative decisions. But there is a dearth of 'good intentions', skilled and committed personnel for wildlife management. The setting up of the crocodile rearing centre at Karamjal was an appropriate initiative and gave some hope for the recovery of the crocodile population. The objective was to procure/collect the young crocodile hatchlings that get caught in the fishing nets, rear them to a meter-size and the release them in the wild. But it could not fulfill the objective due to a lack of proper monitoring, capacity, funding and foresightedness. Only a few of the juveniles were released since the establishment of

the Karamjal wildlife centre and the attention has now diverted to captive breeding and primarily revenue collection from visitors.

Turtles

Bangladesh supports a diverse and rich assemblage of 30 turtle species including the recently found *Amyda cartiliginea* (Rashid 2011) and *Cuora mohouti* (Rahman 2012), which comprise more than 10% of the total numbers of species known to exist in the world. Among these 30 odd species, five are marine turtles, four tortoises and the remaining 21 freshwater turtles. Of the 21 freshwater turtles seven are soft-shell turtles and the remaining 14 hard-shelled turtles. In a recent survey on turtle trade conducted by the Centre for Advanced Research in Natural Resources & Management (CARINAM) it was found that three or four freshwater turtle species are commonly found while the remaining 13-14 species are seldom found. Marine and freshwater turtle species that have been recorded (Rashid & Swingland 1997, Rashid & Khan 2000, Rashid & Islam 2006,) and traded from the Sundarban and adjoining areas are listed in Table 1. Among the threatened freshwater turtle species five are known to be found in the Sundarban and adjoining areas.

Table 1. Turtles and crocodile species recorded in and adjoining rivers/estuaries of the Sundarban.

English Name/ Local Name	Scientific Name	Status (IUCN Redlist 2000)	Threats
Saltwater Crocodile/ Lunapanir kumir	*Crocodylus porosus*	Least Concern (needs updating) CITES-I	Habitat destruction, human disturbance, killing, poaching, hatchlings killed in fishing nets
Olive Ridley/ Jolpai Kasim/Ural kaitta	*Lepidochelys olivacea*	Vulnerable (needs updating) CITES-I	Harvest for food, marine habitat pollution, loss of nesting beaches, drowning in nets, low natural recruitment
Green Turtle/ Sabuj Kasim/Ural kaitta	*Chelonia mydas*	Globally endangered; Rare in The Sundarban CITES-I	Harvest for food, marine habitat pollution, loss of nesting beaches, drowning in nets, low natural recruitment
Narrow-headed Softshell Turtle/ Sim kasim, Dhusha	*Chitra indica*	Endangered; Rare in The Sundarban CITES-II	Habitat destruction, commercially traded for food, cartilage for soup, traditional medicine

English Name/ Local Name	Scientific Name	Status (IUCN Redlist 2000)	Threats
Frog-faced Softshell Turtle/ Thal kasim	*Pelochelys cantorii*	Endangered (needs updating) CITES-II	Habitat destruction, commercially traded for food, cartilage for soup, traditional medicine
Gangetic Softshell Turtle/ Khalua Kasim, Gangua, Nalua	*Nilssonia gangeticus*	Not assessed (needs updating)	Habitat destruction, commercially traded for food, cartilage for soup, traditional medicine
Peacock Softshell Turtle/ Jat kachhim	*Nilssonia hurum*	Vulnerable (needs updating) CITES-I	Habitat destruction, commercially traded for food, cartilage for soup, traditional medicine
Spotted Flapshell Turtle/ Dhur, Futi kasim	*Lissemys punctata andersoni*	Least Concern (needs updating) CITES-II	Habitat destruction, commercially traded for food, shell for gelatin, traditional medicine
Northern River Terrapin/ Mukhpura kaitta, Shalgum, Boro kaitta	*Batagur baska*	Critically Endangered CITES-I	Habitat destruction, commercially traded for food, traditional medicine
Roofed Turtle/ Kori kaitta, Taposhi	*Pangshura tecta*	Least Concerned (needs updating) CITES-I	Habitat destruction, threatened due to commercial trade for food, shell for gelatin, traditional medicine

The northern and northeastern areas within the Sundarban support limited populations of freshwater turtles. The deeper rivers and estuaries support large softshell turtles. The few sandy beaches of the Sundarban are visited by the marine turtles – Olive Ridley and rarely Green Turtles to lay eggs. Two of the species found in the Sundarban – *Batagur baska* and *Chitra indica* – are listed in the recently published "Turtles in Trouble: The World's Top 25 Most Endangered Species of Tortoises and Freshwater Turtles" (TCC 2011).

The fishermen of the Sundarban are the main collectors of turtles while some professional collectors are involved in areas adjoining the Sundarban. Marine turtles that get entangled in the fishing nets are brought to Khulna and Mongla and traded for meat as well.

Another critically endangered turtle species worth mentioning is *Batagur baska* (Northern River Terrapin). During a survey conducted by the author and Prof. Edward Moll during 1989-90 only four male *Batagur baska* were collected. Later surveys carried out in 2005 by A. H. M. Ali Reza under a Rufford Small Grants no *Batagur baska*

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was found. However interviews carried out by CARINAM of the fishermen fishing in the Sundarban indicated that the *B. baska* population is extremely low. Recent information indicates that *B. baska* may still be breeding in the Sundarban and the latest collection of some hatchlings by TSA/IUCN/CARINAM team is proof to claim it.

Among the softshell turtles *Lissemys punctata* is found in the adjoining areas as well as in the northern areas of the Sundarban where freshwater is prevalent. Large softshell turtles mainly the *Pelochelys cantorii*, *Chitra indica*, *Nilssonia gangeticus* and *N. hurum* have mostly been recorded in the estuaries close in the eastern Sundarban.

The turtles are threatened due to turtle trade as they are consumed as food by many. The marine turtles were not on the list but during the last five-six years these are also traded. The prices vary from BDT 350-500 per kilogram depending on the species. Some of these turtles are also transported to the capital Dhaka for sale in the weekly market at Tanti Bazaar (in Old Dhaka).

Conclusion

Protecting these endangered crocodiles and helping them to breed and survive in nature is essential to keep the Sundarban mangrove ecosystem in balance and to ensure that the aquatic environment remains clean. In addition to protecting the natural heritage of the country, by conserving the crocodiles the government complies with the obligations spelled out in the Convention on Biological Diversity (CBD), Ramsar Convention, Millennium Development Goals (MDG) and several other national documents like NEMAP, NBSAP, 4th CBD Country Report, etc.

The actions needed to conserve the dwindling crocodile population involve the government's political will in its entirety, the honest endeavors of multifarious government agencies, putting the right persons at the right places, enforcement of the Bangladesh Wildlife Act 2012, and much more. Many of these issues are inter-related and should be prioritized based on the merits or objectives, capacity and/or economics of the various government agencies and hence deserve co-ordination among all relevant departments and personnel. The mystic recipe for this conundrum of co-ordination to unfold includes ingredients from politics, bureaucracy, academia and the public in

general.

It is high time that the government create a Biodiversity Conservation Fund from its revenue budget specifically to conduct research and monitor the status of biodiversity in the country.

LITERATURE CITED

Fittkau, E. J. 1970. *Role of the caimans in the nutrient regime of mouth lakes of Amazon affluents (an hypothesis)*. – Biotropica 2: 138-142.

Fittkau, E. J. 1973. *Crocodiles and the nutrient metabolism of Amazonian water*s. – Amazoniana 4: 103-133.

Husain, K. Z. 1977. Wildlife management in Bangladesh. Department of Films & Publications, Government of Bangladesh. pp. 56.

Khan, M.A.R. 1982a. *Present status and distribution of Crocodiles and Gharial of Bangladesh*. Crocodiles. IUCN, Gland, Switzerland. pp. 229-236.

Khan, M. A. R. 1982b. Wildlife of Bangladesh – A Checklist. Dhaka University Press, Dhaka. vii + pp. 160.

Rashid, S. M. A. 2003. *Crocodiles in Peril*. The Star Weekend Magazine, Publication of the Daily Star, Dhaka, Bangladesh. Cover Story. September 5, 2003.

Rashid, S. M. A. 2004. Faunal diversity of Bangladesh: Conservation Prospects and Constraints. National Biodiversity Strategy & Action Plan report to IUCN-Bangladesh Country Office. pp. x + 196 pp.

Rashid, S. M. A. 2012. *Status of the crocodiles in Bangladesh*. Report to the IUCN/SSC/Crocodile Specialist Group, presented at the Crocodile Specialist Group Steering Committee Meeting held at the National Museum of the Philippines, Manila. 21 May 2012.

Rashid, S. M. A., A. Z. Khan & A. W. Akonda. 1994. *Faunal diversity of the The Sundarban. In: Ecology and Management of Mangroves in the The Sundarban, Bangladesh*. Vol.2. IUCN Wetland Program Paper Series, Southeast Asia Regional Office, Bangkok, Thailand. pp. 115-131.

Rashid, S. M. A. & I. R. Swingland. 1997. *Ecology of some freshwater turtles in Bangladesh*. Proceedings of the International Conference on Conservation, Management and Restoration of Tortoises and Turtles. New York Turtle & Tortoise Society. pp. 225-242.

Rashid, S. M. A. & M. H. Khan. 2000. *Trade and conservation status of turtles and tortoises in Bangladesh*. Asian Turtle Trade: Proceedings of a Workshop on Conservation and Trade of Freshwater Turtles and Tortoises in Asia. (Eds.) P. P. van Dijk, B. L. Stuart and A. G. J. Rhodin. Chelonian Research Monographs 2: 77-85.

Rashid, S. M. A. & M. Z. Islam. 2005. *Review: Conservation and research on marine turtles in Bangladesh*. In: Shanker, K & B. C. Choudhury (eds.) Sea Turtles of the

Indian Subcontinent. Wildlife Institute of India, Dehradun, India. pp. 200-216.

Turtle Conservation Coalition (TCC). 2011. *Turtles in Trouble: The World's Top 25 Most Endangered Species of Tortoises and Freshwater Turtles*. Lunenburg, MA. USA. p. 54.

The Snake Fauna of the Sundarban

The Sundarban of Bangladesh possibly supports the highest density of many species of reptiles and only living population of Saltwater Crocodile than any other forest or areas in the country. The simple reason for this is its inaccessibility to human beings. Moreover, reptile hunters and snake catchers cannot trick the eyes of the foresters sitting at the mouth of almost every river and canal that jut out of the Sundarban. In addition, it is really difficult to move through major parts of the Sundarban to look for the creepy-crawly reptiles living deep inside the Sundarban.

Under such a context one is likely to expect a good assemblage of reptiles, especially the snakes in the Bangladesh part of the Sundarban with a land area of about 4000 km^2 and another 2000 km^2 of water.

By **Editorial Desk**

Snakes as a group of reptiles have no limbs, excepting some tiny vestigial spur in places of hind limbs in pythons and boas. They are in Class Reptilia, Order Squamata and Suborder Serpentes. They have the most elongated and slim bodies of all the reptiles; their internal organs have become lengthened while some organs have been dropped altogether and others are present not in pairs but as singletons or one placed atop the other. Like other reptiles their bodies are covered with epidermal scales, many of which serve as clue to their species identifications. They have no external ears and hence they cannot receive any airborne sound. They receive the sound signal through certain bones in the lower jaw when such sound is produced on the substratum on which a snake might move or rest. Limbless reptiles or lizards have external ear openings. Snakes are carnivorous and kill their prey by constricting or by venoms that are nothing but modified saliva produced in paired venom glands, each of which is usually joined to a venom tooth for delivering the venom to the victims' bodies. Most are egg laying but some could produce live babies through a process called ovoviviparity where a mother lays her clutch of eggs inside a bag in the belly and when the embryos develop into babies they cut the egg membrane and case, and then crawl out of mother's body through the cloaca.

Non-venomous Snake Species

The non-venomous snakes are the ones that do not have proper venom glands, venom delivery fangs and associated muscular developments present in our cobras, kraits and vipers. This is a diverse group that includes one of the smallest to the largest or longest snakes of the world such as *Dumukha Shap*, Brahminy Blind Snake *Ramphotyphlops braminus* – smallest and *Moyal Shap*, Reticulated Python *Python reticulatus* – the longest and the largest. The second largest snake of the world is the *Ajagor*, Indian Python *Python molurus*. *Dumukha Shap* and *Ajagor* are present in the Sundarban. In addition to the purely non-venomous species, this group also includes mildly venomous or back-fanged colubrid snakes. Such species, for example Mangrove Snake, Cat Snakes, etc., have small fang-like structures toward the back of the maxilla. These fangs are connected to certain specialized salivary glands, also called Duvernoy's gland. It is

positioned posterior to the eye, encased in a thin cover of connective tissue, and consists mostly of serous cells. A single, short duct extends anteromedially from the lumen of the gland to the base of the posterior fangs.[1] Secretion of this gland is said to be mildly venomous that can usually kill or just paralyse or immobilise small animals such as lizards, frogs and mice, etc., on which these snakes feed on.

Most colubrids possess modified supralabial salivary glands which in many cases are in the form of so-called Duvernoy's glands. The saliva produced by such glands may contain various amounts of toxic compounds. Duvernoy's glands are structures that are homologous to the venom glands of true venomous snakes. Secretions from these glands empty through a duct into the region of the posterior maxillary teeth. In many species, the teeth are elongated in this region. In this regard, colubrids can be divided into those with grooved teeth or fangs (opisthoglyphs) and those without grooved teeth (aglyphs). Secretion of venom through Duvernoy's glands is generally slower than in the true venomous snakes with their highly developed venom glands. Envenoming from a colubrid bite is more likely if the snake does not let go its prey immediately and injects the venom through of a chewing motion. Nonetheless, very quick bites can also cause envenoming. The opisthoglyphs possess the most efficient venom apparatus amongst the colubrids, as the venom, which is released at the base of the teeth, is channelled into the grooves and can thus flow quickly along the teeth and into the bite[2].

However, Leviton *et al*, 2003 mentioned that known mildly-venomous snakes belong to the family Colubridae that include the rear-fanged snakes of the Asian vine or whip snake genus Ahaetulla, the cat-eyed snakes (genus Boiga), the genus ***Psammodynastes***, and the aquatic and semi-aquatic snakes of the genera ***Enhydris***, ***Cerberus***, ***Cantoria***, ***Fordonia***, and Bitia. How dangerous any of these are to humans is still an open matter for research. In a like manner, several of the supposedly non-venomous colubrids have been shown to have toxic saliva and some should be considered mildly if not dangerously venomous. Among these are members of the genera *Xenochrophis*, *Amphiesma*, and *Rhabdophis*. We have all these genera in the country

1 http://en.wikipedia.org/wiki/Duvernoy's_gland nd
2 http://www.vapaguide.info/catalogue /TER-COL

barring *Cantoria* and *Bitia* when all but the *Rhabdophis* are present in the Sundarban.

Chhoto Dumukha Shap, Blind Snakes

Of the several species of blind snakes, Jerdon's Blind or Worm Snake ***Typhlops jerdoni*** Boulenger, 1890 is one of the commonest in the country. It does not occur in saltwater environment but is present in the villages bordering the Sundarban.

One of the smallest snakes of the country, it measures about 23 cm maximum. To an average person it looks more like a hefty earthworm than a snake. But it has proper jaws and the body is cylindrical and covered with glistening minute smooth, black scales. Both head and tail ends look similar hence its Bangla name *Dumukha* (*du* means 2 and *mukha* means headed) ***Shap***. It is a burrowing animal but has a special preference for the decaying leaf bases of banana plants or other wet or moist debris. It feeds largely on subterranean insects and their larvae. It does not produce live babies but lays eggs. It is internationally not an endangered species but possibly so in the country.

The related species *Bamun Dumukha Shap*, Brahminy Blind Snake *Ramphotyphlops braminus* has just 20 rows of dorsal scales along the entire body[3]. Interesting fact about it is that scientists have not yet found any male specimen of it and all living specimens are considered female. So, this is one of the rarest of the vertebrates that reproduces through a process called 'parthenogenesis' meaning production of viable eggs without fertilisation having occurred. The individuals that result are genetically identical to their mother[4]. It is neither in IUCN red list nor in any appendices of the CITES. Its number is slowly going down in the country due to the loss and alteration of habitats.

Balu Bora Shap, Common Sand Boa *Gongylophis conicus* (Schneider, 1801)

It is also called Russell's Sand Boa. I was possibly the first to report it from Bangladesh Sundarban in 1981 when I presented a paper on the wildlife of the mangrove forest of Bangladesh in the Dhaka Meeting-cum-conference of SACEP – ESCAP during August 1983

3 http://en.wikipedia.org/wiki/ Ramphotyphlops braminus
4 http://www.arkive.org/brahminy-blind-snake/ramphotyphlops-braminus/#glossary

and its modified version was later on published in the Journal of the Bombay Natural History Society in 1986 (Khan, 1986). It was then called *Eryx conicus*.

Sand Boa is a hefty, small snake, rarely seen in the western parts of the Sundarban. It is quite a colourful snake with a small head and heavy body, and short and blunt tail. Overall dark or sandy brown, off white and creamy with lots of dark blotches marking the upperside of the body while the underside is pale and unmarked. Dorsal scales are slightly keeled, in 51 to 65 rows. Ventral scales: 194-210. The anal scale is single. Subcaudals: 26-36[5]. Measures about a metre with a 7 cm long tail. It feeds largely on small vertebrates and hides under trash and vegetation being active by night. It produces life babies through ovo-viviparous method.

Ajagor, Pythons

Ajagor, Indian Python *Python molurus* (Linnaeus, 1758) is the largest snake in the Sundarban as Reticulated Python does not occur here. An adult python could measure up to 5 m although generally found specimens do not range more than 3 m while their weight ranges from 20 to 30 kg. It is much like the sand boa but python is more than 100 times heavier and more gaudily coloured in yellowish to whitish than the boa. Overall pale yellow to white with blotches and markings all over the body minus the white belly. Outwardly it appears to have well connected venation of pale or white where each block encompasses a dark blotch. ***Ajagor*** has a lance-shaped mark punctured centrally by a pale vertical line. In case of this python two distinct lines that run horizontally on the head, across each eye get merged with the head colour where as in Burmese Python *Python bivittatus* or *Python molurus bivittatus* these two run in front of the eye and meet each other forming a closed circuit. Formerly Indian and Burmese Pythons were considered as two separate subspecies included in one species. Now both have been given the status of species. These pythons' neck are narrow and their heads are rhomboidal. Their average length is 2.5 m with a 30 cm tail while their weight ranges from 15 to 50 kg. Maximum about 6.4 m (21 ft)

5 http://en.wikipedia.org/wiki/Gongylophis_conicus

in length, and weighing as much as 91 kg.[6] Python produces a clutch of 8 to 20 eggs in another animal's disused burrow or inside hollows in old logs. Python feeds largely on vertebrates, including barking and spotted deer, Sambar, serow, wild boar, wild cats and civets, primates, larger birds such as junglefowl and monitor lizards. Considering its population decline IUCN has kept it as Near Threatened species while CITES put it in Appendix II.

Laodoga, Vine Snakes

We have two species of vine snakes in the Sundarban. Earlier we had record only of *Sutanoli/Laodoga Shap*, Common Vine Snake *Ahaetulla nasuta* (Lacépède, 1789) and *Buncha-nak Laodoga*, Short-nosed Vine Snake *Ahaetulla prasina* (Boie, 1827) but in 2010 Neumann-Denzau, and Denzau recorded a third vine snake as Badami Laodoga, Brown Vine Snake *Ahaetulla pulverulenta* (Duméril, Bibron & Duméril, 1854) from the Sundarban. So, all three species could be present in the Sundarban. However, the *Sutanoli* is possibly one of the commonest snakes of the Sundarban while its population round the country is declining at an alarming rate. Their posterior maxillary are teeth grooved and connected to specialized salivary glands secretion which is mildly venomous and generally considered harmless to people.

Sutanoli or *Laodoga* snakes are among the most slender and elongated snake, in the country with prolonged triangular head having a pointed snout; eyes petty large with horizontal pupil that in the Short-nosed is like a key-hole and devoid of any brown of the Brown Vine Snake. Its total length over 2 metres with a 60 cm long tail. It and all the other species in the genus are ovoviviparous. The are basically diurnal and ambush predator.

Buncha-nak Laodoga, Short-nosed Vine Snake

This Laodoga is widely distributed in the country and second to Common Vine. In the field it can be confused with this common vine but its pupil is like a key-hole. Moreover its snout is obtuse less pointed than the other two species.

6 http://eol.org/pages/1055458/details

As per Boulenger (1890) this snake has the following features: snout acuminate, projecting, without dermal appendage, rather more than twice as long as the eye. The snake is bright green, pale olive, or grey-brown, with a yellow line along each side of the lower parts; interstitial skin of the neck black and white. Length 150 cm including 50 cm tail. Ovoviviparous. Its habits are similar to the Common Vine.

Badami Laodoga, Brown Vine Snake

This snake has just been reported from Bangladesh Sundarban in 2010 by two scientists mentioned earlier in this article. It differs from the other two because it is not green. Moreover, the snake is characterized by a dark brown rhomboidal mark on top of the head, a stripe passing through the eye, and an extremely pointed head with an enlarged nose tip (Neumann-Denzau and Denzau, 2010). Greyish, powdered with brown, with blackish transverse spots above; a dark brown rhomboidal spot on the upper surface of the head, and a brown band on each side, passing through the eye'. Total length 205 cm with a 70 cm tail.

Jol Bora Shap, Dog-faced Water Snake *Cerberus rynchops* (Schneider, 1799)

The species is so named because of its distinctive head shape with large scales (shield), small eyes positioned close to the top of the head and nostrils, with well defined "lips".[7] This is possibly the most common semi-aquatic snake found in the Sundarban. During ebb the snake is mostly seen resting idly on the mudflat near the receding water or close to roots and vegetation by the flat river and canal banks. It is partial to mangrove vegetation and does not occur beyond our coastal waters. It is purely a saltwater species. It is quite colourful but not as dazzling as the patterns merge with the muddy background. It can be separated from the rest of the water snake from the colour pattern alone followed by small head and strongly keeled scales. The snake feeds almost entirely on fishes. Once I found it trying to manipulate a *Guilla Tengra*, *Mystus gulio* for over an hour after which I moved away from the site for other work. I have seen it from the Sundarban to the St. Martin's as well as Chokoria Sundarban, all

7 http://www. naturia.per.sg/buloh/verts/water_snake.htm

along coastal areas especially with natural and man-made mangrove vegetations. The snake possibly not under any threat as most people seem to be tolerant to this species. Although mildly venomous it is considered a mild tempered snake and is harmless for people.

Other than the *Dhora Shap*, Checkered Keelback *Xenochrophis piscator* (Schneider, 1799) the common snake in the Sundarban is possibly the *Daraj Shap*, Rat Snake *Ptyas mucosa* (Linnaeus, 1758), *Dora Shap*, Striped Keelback *Amphiesma stolatum* (Linnaeus, 1758), *Gechho Shap*, Common Bronze-back Tree Snake *Dendrelaphis tristis* (Daudin, 1803), *Uranta Shap* or *Kalnagini*, Ornate flying snake *Chrysopelea ornata* (Shaw, 1802), *Kukri Shap*, Common Wolf Snake *Lycodon aulicus* (Linnaeus, 1758), Glossy marsh snake *Gerardia prevostianus* (Edydoux & Gervais, 1822) and *Dudhraj Shap*, Copper Head Trinket Snake *Coelognathus radiata* (Boie, 1827).

The Bangladesh part of the Sundarban has possibly the highest density and species diversity of the snake fauna of the country. It seems that most people entering into the Sundarban for their livelihoods are tolerant to the non-venomous snakes although the rat snake is sometimes killed as many people mistake it as a 'cobra'. By and large, people in this region are more tolerant to the snakes than in others parts in the country. The main reason is that the general members of the public do not venture into the Sundarban. Let us hope Sundarban will remain intact and will remain a safe home for the snakes.

Venomous snakes of Sundarban

All the venomous snakes of the Sundarban could be described as ones having venom fangs and venom glands. Species having round pupil; no loreal scale, short, erect and fixed venom fangs followed some smaller teeth on the maxillary bone or upper jaw would include popularly known cobras, kraits and coral snakes as well sea snakes. All but the sea snakes have cylindrical tails when the sea snakes have flattened, oar-like tails barring two species of Sea Kraits under genus Laticauda. These belong to the family Elapidae with 2 subfamilies Elapinae and Hydrophiinae or two separate families: Elapidae and Hydrophiidae, the latter includes only the sea snakes.

Venomous snakes having pupil of the eye vertically elliptical; loreal scale is absent but upper surface of head is covered by small scales as

in Russell's Viper. When the head is covered by large, symmetrical shields, then a deep sensory pit is present immediately behind the nostril as in all the Pit Vipers we have. All vipers have venom fangs fixed to a short moveable maxillary bone that allows for rotation of the fangs backward when the mouth is shut and generally no teeth behind the venom fangs (Leviton *et al*, 2003).

Cobra

All cobras are popularly called *Gokhra* in Bangla. All cobras, kraits and seas snakes are venomous and belong to either a single family of Elapidae or that is sometimes divided into Elapidae with cobras and kraits while sea snakes fall under Hydrophiidae. These snakes basically produce neurotoxic venom that are delivered to the victims' body through a pair of venom-delivering teeth, called fangs, fixed each on either side of the jaw. Unlike vipers that have hypodermic needle-like fangs elapid fangs have canals on the inner curvature of the fang through which the venom is forced when special muscle pump the venom gland delivering the same to the victim's body through the skin perforated by the fang. This venom sometimes may contain cytotoxic and cardiotoxic elements in the venom causing severe muscle damage, stopping blood coagulation and leading to heart failure. Highly venomous Cobra envenomation can cause human fatalities.

Our largest venomous snake is the *Raj Gokhra*, King Cobra, *Ophiophagus hannah* (Cantor, 1836). It is also the longest venomous snake of the world measuring a little over 5 metres. On an average we see specimen ranging from 3 to 4 metres. In the olden days the species used to live in every bit of forest we had in country such as mixed evergreen in Chittagong and Sylhet Divisions, Shalbon of Dhaka division and the mangrove forest in the Sundraban. At present it has completely disappeared from the *Shalbon* area, most parts of the mixed evergreen forests but found in good numbers in the Sundarban. I presume that the largest density of *Rajgokhra* occurs in our part of the Sundarban.

Although called a cobra its hood is not as majestic as those of typical Monocled and Binocellate Cobras we have in the country, as well as in the Sundarban. A full grown 4 m long *Rajgokhra* can raise its hood little over a metre, and strike its prey, and a human being as

far as 2 metres! 'Stripe on the neck is a chevron instead of a double or single eye shape' commonly seen in our other cobras. The occipitals – a pair of distinctly visible large scales on the head separate it from all other colubrids and cobras.

Rajgokhra is purely a snake eating snake hence its generic name *Ophiophagus*. In Latin *ophios* refers to snakes, and *phagus* means to eat. It is at home in water, over land and in trees. Its female lays a clutch of eggs in almost a 3-tier nest made from leaf and debris collected from the forest floor by the movement of her body and tail. During the incubation of 75 days, on an average, the female remains almost coiled around the nest or around it when she fasts but the male always live nearby as they pair for life. A female can lay 20 to 40 eggs in a clutch and incubates the same for 2 to 3 months. Hatchlings disperse from the nest immediately after hatching when the mother moves out of the nesting area for fetching food.

The king cobra is said to have sufficient neurotoxic venom to kill an elephant! However, temperamentally it is said to be much cooler than other two cobras and the kraits we have in the country. It may be noted here that there is no antivenin available for this cobra – neither in the country nor in India.

King Cobra is an IUCN registered Vulnerable Species as per its Red Data Book and also in Appendix II of the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora).

Of the two species of commonly seen cobras, especially those that can be seen with the snake charmers include *Khoia Gokhra* Spectacled Cobra *Naja naja* (Linnaeus, 1758) and *Gokhra*, Monocled Cobra *Naja kaouthia* (Lesson, 1831), that were earlier considered as two subspecies of one species, ***Naja naja***. The latter is more common in the Sundarban than the former. The two species are separated on the basis of the presence of single or double spectacles on the hood. The monocled one has just one huge black blotch or the same surrounded by other spots or a lighter ring around it. Binocellate has two such blotches almost near the edge of the hood. Both are often joined by a U-shaped dark band or kinds of bands or rows of spots. In rare cases there could be specimens without any markings.

"Adult Monocled Cobras reach a length of 1.35 to 1.5 m (4.4 to 4.9 ft) with a tail length of 23 cm (9.1 in). They have 25 to 31 scales

on the neck called nuchals, 19 to 21, usually 21, on the body or dorsals, and 17 or 15 on the front of the vent. They have 164 to 197 ventral scales or ventrals and 43 to 58 subcaudal scales after the vent.[8] Binocellate species is known to range from 1.8 m to 2.2 m in length. Its scales are smooth and shiny, there are 21–23 rows at mid-body; ventrals numbering 182–196, and subcaudals 53–67; single pair of prefrontals, absence of loreal scale and smooth dorsals are species specific[9]. Clutch size varies from 10 to 30 eggs that are usually laid in rat holes or termite mounds. Incubation lasts from 48 to 69 days. All venomous snake babies are hatched with potential venom that can kill preys or accidentally kill human beings and other animals.

All cobras are in Appendix II of the CITES but our two species are in the Least Concern category of the IUCN.

Kraits

Kraits are called *Keotey*, *Kal Shap* or *Jati Shap* in Bangla and they are cousins of the cobras but lacking hood. Outwardly they look very similar to non-venomous snakes as most lack any appreciable physical markings but the Shakini or Shonkhin Shap, Banded Krait *Bungarus fasciatus* which has prominent and broad black and yellow bands across the whole body and tail. Also its body is to some extent triangular, instead of cylindrical form of most snakes. They are all nocturnal and show much inactivity at daytime. Envenomation can result in human fatalities as these are highly venomous snakes.

All kraits have vertebral series of scales that is the central ones along the back of the body, are enlarged and distinctly larger than scales on sides of body. Moreover, their scales on the sides of the body are not obliquely arranged. The features of kraits are very similar to the cobras but they are hoodless and all have 15 dorsals at mid-body. In case of Common and Black kraits the tail gradually tapers towards the tip and in Banded Krait it ends abruptly like the tip of our fingers.

Kal Keotey, Common Krait *Bungarus caeruleus* (Schneider, 1801)

It can possibly be considered as the number one silent killer of human beings so far as human deaths from snake envenomation are concerned, while blames for such deaths go to the ill-tempered and

8 http://en.wikipedia.org/wiki/ Monocled_cobra
9 http://www.wildlifeofpakistan.com/Reptilesof Pakistan/cobra.htm

showy Cobras. It is pale olive to olive brown in overall colour with many, up to 60 paired white, narrow transverse on the dorsal side of the body that could sometimes be completely missing in some or older specimens. There are a few pale vertebral spots on the neck after which the half-ring begins. The lip and underside are whitish. The beady eyes are nearly invisible. The head shields are normal. There are four shields along the margin of the lower lip while the 3rd and 4th supraoculars touch the eye. The snake measures 100 cm usual but some specimens could reach up to 175 cm[10] that include a 14 to 16 cm long tail. These snakes are nocturnal and live close to human habitation and prefer dry places hiding under trash, debris, logs and roots at day time. They feed on other snakes and small vertebrates. A female lays a clutch of 6 to 12 eggs that hatch after about two months. Parents take no care of the babies. Kratis bites are deadly because the venom is neurotoxic and they bite people at night most victims might die in sleep.

Shakini Shap, Banded Krait *Bungarus fasciatus* (Schneider, 1801)

This is the longest and most colourful of all the kraits and snakes. Its triangular body has the cape at the centre looking more like the head of a pyramid that gives rise to vertebral ridge. Also its tail tip is blunt and the postanal scales are divided. Preanal scale or the anal plate is undivided. Black and yellow crossbands cover the whole body baring the heads that has no yellow marks but two oblique bands from the lip to the tip of the head forming a kind of chevron over the head. Its black and yellow bands can be confused with non-venomous Mangrove Snake and Wolf Snake. Mangrove has black body and very thin yellow bands and in case wolf snake's black bands are 3-4 times larger than that of the krait's. Head and body length about 1.8 m but highest record being 2.25 m and tail is about 10 cm. It lays a clutch of 4 to 14 eggs that the female guards for 2 months when they hatch. Shakini feeds largely on other snakes, reptiles, amphibians, birds, mammals and even fishes. At daytime it is very sluggish and snake charmers usually handle it without first removing its fangs and any protective gears. But at night it is very active and aggressive animal. It

10 http://en.wikipedia.org/wiki/Common_krait

is highly venomous and envenomation can kill a person.

Kalo Keotey, Greater Black Krait *Bungaurs niger* (Wall, 1908)

This is a medium sized, about 100 cm long krait that has recently posed as a nuisance to the people in Chittagong region as it has envenomated half a dozen people there in a short period (Faiz *et al*, 2010). This study has demonstrated that *Bungarus niger* is widely distributed in Bangladesh and confirms the risk of fatal neuro-myotoxic envenoming, especially as no specific antivenin is currently manufactured. As its names indicates it has a dark body, nearly black or sooty with virtually no bands on the body. Its upper lip, chin and throat are yellowish while the underside is whitish with or without yellow tinge. It is not common in the Sundarban. It is also not in CITES or IUCN red list.

Sea Snakes

All sea snakes are known as *Samudrik Shap* in Bangla. They are well known to the fisherfolks and people living in coastal areas and on islands along the Bay of Bengal in Bangladesh. Although most consider them to belong to a subfamily of Hydrophiinae under Elapidae some do fit them into a separate family of its own as Hydrophiidae. They all have an oar-like tail, granular scales over the whole body and lack any elongated ventral scales. As a modification to lead life in water their eyes have shifted to the top of the head that are not so prominent. Like all higher vertebrates they are lung breathers so they need to surface often to air in for breathing purposes. To make their underwater life little easier their lungs have become elongated almost to the whole length of the abdomen, one atop the other. To lead a life in the sea or salt water they have salt excreting glands under the tongue and have valve-like flaps over their nostrils to prevent water making inroad into the lungs. They are all ovoviviparous or baby producers barring two species that are also termed as Sea Kraits because they have some elongated belly scales and they lay eggs overland. However, none of the other hydrophids move overland on their own and cannot do so because they do not have proper belly scale that can help in progression over land or hard surfaces. All their adaptations are for leading a life in salt water.

Their venom fangs are pretty small and fixed on maxilla as in

other elapids. However, their venom is said to be the most toxic among the snakes. When envenomated by a sea snake a victim dies within hours if not treated with proper antivenin. Fortunately most sea snakes have a small head with short fangs that are not so suitable for biting a human being. So far there is no record of human death resulting from sea snake bite in Bangladesh. Also no antivenin for these species is available in the subcontinent. I have seen fisherfolks pulling live snakes out of fishing nets and throwing them back into the water in our coastal areas.

We have over a dozen species of sea snakes in the country, at least five of which live in and around the Sundarban (Khan 1985, 2004, 2010).

Mathakalo Samudrik Shap, Black-headed Sea Snake *Disteira nigrocincta* (Daudin, 1803)

It was founded as a species based on the specimens collected from the Sundarban "Type-locality: Given as Sunderbunds, Bengal, in BMNH catalogue; given as Sandarbans by M. A. Smith, 1943, 1943, Fauna Brit. India, Rept. Amph. 3:1-583[452]."[11] It is one of the common sea snakes in our water.

Leviton *et al* (2003) have provided key to identification of most of the snakes found in Bangladesh as their paper actually deals with all the venomous snakes of the neighbouring Myanmar. Their total length is 108 cm mm and tail length 12.5 cm (Leviton et al, 2003). They are neither in CITES appendices nor in the red book of the IUCN. However, populations of all sea snakes in Bangladesh are apparently going down because of over fishing in the Bay and merciless killing of sea snakes as they get entangled in fishing nets. Also there is no effective conservation measure from the government not only for these but also for all the other snakes barring some of them whose names have been mentioned in the recently promulgated Bangladesh Wildlife (Protection and Safety) Act 2012.

Borshi-nak Samudrik Shap, Hook-nosed/ Beaked Sea Snake *Enhydrina schistosa* (Daudin, 1803)

This is possibly the most common sea snake caught in fisherfolks'

11 http://snakesoftheworld. lifedesks.org/pages/1886 Accessed on 20 January 2013

nets in our coastal area. Also it has a very hefty body which tapers towards a narrow neck and small head, and thick, fleshy paddle-like tail. Overall, its dorsal side appears olivaceous with or without any markings but young ones always have prominently fused crossbars. Its very name comes from a hook-like down curving of the snout in the upper jaw.

Its head and body are 111 cm long while the tail is 19 cm. Between 45 and 55 obscure dark bars extend over its upper side and onto the flanks and are wider than the pale interspaces. The head is dark grey dorsally and pale ventrally. The head shields are enlarged and regular. The mental shield is elongate and dagger-like. In northern Australia, its gestation is thought to take six to seven months and females give birth between March and June (Fry *et al*, 2001).

Lati Shap, Banded Sea Snake *Hydrophis fasciatus* (Schneider, 1799)

This is another species of banded sea snakes common in our coastal water as well as in the Sundarban. Outwardly it resembles the *Borshi-nak* species from the banding but its overall body colour and especially the very narrow body from the anterior one fifth to the narrowest head in contrast to the rest of the bulky body is remarkable. Its head and neck confluent. Its total length for males is 1100 mm, and for females is 990 mm; its tail length is for males 100 mm, and for females 75 mm.[12]

Sadharaon Shoru-matha Samusdrik Shap, Common Narrow-headed Sea Snake *Microcephalophis gracilis* (Shaw, 1802)

Another near shore species of sea snake with bands over the body with a small head but its frontal one third of the body is not as narrow as in the preceding species. "Head small, body long and slender anteriorly; scales on thickest part of body juxtaposed. Total length males 950 mm, females 1025 mm; tail length males 80 mm and females 95 mm" (Leviton *et al*, 2003).

Kalo-Holud Samudrik Shap, Yellow-bellied Sea Snake *Pelamis platura* (Linnaeus, 1766)

This is a deep sea species but often brought ashore by rough

12 http://en.wikipedia.org/wiki/Hydrophis _fasciatus Accessed on 23 January 2013

seas and bad weather or occasionally found in clear water area of the Sundarban facing the main Bay of Bengal. It is not so common but could occasionally be found with fish catch brought ashore for sorting. It has the most uniform and permanent colour of all the sea snakes we encounter in the country. The sides, lips and the underside of the body are yellow that can sometimes be off white with dark dorsal or upperside. On the posterior side of the body the dark of the back may keep extending towards the side of the body that in the tail form distinct half cross bands, of which one set descends from top and another from bottom giving the tail a variegated pattern.

The total length for males is up to 72 cm, and for females 88 cm; the tail is for males up to 8 cm and for females up to 9 cm.[13]

Vipers

A not so common Bangla name for this group is *Bora Shap*. Sand Boas are called *Balu Bora Shap*. We have two distinct groups – the proper viper that is represented by the Russell's Viper and the pit vipers known through several species of Green and Bamboo Pit Vipers – all restricted to the forests and tea gardens of the country. By and large, all vipers have a very pronounced head that can always be separated from an appreciably narrow neck. However, our cat snakes do have such features though their head is not as thick and bulky like the vipers because all vipers have two pairs of venom fangs that can be kept folded on the floor of the upper jaw when not in use. Also their venom glands are much larger than the similar sized elapid snakes. All vipers belong to the family Viperidae.

Common features for the Family Viperidae as stated by Leviton et al, 2003 are as follows: Pupil of eye are vertically elliptical; loreal scale, if absent, then the upper surface of head is either covered by small scales or, if covered by large, symmetrical shields, then a deep sensory pit is present immediately behind the nostril (also present in many in which the head is covered by small scales); venom fangs are variable in length, fixed to a short moveable maxillary bone that allows for rotation of the fangs backward when the mouth is closed; there are no post-fang teeth behind fangs.

Vipers present in Bangladesh vis-à-vis the Sundarban belong to

13 http://en.wikipedia.org/wiki/Pelamis_platura Accessed on 23 January 2013

two subfamilies – Viperinae with the lone Russell's Viper that has no pit organ and the Crotalinae having such an organ in front of the eye and behind the nose. They all have hollow fangs that work like hypodermic needles when venom is injected from the venom glands.

The great majority of the vipers have vertically elliptical, or slit-shaped pupils that can open wide to cover most of the eye or close almost completely, which helps them to see in a wide range of light levels. All our species have keeled scales and are ovoviviparous. Viperid venoms typically contain an abundance of protein-degrading enzymes, called proteases, that produce symptoms such as pain, strong local swelling and necrosis, blood loss from cardiovascular damage complicated by coagulopathy, and disruption of the blood clotting system. Death is usually caused by collapse in blood pressure.[14]

Chandrobora Shap, Russell's Viper *Daboia russellii* (Shaw & Nodder, 1797)

It is possibly the largest and the heaviest viper of the country. Also when alarmed it produces a very loud sound by rubbing scales of one part of the body against the other to warn the intruders. This viper has the longest venom fangs, 16 mm, and can produce the highest quantity of venom in comparison to the size of its body. It is quite colourfully marked too. Its length is on average or maximum of 166 cm – the body being 125 cm and the tail 16 to 20 cm. The girth at mid-body is more than 15 cm; the head length and breadth are 5 cm each. Sometimes the species name is spelt as "ruesslii" that is the original description but misspelling of herpetologist Patrik Russell[15] on whose name the species was first named.

Russell's Viper is distinguished by its light brown bodies with three rows of dark edged brown blotches down its back. The head is flattened, triangular and distinct from the neck. The crown of the head is covered with irregular, strongly fragmented scales. There are two pairs of chin shields, the front pair of which are notably enlarged. The colour patterns of the body consist of a deep yellow, tan or brown ground color, with three series of dark brown spots that run the length of its body. Each of these spots has a black ring around it, the

14 http://en.wikipedia.org/wiki/Viperidae Accessed on 23 January 2013
15 http://en.wikipedia.org/wiki/Daboia Accessed on 23 January 2013

outer border of which is intensified with a rim of white or yellow. The last one on the vent is parabolic in shape.[16]

Its gestation period is around six months after which a gravid female can give birth from 20 to 40 viper babies or viperlings, each of which is more colourful than the mother but has the same or similar markings to her.

Pit Vipers

There are about 7 pit vipers in the country (Khan, 2010). Of these the Green or White-lipped Pit Viper is common in the Sundarban. All pit vipers have a pit organ – a heat sensitive structure between the eye and the nostril externally that is visible as a big hole or depression right in front of the eye. All greenish pit vipers have prehensile tail that aid in a snake hanging down from a branch to strike a prey or movement through foliage.

Sabuj Bora Shap, Green or white-lipped pit viper *Trimeresurus albolabris* (Gray, 1842)

IUCN still keeps its name as *Cryptelytrops albolabris* (Gray, 1842) as proposed by Malhotra and Thorpe (2004) but David et al (2011) returned it to the genus *Trimeresurus*. All *Bora Shap* are well known to people wherever they are found. The Sundarban is no exception. Although its outward look could be slightly confused with *Laodoga* or Green Whip Snake and Green cat Snake its hefty body, large head and scalation separate its from the rest. All pit vipers we have in the country are basically green barring one that lives in high hills. This one has whitish lip and underside, which could also be faded yellow. Its tail prehensile and often reddish in young specimens but not spotted. Sometimes there could be a white lateral line below the eye. The former measures 60 cm in head and body and 12 cm in tail while the same for the latter 81 cm and 13 cm respectively (Leviton *et al*, 2003).

All pit vipers are nocturnal and basically arboreal. A viper spends daytime coiled up on a branch camouflaged by green foliage. It kills prey by injecting venom that is generally haemotoxic and muscle damaging. Major prey includes rodents, birds and other small

16 http://factsanddetails.com/Asian.php?itemid=2437&catid=68&subcatid=434#140

vertebrates. Generally people do not die from the envenomation of this species but suffer from severe damages from tissues and external organs with permanent disabilities. "In adults, envenomation with *T. albolabris* is frequently associated with local oedema and inflammation, while disturbance of coagulation is less common and rarely life-threatening" (Cokram *et al*, 1990) in Thailand.

Chitrito-Lej Sabuj Bora, Red-tailed Bamboo Pit viper, *Trimeresurus erythrurus* (Cantor, 1839)

Very similar to the above species and confusable with it in the field unless seen from close quarters. Its tail is usually always reddish and have spots. Its upperside is generally green but is not as prominent as in the preceding species while the males have a pale ventro-lateral line that might be lacking in females.

It is less common than the White-lipped or is less noticed because of confusing colour patterns.

Overall we in Bangladesh have less tolerance for snakes in general and venomous snakes in particular. There is a general trend of decline of snakes in the country first due to the wholesale loss of habitats in the countryside and in most forests but the Sundarban followed by large scale killing by people due to ignorance about the snakes and use of specimens for snake charming, as exhibits in zoos and use in traditional medicine.

Because of the remoteness and inaccessibility of the Sundarban and since no human being permanently lives inside it most snakes have least interaction with people. They have found a natural refuse in the Sundarban.

REFERENCES

BOULENGER, G. A. 1890. *The Fauna of British India, including Ceylon and Burma. Reptilia and Batrachia*. London: Taylor and Francis; Calcutta: Thacker, Spink, & Co.

BOULENGER, G. A. 1893. *Catalogue of the snakes in the British Museum (Natural History*). Vol.1. British Museum (Natural History), CROMWELL ROAD, London, U.K.

Cockram, C. S., Chan, J. C., and Chow, K. Y. 1990. *Bites by the white-lipped pit viper (Trimeresurus albolabris) and other species in Hong Kong*. A survey of 4 years' experience at the Prince of Wales Hospital. J Trop Med Hyg 93:79-86.

Cogger, H.G. 2000. *Reptiles and Amphibians of Australia* - 6th edition. Sydney, NSW:

Reed New Holland.

David, P., Vogel, G. and Dubois, A. 2011. *On the need to follow rigorously the Rules of the Code for the subsequent designation of a nucleospecies (type species) for a nominal genus which lacked one: the case of the nominal genus Trimeresurus Lacépède*, 1804 (Reptilia: Squamata: Viperidae). Zootaxa 2992: 1-51.

Faiz, M. A., Ghost, A., Ashen, M. D., Rahman, M. R., Amin, M. R., Hassan, M. M. U., 3 Mad A. Wahid Chowdhury, M. A. W., Koch, U., Rocha, T., Harris, J. B., Thomaston, D. G. and Darrell, D. A. 2010. *The greater black krait (Bungarus niger), a newly recognized cause of neuro-myotoxic snake bite envenoming in Bangladesh*. BRAIN-A JOURNAL OF NEUROLOGY vide Brain 2010(133): 3181–3193 doi:10.1093/brain/awq265. Downloaded from http://brain.oxfordjournals.org/ by guest on January 20, 2013.

Fry, G.C., A. Milton and Wassenberg, T.J. 2001. *The reproductive biology and diet of sea snake bycatch of prawn trawling in northern Australia: characteristics important for assessing the impacts on populations*. Pacific Conservation Biology. 7:55-73.

Khan, M. A. R. 1985. St. Martin's: A vanishing coral island of Bangladesh. Tiger Paper 12, 6-12.

Khan, M. A. R. 1986. *Wildlife in Bangladesh mangrove ecosystem*. J. Bombay Nat. Hist. Soc. 83 (1): 32-48.

Khan, M. A. R. 2004. *Checklist of the herpetofauna of Bangladesh*. Cobra 57: 1-31.

Khan, M.A.R. 2010. *Wildlife of Bangladesh from Amphibia to Mammalia*. A checklist. Shahitya Prakash, 87 Purana Palton Line, Dhaka 1000, 128 pp.

Leviton, A. E., Wogan, G. O.U.;. Koo, M. S., Zug, G. R., Lucas, R. S. and Jens, V. 2003. *The Dangerously Venomous Snakes of Myanmar- Illustrated Checklist with Keys*. Proc. Cal. Acad. Sci. 54 (24): 407-462.

Malhotra, A., and Thorpe, R.S., 2004. *A phylogeny of four mitochondrial gene regions suggests a revised taxonomy for Asian pit vipers (Trimeresurus and Ovophis). Molecular Phylogenetics and Evolution* 32: 83-100.

Neumann-Denzau, G. and Denzau, H. 2010. *The Brown vine snake Ahaetulla pulverulenta (Duméril, Bibron & Duméril, 1854) in the Sundarban*, Bangladesh – first record from the eastern part of the Indian subcontinent. Herpetology Notes, 3: 271-272.

O'Shea, Mark. 2005. *Venomous Snakes of the World*. New Jersey, USA: Princeton Uinv. Press.

Roofing, Nelly de. 1917. *Reptiles of the Indo-Australian archipelago*. E J Brill.

Theophilus, E., Captain, A., Tillack, F., and Kuch, U. 2008. *Notes on geographic distribution: Reptilia, Elapidae, Bungarus niger- Distribution extension and first record for the state of Uttarakhand*, India, with notes on snakebites in the Gori River valley. Check List 4(4): 404-409, 2008.

Lizards and Frogs of the Sundarban

The Sundarban is full of life. The *Ganga-Brahmaputra-Meghna* river system blends with the Bay of Bengal at the southern part of Bangladesh and forms the delta. The Sundarban lies at the head of this delta. Over the years deposition of silts has made this area productive. This magnificent forest is rich in both land and aquatic ecosystems. Thus a huge proportion of wildlife inhabits it.

The Sundarban is the last remaining home of charismatic Bengal Tiger – the national pride of Bangladesh. Along with such fascinating mammalian species this forest supports a wide range of bird species. A large number of amphibians and reptiles are also common resident in the Sundarban including the world's largest venomous snake – *Raj Gokhra*, King Cobra (*Ophiophagus hannah*), largest living reptiles of the

By **Mushfiq Ahmed**

world – *Lonapnair Kumir*, salt-water Crocodile (*Crocodylus porosus*), etc. Different amphibians, turtles, lizards and snakes comprise the major part of herpetofauna here. It is assumed that there are 49 species of mammals, 320 birds, 53 reptiles and 11 amphibian species in the Sundarban (Shariar, 2011).

In Bangladesh, there are three species of *Varanus* (Bengal Monitor, Yellow Monitor and Water Monitor), all of which occur in the Sundarban. Among these Ramgadi, Water Monitor (*Varanus salvator*) is common in the Sundarban. It is the largest lizard in Bangladesh, but the second largest in the world. It measures 1.5 to 2 m that could be up to 3 m. A common mature weight of *Varanus salvator* can be 19.5 kg[1]. It is an excellent swimmer and usually resides close to water. The raised fin located on its tail helps it steer through water and grab prey like fishes, frogs, birds, crabs, snakes, etc. It also eats turtles as well as young crocodiles.

Another superbly coloured lizard of the Sundarban is the Shona Gui, Yellow/Golden monitor (*Varanus flavescens*) which is a bit partial to land than water, unlike the previous one and prefer the boundary of the Sundarban that borders human habitations. It measures about 37 cm in head and body or snout to vent while the tail is about 50 cm, being the smallest among the three species of *Varanus* we have in the Sundarban and other parts of the country. This monitor feeds on small invertebrates and vertebrates. It is more fossorial than the other two species.

The third Varanus species of the Sundarban is the Gui, Bengal Monitor (*Varanus bengalensis*) that is widely distributed all over the country. It is mainly terrestrial though the young are arboreal in nature. This lizard is usually found taking shelter in the burrows it digs in this forest. Like other varanids of Sundarban it is also diurnal. This species is usually seen in and around the villages bordering the Sundarban, though it is shy and tries to avoid humans. The snout to vent length is about 75 cm while the tail extends up to 100 cm. It loves to feed on crabs, fishes, some birds and small mammals, including rats and mice.

All three species of varanids love to bask on trees during winter.

1 http://en.wikipedia.org/wiki/Water_monitor downloaded on 25 September 2012

None of these hibernates. Also these are considered the Least Concerned Species as per the Red Book of the IUCN (International Union for Conservation of Nature and Natural resources).

Along with these varanids few a small lizard species like Raktochusha, Garden lizard (*Calotes versicolor*), Daksara Tiktiki, Common House Gecko (*Hemidactylus frenatus*) and Khoshkhoshe Tiktiki, Brook's House Gecko (*H. brookii*) are commonly seen in the Sundarban along with the Keeled Indian Mabuya (*Eutropis carinata*). The Tokkhok, Tokay Gecko (*Gekko gecko*) is apparently not uncommon in the Sundarban, although it is more often heard than seen. One of the largest among the house geckos is the Goda Tiktiki, Yellow-bellied House Gecko (*Hemidactylus flaviviridis*) is partial to human habitations bordering the Sundarban.

The Common Toad, Marbled Toad, Bull Frog, Ornate Narrow-mouthed Frog, Indian Skipper Frog, Green Pond Frog, Crab-eating Frog and Cricket Frog are the common residents of the Sundarban mangrove forest area. Amphibians on the whole though are intolerant to saline conditions but the Kankra-bhook Bang, Crab-eating Frog (*Fejervarya cancrivora*) among them is an exception. This frog is found in the brackish water of mangrove streams and also in the adjacent damp grassy areas. It is usually found during low tide on the mud banks, beneath the mangroves when these get exposed.

The Kuno Bang, Common toad (*Duttaphrynus melanostictus*) is found in many areas of the forest. The remaining species of frogs are usually found in the freshwater ponds and ditches within or near the forest. Of these the most charismatic species is the Sabuj Bang, Green Pond Frog (*Euphlyctis hexadactylus*) which in addition to small animal food also eats leaves and some flowers.

All the species of amphibians have their specific roles to the environment they belong to. As they require both terrestrial and aquatic habitats to sustain their lives they maintain the linkages between these two ecosystems.

Lizards and frogs have a great role in controlling harmful insects. In this way they control disease. The members of *Varanus* genus are mainly carrion eaters and they clean the environment by eating dead and rotten materials. They also feed on live animals. Frogs are good biological indicators because of their intermediate position in the

food webs. Recently scientists discovered that they can indicate the change of environment like earthquake. Most of the lizards are not harmful to humans.

Some species of lizards and frogs are threatened and rarely seen in Sundarban. Their habitats are being destroyed day by day. Frogs and Varanids need fresh water to survive. But increase of salinity is pushing their existence in danger. Moreover, killing, poaching, lack of awareness and law enforcement, etc., are crucial threats to their survival.

Prevailing misconception that *Gecko* has high medicinal or aphrodisiac value is enticing the poachers to catch and kill Tokay Gecko in the Sundarban and other parts of the country. The economic value of skin of varanids allures poachers to hunt them. Though all the three varanids found in the Sundarban have no strong predator but the reason why they are in the endangered list in Bangladesh is that people use their skin for fashion items. Most of the people are not aware about the biological importance of this wildlife. Frog population is decreasing because of indiscriminate use of pesticides that kills the tadpoles, and the poisoning water to catch fish in the canals of the Sundarban. Explosion of human population around the Sundarban and in the country in general is gradually occupying the wilderness and making the wild inhabitants threatened. A holistic management approach should be taken to protect the frogs and lizards of the Sundarban. Mass people awareness, scientific study, long term conservation plan, policy development and proper law enforcement can help save them from further decline in population.

Birds of the Sundarban

It is commonplace to meet discontented tourists who whine on not being able to see tigers, deer, monkeys, boars, otters and crocodiles in the Sundarban as much as they anticipated. They can be forgiven for forgetting that our yearning to see the wildlife is not matched by the desire of those creatures to see us except, in case of tigers and crocodiles, at dinner. But we find it hard to exonerate those who go by and do not celebrate the gems that are aplenty on even a very short tour in the Sundarban. One does not have to be a bird-watcher, for example, to come across quite a few bold and beguiling birds in this beautiful forest.

The Sundarban is famous for tigers, not birds. But in terms of birdlife it is the richest forest in Bangladesh. It is home for nearly 300

By **Enam Ul Haque**

species of birds including 13 globally threatened and near-threatened birds (Table-1). For the three of the 13 birds of global conservation concern – Masked Finfoot, Brown-winged Kingfisher and Mangrove Pitta – the Sundarban may easily be the largest and the safest home in the world. Other known habitats of these three birds anywhere on earth do not have the immensity and protection the Sundarban.

To a typical tourist in the Sundarban, however, the sights and sounds of birds are common, confiding, loud and big and are much more impressive than the statistics of diversity. As the tourists' boat moves in this forest it keeps flushing Brown-winged Kingfishers from their retreat. The dazzling Kingfisher with large red bill and a loud cry *ka-ka-ka-ka-ka* never fails to startle the tourists lulled by the overpowering tranquility of the forest. Besides this grand fellow, seven species of kingfishers can be seen here. Three of those – Collared, Black-capped and White-throated Kingfishers – are big, bold and numerous enough to claim tourists' attention. The Ruddy Kingfisher prefers narrow creeks which tourists' boats cannot venture in. Common and Blue-eared Kingfishers are too tiny and furtive to be generally loved. Pied Kingfisher is seen too infrequently and only at the forest fringes. Brown-winged Kingfisher, therefore, easily wins the trophy as the most charming fisher of the Sundarban.

In the Sundarban, the tourists' boats are often followed by the Brahminy Kites. Being poor hunters these clever birds make a living by snatching fish when those are stunned by the rotating propellers of the boats. At places like Kotka and Kochikhali a boat may be accompanied by a dozen kites flying silently in beautiful saffron dress of the Brahmins. The kites do not follow a boat for a long time or sit on water to rest like gulls and terns. They watch the boats from their roost in the trees or soaring circuits in the sky and fly in at the opportune moments to swoop down on floating fish or offal.

Brahminy Kite may be the most visible raptor of the Sundarban, but certainly not the most elegant. We have to cede that title to the White-bellied Sea Eagle. These huge eagles with white belly and grey back soar incessantly over the coastal water and the wide channels in the forest. It does not take too much luck to see the massive eagle fall from the sky as fast as gravity can pull it, and take a large struggling fish in its talons from the brown water of the bay. In summer, the

eagles are found sitting in pairs on high perches and cackling like some crazy ducks. The Sundarban may be one of the best nesting grounds of the White-bellied Sea Eagle.

Besides the White-bellied Sea Eagle four other eagles nest in the Sundarban. They are Pallas's Fish Eagle, Grey-headed Fish Eagle, Crested Serpent Eagle and Changeable Hawk-Eagle. The two fish eagles are 'Vulnerable' – the threatened birds of the world as per the Current IUCN Red List category[1] and by nesting here augment the conservation values of the Sundarban. This forest is the only breeding ground of Pallas's Fish Eagle in Bangladesh outside the haor basin. Bird-people love the Sundarban as the breeding ground of the five of the six resident eagles of Bangladesh. The sixth resident eagle named Indian Spotted Eagle, is another globally vulnerable bird. It has been seen but not recorded to be nesting in this forest.

The Sundarban is frequented by three migratory eagles. They are Greater Spotted Eagle, Steppe Eagle and Booted Eagle. The Greater Spotted Eagle, a vulnerable bird of the world, makes the Sundarban, the haor basin and coastal wetland of Bangladesh its winter home. Of these three areas, the Sundarban can confidently be termed the least disturbed. It is disturbing to note that even here the sightings of this threatened bird have been declining.

Five hawks and harriers are seen in the Sundarban. Of these Shikra is the most common bird of prey in this forest. The Besra is seen less frequently; and the three harriers – Western Marsh, Northern and Pallid Harriers – are seen still less. More frequent and impressive presence of Peregrine Falcon has been noted in this forest. This formidable falcon is seen perching atop high branches of mangrove manfully sitting on the sand or loam at the edge of the forest.

That is all about the birds of prey that hunt by day in the Sundarban. But this forest does have a busy nightlife; and that is not only about the tigers and a few lesser cats on the prowl. The Sundarban is a good place to see the last surviving large owls of Bangladesh. The largest owl of this forest is the Dusky Eagle Owl. It is easily seen at north-east edge of the forest, especially the place called Laodob. The forest also has three fish-owls: Brown Fish, Buffy Fish and Tawny

1 http://www.birdlife.org/datazone/speciesfactsheet.php?id=3363

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Fish Owls. Brown Fish Owl is probably the most widespread owl of the Sundarban. Two medium-sized owls are also seen in areas where human habitations meet the forest. They are Barn Owl and Brown Hawk Owl.

The bird that helps make the beating heart of the Sundarban audible at night is called Large-tailed Nightjar. As the dusk sets in the forest the nightjar commences an endless calls *chaunk chaunk chaunk chaunk...* and carries it on intermittently till dawn. The nightjar is widespread and the rhythmic, mechanical beats can be heard throughout the forest. The other, albeit less widespread, rhythmic nightly caller of this forest is Indian Nightjar. Its call is again a single note *chuk* often repeated at a higher frequency than that of its more widespread cousin.

A casual tourist in the Sundarban is very likely to miss the owls and the nightjars because of the odd hours they keep. He is also likely to miss two species of very interesting birds not because of their nightlife, but because of their bashfulness and surreptitiousness. Their names are Mangrove Pitta and Masked Finfoot. Of the five species of pitta we have, Mangrove Pitta belongs exclusively to the Sundarban. It has not been seen anywhere else in Bangladesh. This dainty, many-coloured bird is a viewer's delight. But to have a peek at it may be one of the hardest goals one can set on a short tour of the Sundarban. Its haunting calls '***hhwa-hwa hhwa-hwa...***' are heard all over the forest but hardly ever seen. It walks on the forest floor to feed on crawling insects, etc., and nests high up in the mangrove. It is a near-threatened bird of the world. The Sundarban may have the world's largest population of Mangrove Pitta.

The other strange bird of the Sundarban is Masked Finfoot. It is as mysterious as its name suggests. It is also an endangered bird of the world. The Sundarban may be the largest home of this unique bird in need of our conservation efforts. To a casual observer it may just be a diffident duck of an indefinite genus. But it is no cousin of a duck or goose but distantly related to Purple Swamphen, a familiar bird of the haor basin. Water Rail is its only distant cousin seen in the Sundarban. It walks the water-edge to feed on aquatic insects. But rail is a migratory bird and lives here only in the winter months when finfoot is a resident bird and breeds here during June

to August. Masked Finfoot is a much larger bird with very different habits. It usually swims alone stealthily in the tidal creeks in the most undisturbed parts of the forest and feeds on fish, mudskipper, crab and aquatic insects. It nests in the mangrove in monsoon and the little duckling-like chicks leave the nest and enter the tidal world of mud and water on the first day of their lives.

A large bird accompanying a pack of Spotted Deer feeding along the mud-banks of rivers and creeks at low tide in the Sundarban often astounds the tourists. The bird stands as tall as the deer. With the bald head and very large bill the bird looks a little ungainly. The bold bearing and equanimity of the bird are bound to impress a viewer. The name of the bird is Lesser Adjutant. Weighing a little over five kilograms it is the largest and heaviest resident bird of Bangladesh. Unfortunately very few of them exist in our country outside this forest. It is a globally vulnerable bird and we must act now to conserve it in the Sundarban.

The Red Junglefowl is another flamboyant bird like the Mangrove Pitta that is more often heard than seen in the Sundarban. From its famous calls 'cock-a-doodle-do' heard all over the forest we guess that a good population of it exists here. We know that it feeds and nests on the ground; and the tidal water inundates three fourth of the forest floor twice every day. Life of this ground dwelling bird cannot be too easy here. How it shares the dry ground with its predators is a mystery to us. Whatever it does to survive here it seems to be doing that effectively enough so far. We still do not have to worry for its continued existence in the Sundarban.

The other flamboyant and visible birds of the Sundarban are the migratory ducks. Several species of ducks are seen in winter in the wider waterways of the forest and the newly-formed coastal islands on the south. The more commonly seen ducks are Ruddy Shelduck, Common Shelduck, Northern Pintail, Northern Shoveller, Eurasian Wigeon, Gargany and Gadwall. Big flocks of locally migrating Lesser Whistling Duck are also often seen. Fortunately a healthy population of these ducks exists in the world and none is a big conservation concern. But we cannot say the same about the Black-headed Ibis, a winter visitor to the mudflats south of the forest. It is a near-threatened bird of the world and in need of our protection.

: Enam Ul Haque

Flocks of shorebirds are occasionally seen on the mudflats south of the Sundarban in winter. The species worth mentioning here are Black-tailed Godwit, Eurasian Curlew, Whimbrel, Common Redshank, Wood Sandpiper, Common Greenshank, Ruddy Turnstone, Curlew Sandpiper and Pacific Golden Plover. Of these birds the first two are globally near-threatened birds. A critically endangered bird of the world, Spoon-billed Sandpiper, was seen here in large number and may still be thriving here in small number. These mudflats need to be checked for the presence of this critical species.

The only shorebird known to breed in the Sundarban is the Great Stone-curlew, also known as Great Thick-knee. The sandbar at Kochikhali is its usual breeding place. Because of its sand-colored plumages the small flock generally remains invisible and safe at the beach. While incubating eggs on the sand and raising the flightless chicks on the beach, however, the breeding pairs become vulnerable to natural predation and human disturbances for about two months. We need to tread on this important place cautiously and hope that the Forest Department will soon mark off and guard the breeding site in winter and early monsoon.

The other bird that breeds in the sand in the Sundarban is the Blue-tailed Bee-eater. In winter, it burrows in the sand to lay eggs. Several large nesting colonies of these beautiful blue birds are there where tourists hang around in front of the observation tower at Kotka. These nesting areas have also not been marked. No sign has been posted beseeching tourists not to disturb the breeding birds. The other bee-eater common in the Sundarban is the Chestnut-headed Bee-eater. Both the bee-eaters are seen dashing out after the flying insects in their foraging flights. While the Blue-tailed perches on exposed sticks, the Chestnut-headed sits partly hidden in the foliage.

The lush foliage of the mangrove gives ample cover to many birds weary of flying predators such as hawks, harriers and falcons. Peregrine Falcon is the only predator the larger birds suck as Orange-breasted Green Pigeon need to worry about. It is the most numerous Green Pigeon of the Sundarban. It is a pleasure to watch flocks of these beautiful birds descend on a fruiting tree. The yellow, lilac and orange colours on the breast of the males are feasts for the eyes. Thick-billed Green Pigeon is another beautiful but less numerous

bird of this forest.

While dwelling on the pleasure of watching colorful birds in the Sundarban we will miss out much if we do not name a few woodpeckers. This forest is a veritable paradise for the peckers. As the sand accumulates over the breathing roots the mangroves die fast, and the ants colonize the dead trees even faster. The woodpeckers come immediately to knock at every door of those colonies and take a few residents to lunch. The six most dazzling peckers of this forest are Lesser Goldenback, Common Goldenback, Greater Goldenback, Lesser Yellownape, Greater Yellownape and Streak-throated Woodpeckers. Streak-breasted Woodpecker is, however, a very distinctive bird because it has not been recorded in Bangladesh anywhere outside this forest. Greater Yellownape and Greater Racket-tailed Drongo make an odd couple of the Sundarban. The Drongo routinely follows the Yellonape. The Drongo seems to benefit from the insects flying away from chiseling bills of the Yellonape. Two unbelievably tiny peckers also live here: Grey-capped Pygmy Woodpecker and Speckled Piculet. The piculet is probably the 2nd smallest bird of the Sundarban next only to Orange-bellied Flowerpecker that ranges from 7.5-9 cm in total length.

A woodpecker climbs slowly up the tree-trunk in a number of short and awkward jumps. But a nuthatch can run up and down a vertical trunk at a speed and ease no woodpecker can even dream of. The only nuthatch seen all over the Sundarban is the Velvet-fronted Nuthatch. This remarkable bird has a very long and strong hind toe with a special claw that helps it go up and down the vertical trunk at great ease.

To the seasoned bird-watchers the Sundarban in winter seems to be teeming with flycatchers, warblers and thrushes. Every year these little migrants make the mangrove their winter home. Those indescribable enigmas are better left to the specialists. We will grapple only with a few big, bold and beautiful ones. The most obvious flycatcher in this forest is the Verditer Flycatcher. This beautiful blue bird often perches on an exposed twig high up. Watch-tower at Kotka is a good place to watch this bird. The thrush that faithfully visits Kotka forest office every winter is the Blue Rock Thrush.

: Enam Ul Haque

There are several families of petite birds in the Sundarban that champion in minuteness. Yellow-belied Prinia may be the most obvious of all tiny birds of the Sundarban. It is usually seen in the reed and grass. It is an amazing fact that a Lesser Adjutant is equal to 500 Prinias in weight. Orange-bellied Flowerpecker and Crimson Sunbirds are the other two little jewels of this forest. These birds thrive on the abundant flowers of the mangrove and the berries of parasitic plants. While insignificant in size these birds are outstanding in colour.

The black group of birds that keep the Sundarban reverberating in sounds and sights are the drongos, most obvious of which is the Greater Racket-tailed that is seen almost everywhere in the forest and imitating noises of most animals that live in its environs. The smallest of the lot is the Bronzed Drongo, which is also one of the commonest resident birds of the Sundarban.

The bird bio-diversity of the Sundarban is truly enormous. The Sundarban is the most precious habitat for many of these birds. As the Sundarban shrinks these birds lose their homes and the risks in the lives of a dozen of the threatened birds of the world increase. The Sundarban must be saved as much for its birdlife as for its tigers.

Table 1: The Sundarban's 13 Birds of Global Conservation Concern based on IUCN's Red Data Book

Name	Threat Category	Presence in the Sundarban
White-rumped Vulture	Critical	All over forest, rare
Spoon-billed Sandpiper	Critical	Seen in Egg Island, rare
Masked Finfoot	Endangered	All over forest, rare
Lesser Adjutant	Vulnerable	All over forest, uncommon
Pallas's Fish Eagle	Vulnerable	North-east edge, rare
Greater Spotted Eagle	Vulnerable	Northern fringe, rare
Indian Spotted Eagle	Vulnerable	Northern fringe, rare
Grey-headed Fish Eagle	Near-Threatened	Northern fringe, rare
Brown-winged Kingfisher	Near-Threatened	All over forest, common
Eurasian Curlew	Near-Threatened	Southern fringe, uncommon
Black-tailed Godwit	Near-Threatened	Southern fringe, uncommon
Black-headed Ibis	Near- Threatened	Southern fringe, rare
Mangrove Pitta	Near- Threatened	All over forest, common

Glimpses of the Threatened Wildlife of the Sundarban

When I first read about the Sundarban, I dreamt of seeing a tiger crossing a narrow creek and looking towards me once ashore. After a few first visits to the Sundarban, I soon realised that this far-flung forest has a lot more fascinating glimpses to offer. I have been lucky to experience the wonderful winter mornings, riding over the murky waterways of the thick green mangroves to witness the golden sunrays filtering through the dense canopy and mist; and the magical monsoon downpour making it even more exciting with the added velocity of the water. The fantasy of seeing a tiger did not strike me for long as the legacy of the mighty mangrove and its diversity soon began to rule my mind.

By **Sayam U. Chowdhury**

It has become common knowledge that the Sundarban is home to the globally endangered species like the Bengal Tiger but it is news flash to most that our Sundarban also supports critically endangered species like the River Terrapin or the endangered Fishing Cat. Both of these species are undergoing a sharp decline and has already disappeared from most of their ranges throughout Asia.

Ever since I got interested in wildlife, I was always captivated by rare, threatened or endangered species. While looking for them in the Sundarban, the Critically Endangered White-rumped Vulture was the first one to greet me, soaring just a few kilometers downstream from Mongla Port. So far, the Sundarban remains one of the few places where one can see this species, which was once widely distributed throughout Bangladesh and the Indian Subcontinent. This widespread decline perhaps began in the 1990s, which resulted in an overall population decline of more than 99% over a 10-15 year period. In the wake of this population crash, the White-rumped Vulture was reclassified as Critically Endangered, placing it amongst the species most threatened with global extinction (Birdlife International 2012).

The Pallas's Fish Eagle would most likely be the second one to grab attention of a threatened species-hunter. It occurs in the freshwater areas close to the buffer zones of the Sundarban, especially around Laadobe. The wetlands and riverbanks of Bangladesh host unique biodiversity even in areas with varying degrees of human utilisation. However, their high biomass productivity also leads to ever-intensifying human use. Moreover, increased population pressure of Bangladesh has resulted in the conversion of natural wetlands into agricultural lands and commercial fisheries. Encroachment and many other human activates have created intense pressure on resources available to native biota. A victim of this environmental degradation is the Pallas's Fish-eagle, a globally threatened raptor (recently recommended IUCN status is Vulnerable). This breeding visitor was quite common in Bangladesh in the freshwater wetlands and along the major rivers with regular nesting records (Birdlife International 2012). However, to date this species has become a rarity and only a few nesting sites (Sundarban and freshwater wetlands in the northeast) are known to scientists. According to Birdlife International the decline of Pallas's Fish-eagle is taking place due to habitat loss,

prey scarcity, lack of suitable nesting trees, pesticide use, etc. The presence of this sensitive species indicates that the freshwater zones of the Sundarban are still in healthy state.

As you travel through the Sundarban you will be fascinated by the flashes of the Ganges River Dolphin or Shushuk over the water surface and you can certainly catch a close glimpse of these greyish brown river-mammals, especially in Dhangmari, Chandpai and Dudhmukhi of the Eastern Sundarban. The Ganges River Dolphin is a globally Endangered species and rapidly disappearing from large rivers of Bangladesh, although Sundarban still supports one of the largest populations of this species in the world.

> There are 1,140 species of threatened mammals, 1,313 species of threatened birds and 802 species of threatened reptiles around the world and amongst these our country supports 34 species of mammals, 31 species of birds and 22 species of reptiles (IUCN 2012). The Sundarban holds three species of globally Endangered mammals - Bengal Tiger *Panthera tigris*, Ganges River Dolphin *Platanista gangetica* and Fishing Cat *Prionailurus viverrinus*, Finless Porpoise *Neophocaena phocaenoides*, Irrawaddy Dolphin *Orcaella brevirostris* and Oriental Small-clawed Otter *Aonyx cinerea* are categorized as globally Vulnerable; five species of globally threatened birds, amongst these Pallas's Fish Eagle *Haliaeetus leucoryphus* and Lesser Adjutant *Leptoptilos javanicus* are listed as globally Vulnerable, Masked Finfoot *Heliopais personatus* as Endangered and White-rumped Vulture *Gyps bengalensis* and Spoon-billed Sandpiper *Eurynorhynchus pygmeus* (last record was in 1992 from Dimer Char or Egg Island) as Critically Endangered; four species of globally threatened reptiles – the Critically Endangered turtle Northern River Terrapin *Batagur baska* and Vulnerable Olive Ridley Sea Turtle *Lepidochelys olivacea*, King Cobra *Ophiophagus hannah* and Burmese Python *Python bivittatus* (Bird Life 2012, IUCN 2012). The Critically Endangered ones are heading faster to global extinction than the others.

Another species that is known to lurk under the muddy water of the numerous rivers and creeks of the Sundarban is the Critically Endangered Northern River Terrapin or *Batagur baska*, although very few people have seen it in the wild.

While only a thousand or less mature individuals of Masked Finfoots are left in the world, our Sundarban supports a considerable number of them. The species is classified as Endangered due to the destruction and increasing disturbance to rivers in lowland riverine forests, hunting and collection of eggs and chicks. And now Masked Finfoots are thinly distributed from north-east India to south-east

: Sayam U. Chowdhury

Asia but yet the Sundarban of Bangladesh remains a definite place to see this elusive bird. It is possible to spot this rare bird at low tide foraging along the edge of the canals and rivers, especially from Supoti to Chhita-kotka in the eastern Sundarban. It's a pity that many fisherfolk in the Sundarban capture Finfoot or destroy their nests while setting up *Charpata Jaal* along narrow streams. Fisherfolk usually set up long fishing nets at low tide along banks of canals or *khals* and harvest fish after high tide. Many of them flush incubating Finfoots while affixing *Charpata net* underneath or near the nest and came back at night to grab the unfortunate Finfoot, eggs or chicks on nest.

The Oriental Small-clawed Otter can be spotted anywhere in the Sundarban, crossing or walking along narrow creeks and then suddenly vanishing into the vegetation. This species is the smallest of all the otters in the world and considered globally Vulnerable due to habitat destruction, hunting and pollution.

The King Cobra and the Burmese Python are now red listed as Vulnerable by the IUCN. Both of these occur in the Sundarban but the King Cobra is more often seen swimming through the water surface than the secretive Python. The Olive Ridley Sea Turtle, sharing the same threat category comes to the Sundarban's shore to lay eggs during the dry season. The sandy beaches of the Sundarban are among the few places in Bangladesh that provides vital breeding grounds for these rare sea turtles.

The Critically Endangered Spoon-billed Sandpiper was once recorded in 1992 from *Dimer Char* (Egg Island) of the edge of the Sundarban. One might not be lucky enough to see this species or the Tiger in the Sundarban but can enjoy the presence of the globally Vulnerable Lesser Adjutant foraging on the exposed mud along rivers or sitting on the top of a Keora tree or the Greater Spotted Eagle soaring over the mangrove or resting on the grassy plains.

Altogether, this magical mangrove forest supports a handful of species that are rare, highly threatened worldwide and on their last legs of journey towards extinction. By protecting this fantastic forest we would be saving all these species that are close to extinction and home of thousands of other wild animals and humans.

Table 1: List of nationally and globally threatened and near threatened species of the

Sundarban

Class	English Name	Scientific Name	National Status	Global Status
Mammals	Bengal Tiger	*Panthera tigris*	Critically Endangered	Endangered
	Fishing Cat	*Prionailurus viverrinus*	Endangered	Endangered
	Oriental Small-clawed Otter	*Aonyx cinerea*	Endangered	Vulnerable
	Ganges River Dolphin	*Platanista gangetica*	Endangered	Endangered
	Finless Porpoise	*Neophocaena phocaenoides*	Endangered	Vulnerable
	Irrawaddy Dolphin	*Orcaella brevirostris*	Critically Endangered	Vulnerable
Birds	White-rumped Vulture	*Gyps bengalensis*	Not Threatened	Critically Endangered
	Lesser Adjutant	*Leptoptilos javanicus*	Endangered	Vulnerable
	Masked Finfoot	*Heliopais personata*	Endangered	Endangered
	Spoon-billed Sandpiper	*Eurynorhynchus pygmeus*	Data Deficient	Critically Endangered
	Pallas's Fish Eagle	*Haliaeetus leucoryphus*	Critically Endangered	Vulnerable
	Greater Spotted Eagle	*Aquila clanga*	Vulnerable	Vulnerable
	Mangrove Pitta	*Pitta megarhyncha*	Data Deficient	Near Threatened
	Brown-winged Kingfisher	*Pelargopsis amauroptera*	Not Threatened	Near Threatened
Reptiles	Northern River Terrapin	*Batagur baska*	Critically Endangered	Critically Endangered
	Olive Ridley Sea Turtle	*Lepidochelys olivacea*	Endangered	Vulnerable
	Burmese Python	*Python bivittatus*	-	Vulnerable
	King Cobra	*Ophiophagus hannah*	Endangered	Vulnerable

Source: National Status, IUCN-2000

REFERENCES

BirdLife International (2012) *IUCN Red List for birds*. Downloaded from http://www.birdlife.org on 16/10/2012.

IUCN Bangladesh (2000) *Red list of threatened animals of Bangladesh*. Dhaka: IUCN.

IUCN 2012. *The IUCN Red List of Threatened Species*. Version 2012.1. <http://www.iucnredlist.org>. Downloaded on 19 June 2012.

: Sayam U. Chowdhury

Waterways of the Sundarban: Home to Freshwater Cetaceans

The Bangladesh Sundarban is the home to Ganges River (*Shushuks*) and Irrawaddy dolphins, and it is the only place in the world where both these species live together. Their numbers are much higher in Sundarban – as well as in Bangladesh – in comparison to other areas in Asia. On the other hand, Bangladesh is recognized as a global hotspot for Cetacean (scientific group of dolphins, whales and porpoise) diversity and abundance after the discovery of world's largest population of Irrawaddy dolphins (about 6000 animals) in the Sundarban and adjacent coastal waters, and the world's second largest population of bottlenose dolphins in the Swatch of No-ground, and the occurrence of thousands of animals that belong to five families of cetaceans in the riverine, coastal and marine waters of Bay of Bengal (Table 1).

By **Zahangir Alom**

During the last twelve years, the Wildlife Conservation Society's Bangladesh Cetacean Diversity Project identified a 120km wide estuarine, coastal and offshore area as "hotspot" for Cetacean diversity and abundance where the world's largest mangrove forest meets to the 900+ meter deep under water canyon known as Swatch of No-Ground (SoNG), and three freshwater dolphin "hotspot" sites in the Eastern Sundarban Reserved Forest (ESRF). About half of the Ganges River (*Platanista gangetica*) and a quarter of the Irrawaddy (*Orchaella bravirostris*) dolphins' population of the Sundarban have been recorded from these hotspot sites. For this reason, in January 2012 these hotspots sites were declared as three Wildlife Sanctuaries (Dhangmari, Chandpai and Dudhmukhi) (Figure 1 and 2) by the government of Bangladesh under Article 23(3) of the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974. Responding to Bangladesh's national commitment to the United Nations Convention on Biological Diversity (CBD), these sanctuaries safeguard 31.4 linear kilometers of rivers with a total area of 10.7 square kilometers which supported aquatic resources including the last two remaining species of freshwater dolphins in Asia: the Ganges River and the Irrawaddy dolphins.

Critical safety net for cetaceans

In 1875 the world's largest mangrove forest Sundarban was declared as Reserved Forest. In the 1990s, three areas of the forest were designated as wildlife sanctuaries by the Government of Bangladesh (Sundarban east – 312 km^2, Sundarban south – 370 km^2 and Sundarban west – 715 km^2), covering 23% of the total area of Bangladesh Sundarban (6017 km^2, 30% is tidal water ways regularly inundates twice a day), closed to any extraction of vegetation and wildlife and were collectively designated as a UNESCO World Heritage Site in 1997. A wide belt extending 20 km outside the Sundarban Reserved Forest (SRF) has been identified as the Sundarban Impact Zone (buffer zone) where the majority of resource harvesters are reported to live – an estimated three millions. Along with the three older wildlife sanctuaries the three newly declared wildlife sanctuaries for freshwater dolphins in the eastern Sundarban added crucial conservation value to the freshwater dolphins as well

as estuarine crocodiles, small clawed otter, masked finfoot, white-bellied see-eagle, Pallas's fish-eagle, etc.

The world's third largest river system – Ganges-Brahmaputra-Megna (*Padma-Jamuna-Meghna*) – supplies enormous freshwater to the Bay of Bengal passing over Sundarban which is more than 1.5% of the total annual riverine supply. Salinity levels in the Sundarban are determined by the upstream freshwater supply and tides. The coastal waters are normally lower in depth up to 50 meters that lie over 35 to 165 km offshore from the edge of the coast. The coastal areas are formed of a variety of growing islands in its ground. The cone shaped SoNG is an underwater canyon and is located about 40 km from the southern edge of Sundarban to the south at the northern tip of Bay of Bengal. The SoNG passes 23-29% of the world's nutrient supply to the sea from Ganges-Brahmaputra-Meghna river system. This underwater canyon has high fish productivity due to enormous nutrient and sediments supply by upwelling currents and for this the diversity and abundance of cetaceans in this area are much higher compared to other areas in Asia. The SoNG also works as a thermal refuge for cetacean from global warming. However, Bangladesh has all three kinds of aquatic environments – freshwater rivers, wide belt of coastal waters and deep marine waters – which are perfect habitat for all cetaceans, though there are many issues need to be addressed for better protection of cetaceans.

After the construction of the Farakka Barrage (Ganges, India) freshwater flow has decreased with a significant increase in salinity levels in the Sundarban. Sedimentation has led to the gradual drying up of river channels proscribing navigations; e.g., Ghashiakhali River (Mongla-Morelganj) has dried up to a depth below the level of navigation so that an illegal new route created through Passur-Sela-Betmar-Bhola-Balleshwar Rivers in the Eastern Sundarban Reserved Forest (ESRF) by Bangladesh Inland Water Transport Authority (BIWTA). This new route is a big threat to the inland as well as aquatic wildlife and their habitats due to erosion of river banks especially at the confluences and meanders, fuel discharge, noise pollution and illegal anchoring inside the ESRF. Among the aquatic wildlife, Ganges River and Irrawaddy dolphins are particularly vulnerable, as they prefer the confluences, meanders of the rivers and deep pools as

: Zahangir Alom

suitable habitats because the river bank at confluences and meanders are becoming flat due to the erosion, and deep pools are being filled up the sediments day by day. The noise pollution is another threat to the dolphins, especially to the Ganges River dolphins as they completely depend on echolocation for food and navigation as they don't have vision (blind). Sometimes they also die from propeller inflicted injuries.

Cetaceans so far identified in Bangladesh

Both odontocetes and mysticetes cetaceans of 11 species under five families have been recorded in riverine, coastal and offshore waters of Bangladesh. Among these, only four species are found in the Sundarban: 1) Ganges River dolphins or *Shushuks*, 2) Irrawaddy dolphins or *iraboti*, 3) Finless porpoise or finless and 4) Indo-pacific Hump-backed dolphins or golapi.

The most well known cetacean in Bangladesh is the Ganges River dolphin or Shushuk. Shushuk is the true river dolphin. They are often seen by travelers while crossing any big rivers in Bangladesh. The Shushuks range far upstream in the Ganges-Brahmaputra-Meghna Rivers of Nepal, India and Bangladesh, and in the Karnaphuli-Sangu, Shikalbaha-Bakkhali including all big rivers in Bangladesh. The Irrawaddy dolphin is a facilitative freshwater dolphin, and its distribution extends farther southwest and offshore to the coastal waters of the Bay of Bengal (Smith *et al*, 2006) where fresh water flow met to the marine environments. These two species are categorized as Endangered and Vulnerable, respectively, in the IUCN Red List (IUCN 2011). The Irrawaddy dolphins partition their habitat in the Sundarban with Shushuk according to salinity and turbidity. Shushuk prefers low salinity but high turbid water while Irrawaddy dolphin prefers high salinity zone with low turbidity. The Finless porpoises are often seen in the southern and south-western part of Sundarban during winter and Indo-pacific hump-backed dolphins are the rare winter visitors to the Sundarban. In and around the Swatch of No-ground (SoNG) the Indo-pacific bottlenose dolphin (*Tursiops aduncus*), Pantropical spotted dolphin (*Stenella attenuate*), Spinner dolphin (*Stenella longirostris*) and breeding population of Bryde's whale (*Balaenoptera edeni/brydei*) inhabit in large groups from a depth

of 10 meters to a few thousand meters. Along with these cetaceans two large groups of False killer whale (*Pseudorca crassidense*) (about 30 animals in SoNG and about 40 animals in far offshore to south from St. Martin Island) and a small group of Rough-toothed dolphins (*Steno bredanensis*) have been recorded from the SoNG of the Bay of Bengal in the last few years, and a dead calf of Sperm whale (*Physeter macrocephalus*) was examined from Selarchar of the Sundarban close to the coast in 2007 just after the cyclone Sidr.

Both Shushuks and Irrawaddy dolphins, including other cetaceans are threatened by incidental killing, largely from entanglement in gill nets, set bag nets and long lines with many hooks; reduction in prey availability due to destruction of fish-spawning habitat and by catch of fish and crustacean fingerlings during shrimp and prawn fry collection; pollution; saline encroachment; and excessive sedimentation as a result of irrigation and flood control (Reeves *et al*, 2003; Smith *et al*, 2006, 2008; Mansur *et al*, 2008). Other cetaceans are threatened from gill nets, long line, estuarine set bag net and trawl fisheries in the Bay of Bengal. As cetaceans are air breathing, they have to come to the surface to breathe, so if they get entangled in the fishing gear they cannot come up and quickly get drown just like us. Most of the cetacean entanglements in the Sundarban were recorded from gill nets though there were some incidences found from set bag net and longlines. Two Shushuk carcasses were recorded with propeller cut mark on their body in the Sundarban. The indiscriminate harvesting of shrimp fry from the Sundarban is also a big threat to the food security of dolphins as well as human beings. During an interview survey conducted by WCS/BCDP in 2010-2011, more than three hundred fishermen reported that post-larvae fisheries are responsible for sedimentation in the river bed, as for instance, at the end of an outgoing tide the middle part of Passur river between Mongla port and Chandpai Forest Department Range office dries to a depth that it becomes visible where people often walk on foot. Just 30 years back the Passur was a very deep river and all big ships were able travel through any part of it. During an incoming tide huge amount of sediment comes from the coast to the Sundarban waterways and precipitates on the river bed.

In this article four species of cetaceans found in Sundarban will be briefly described.

Ganges River dolphin (*Platanista gangetica gangetica*) *Shushuk*

The body of the endangered Shushuk is overall gray or light brown. Body colors of the young dolphins are lighter and they often have a pinkish hue. Body length of an adult male is 2.52 meters where the female is 2.12 meter. A new born baby is 70-80 centimeters long. Shushuk has a long snout with numerous narrow pointed visible teeth. The female's snout is longer than the male and often curved upwards at the tip. Their eyes are extremely small and visible as pin-hole openings slightly above the upturned mouth. As they don't have a focusing lens in their eyes they are often called "blind dolphin". The blowhole is a small slit, which is rare but not unique among cetaceans. They have large, triangular, broad flippers. The dorsal fin is a low triangular hump. Except the mother and calf, shushuks are normally unsocial but often two to more animals are seen together while hunting prey. Life span of shushuk is unknown.

Shushuks occur throughout the Ganges-Brahmaputra-Meghna and Karnafuli River system in Nepal India and Bangladesh. A population of 225 Shushuks was found in the Sundarban whereas 125 were found in Karnaphuli, Sangu, and Shikalbaha-Bak Khali Rivers in Bangladesh. There is also a subpopulation of Ganges River dolphins (*Platanista gangetica minor*) which occurs in Indus river of Pakistan. Local people are familiar with these dolphins swimming in rivers throughout the country and fishermen generally regard them favourably as their companions. Instead of the above mentioned threats Shushuk are also threatened from the effects of dams, large embankment schemes, dredging and directed hunting. However, they are occurring in large enough numbers in the Sundarban for future conservation actions to be effective.

Irrawaddy dolphins (*Orcaella brevirostris*) *Iraboti*

Irrawaddy dolphins have a blunt head with no visible rostrum. The dorsal fin is small, triangular with a rounded tip. A crescent or U-shaped blowhole opens to the front, the opposite of most dolphin species. An adult male is 2.75 meter long where a female is 2.32 meter, and length at birth is about one meter with 10-12 kg weight. The animal is grey overall with generally lighter abdomen. They are very social animals and generally seen in a small group of 2-5. Their

life span is about 30 years.

Irrawaddy dolphins generally occur in the near and inshore waters in south and southeast Asia including Ayeyarwady river in Myanmar, Mekong river in Cambodia and Laos, and Mahakam river in Indonesia. They usually occur in pockets of less than 100 individuals whereas about 6,000 Irrawaddy dolphins were found in the waterways of Sundarban and adjacent freshwater affected coastal waters of Bay of Bengal. This means that Bangladesh has the largest Irrawaddy dolphin population in the world. The coastal fishermen are familiar with these dolphins – they consider them as their companions while fishing in the sea. These dolphins are particularly threatened by gill nets estuarine set bag net fisheries.

Finless porpoise (*Neophocaena phocaenoides*) Porpoise/Finless

Porpoises are also members of 'Odontocetes' like dolphins but there are some differences between them. The teeth of porpoises are flattened and spade shaped and are called 'spatulate', where a dolphin's teeth are cone (conical) shaped. The body size of porpoises is smaller than dolphins and male can grow up to 2.0 meter long where female is 1.55 meter. A new born baby is less than 80 cm and weighs about 6 kg. Its body colour is dark-black and has no dorsal fin. They have a blunt snout and rounded head like Irrawaddy dolphin, and are usually found in a group of lower than 10 animals. There are only 6 species of porpoises found in the world of which only one species occur in Bangladesh: the finless porpoise. Their surfacing is cryptic and they look like a flooded black tyre-tube in the tidal water. The population of finless porpoises is estimated at 1400 individuals in the coastal waters of Bangladesh. Gill nets and estuarine set bag net fisheries are the main threats for these animals in our coastal water. Their life span is at least 33 years.

Indo-Pacific humpback dolphin (*Sousa chinensis*) *Golapi*

The comparatively large and healthy dolphins of Bangladesh coast are the Indo-Pacific hump-backed dolphins. They are also rare winter visitors to the Sundarban. The body length of an adult male is 2.79 meter where a female is 2.49 meter. A new born baby is about 1 meter long with 14 kg weight. Their beak is well-defined. The dorsal fin sits on a hump in the middle of the animal's back which is why the

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animals are called “humpbacked” dolphins. Their body color is grey to light cream, and they often have a pink shade but the calves are dark gray which change: with increase in age. They occur in the coastal waters from the east and west coast of northern Australia through the Indo-Malay Archipelago, eastward to central China and westward around the coastal rim of the Indian Ocean to southern Africa. Most of the humpback dolphin group sizes are lower than 10 animals but in Bangladesh more than 40 animals are found together. About one third of these animals have distinct marks on their back fins that possibly occur from entanglement in fishing gears. These animals are also threatened from gill nets and estuarine set bag net fisheries in our coastal water. Their life span is at least 40 years.

A list of cetaceans so far recorded from the Bangladesh is appended in a table while location of cetacean sanctuaries in the country are given in maps in the following pages.

Article continued to next page...

Table 1: List of Cetaceans in Bangladesh (reference WCS/BCDP)

Order	Sub-order	Family	Sc. Name	Eng. Name	Bengali Name	Population Size
Cetacea	Odontoceti	Platanistidae	*Platanista gangetica*	Ganges River dolphin	Shushuk	225 in Sundarban, 125 in Karnaphuli-Sangu, Shikalbaha-Bak khali. Population not estimated yet in other rivers
		Delphinidae	*Orcaella brevirostris*	Irrawaddy dolphin	Iraboti dolphin	451 in Sundarban, 5383 in coastal area
			Sousa chinensis	Indo-Pacific humpback dolphin	Golapi / Indo-prashanta Golapi Dolphin	Large groups
			Tursiops aduncus	Indo-Pacific bottlenose dolphin	Botal-naak / Bharotio Botol-naak Dolphin	2239
			Stenella attenuata	Pantropical spotted dolphin	Futki / Grishma-Mondalio Daagi Dolphin	Large groups
			Stenella longirostris	Spinner dolphin	Ghulli / Ghurni Dolphin	Large groups
			Steno bredanensis	Rough-toothed dolphin	Khorbodati Dolphin	Small group
			Pseudorca crassidens	False-killer Whale	Sadda Ghatok Timi	Large groups
		Phocoenidae	*Neophocaena phocaenoides*	Finless porpoise	Finless / Paakhna-heen Porpoise	1382
		Physeteridae	*Physeter macrocephalus*	Sperm Whale	Gondar Timi / Boro Gondar Timi	One carcass found
	Mysticeti	Balaenopteridae	*Balaenoptera edeni/brydei*	Bryde's whale	Budarer Timi	Large groups

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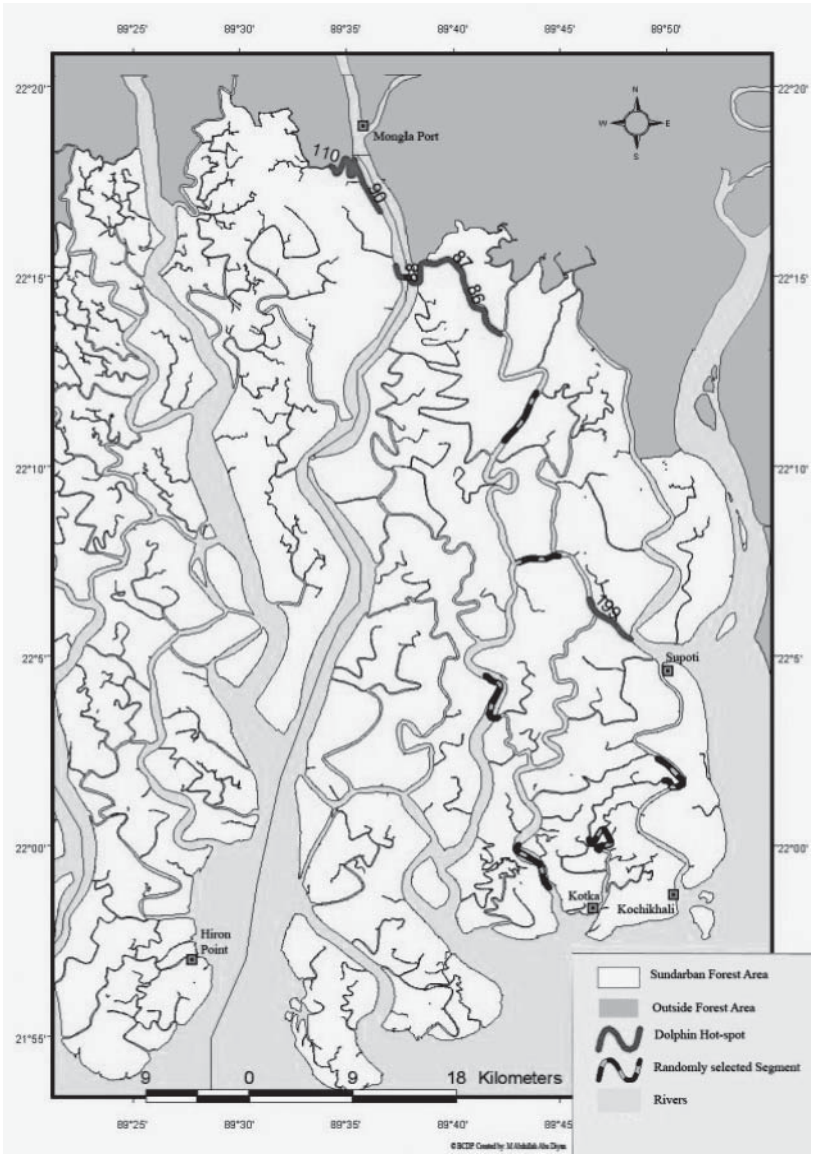


Figure 1. Map of the Sundarban: Eastern Sundarban Reserved Forest showing the three wildlife sanctuaries for freshwater dolphins (in red) (Source WCS/BCDP).

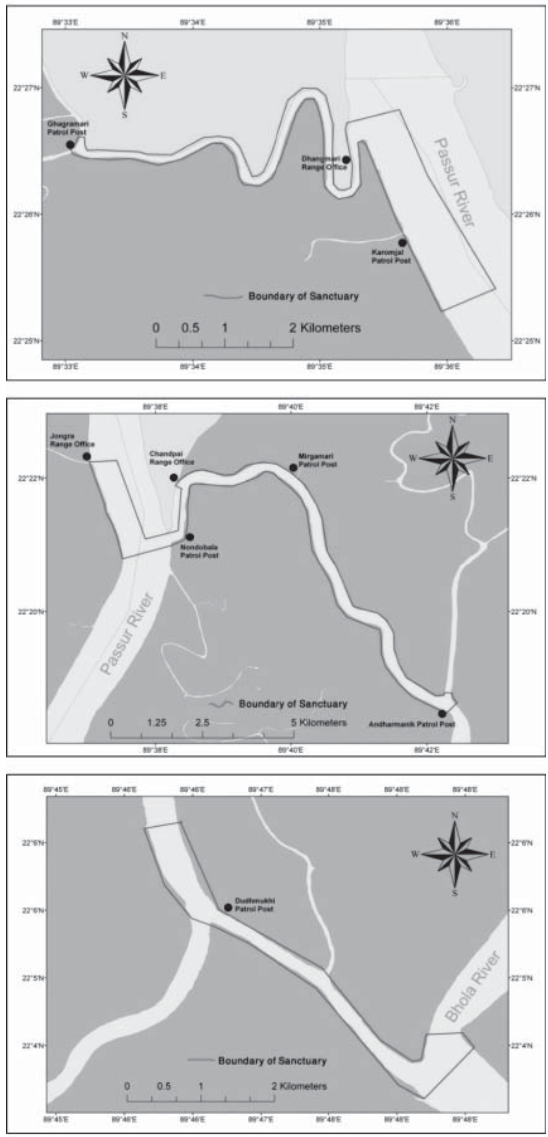


Figure 2. Map of Dhangmari (3.4 km2; top), Chandpai (5.6 km2; middle), and Dudmukhi (1.7 km2; bottom) wildlife sanctuary for freshwater dolphins in the Eastern Sundarban Reserved Forest (Source WCS/BCDP).

Fisheries of the Sundarban

The world's largest mangrove forest as a single entity covers roughly 7.2% of global mangroves and stretches across the southern part of the Ganges delta belonging to Bangladesh and India. The Sundarban is a single entity, its outstretch and resources are divided by political boundary between Bangladesh and India; however, its ecosystem and biodiversities of flora and fauna do not obey political lines, hence its integrity and "profitable sustainability" largely depends on goodwill and joint collaboration of the two countries. Nevertheless, based on available information and knowledge this short note will concentrate on Bangladesh side of the Sundarban.

Recorded fisheries resources of the Sundarban are diverse; fish, crustaceans, shellfishes and other aquatic lives spend the whole or part of their life cycle in the Sundarban.

By **Abul Hossain**

The edible fish and other aquatic organisms harvested from the Sundarban and its peripheral water bodies are not significant as a whole in terms of total biomass, if we consider total marine and estuarine fishes landing in the country. However, the role of the Sundarban is vital for aquatic biodiversity protection; marine, estuarine and partly fresh open water fisheries production and maximum sustainable yield from sea and estuary. This is simply because the mangrove forest based aquatic ecosystem acts as a vast nursery for numerous marine and hypo-saline based aquatic lives. It also serves as a natural sanctuary and provides shelters. The mangrove forest itself and mudflats of the forest provide crucial breeding ground for wide varieties of finfish, crustaceans and mollusks. The mangroves also support fresh water, offshore and deep sea fisheries by playing a significant role as a nursery ground for many fishes and shrimps including the fresh water giant prawn, Golda; and salt water giant tiger shrimp Bagda, two major commercial species that are the backbone of frozen food export from Bangladesh. Larvae of Golda and Bagda spend early stages in the Sundarban and its peripheral waters to complete their larval developmental stages, and then move towards opposite directions, golda to rivers and bagda to the sea. The important breeding and nursery grounds of the fishes need to be identified and preserved. Fishing has to be restricted in seaward offshore waters of the Bay of Bengal through bans on gears, fish species and seasons.

Mangroves, due to their natural configurations, outlandish aerial respiration capabilities, strategic but innate positioning between land and seas, salt tolerance, capacity to submerge periodically with tidal fluctuations are robust providers of unique habitats for copious marine lives including fishes. This is true for all mangroves, but the Sundarban is a perilously important mangrove forest as it is situated adjacent to a delta where a few natural barriers like broken stony shorelines, scattered stony islands, many coral reefs and atolls exist to prevent onslaught on marine lives. Therefore, the existence of the Sundarban mangrove has amplified the significance of coastal, marine and to a certain extent freshwater fisheries resources by providing protection, aid in productivity and supporting biological diversity.

Water-bodies in and around the Sundarban support roughly 196 species of fish in 67 families and all combined they represent

roughly 49% of fish species recorded in Exclusive Economic Zone of Bangladesh (total recorded marine fish species in Bangladesh water is 402 with the latest estimate and documentation). Besides, 25 species of shrimps, 13 species of crabs, 1 species of locust lobster are reportedly available in the Sundarban water. Next to fish and crustacean, 3 species of cephalopods, 32 species of mollusks/ gastropods, 6 species of pelecypods, 3 species of turtles, and a few species of cetaceans are also reported from the Sundarban. Fish landings from the Sundarban water may not be significant, 5% of total marine landings in the country, but 90% of commercial fish and 35% of all fish in the Bay of Bengal reportedly rely on the Sundarban as a nursery for their young life stages.

Commercial fisheries of the Sundarban are of two types – inshore fisheries is limited within the depth zone ranging from 2 to 8 meters towards land, and offshore fisheries area extends beyond 8 meters depth zones in the seaward direction. Various types of fishing gears operate in the Sundarban waters but most of the fishers are subsistence types. Migratory fishermen also enter the Sundarban and establish camps during the dry season, engaging in illegal trapping and hunting. A ban on shrimp/prawn post larvae (PL) collection went into effect in 2000 as concerns about its effect on fisheries and biodiversity increased. However, the law will be very difficult to enforce because of the involvement of large number of PL collectors and the lack of any viable alternative employment opportunities. Very often, it is the only source of income for thousands of rural women.

Two types of fishing gears that are operated in the Sundarban water are the most destructive: set bag nets that are operated setting at fixed position in the estuaries or rivers, and hand operated push nets for shrimp/prawn Post larvae (PL) collection from the estuary and river mouth. The destructive fishing needs to be banned but alternative livelihood options for fishers engaged in this types of fishing are necessary. The suitable alternative livelihood options for displaced subsistence fishers may be forest based apiculture, water based pen and cage farming, commercial shrimp/prawn post larvae nursing, over-wintering and crab fattening.

The mangrove fisheries have been under intense pressure from deleterious fishing activities and deliberate aquaculture development

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by destroying the mangrove habitats. The impact of mangrove has been reflected in the contribution of artisanal fishery catch that has been in a continuous decline since the 1980s. Mangroves are characterized by a higher fisheries biodiversity as well as higher standing stock. The importance of mangrove ecosystems to coastal and marine fisheries, and linkage of mangrove and associated fisheries has been an interesting area to observe and monitor. Mangrove and fisheries are tightly linked, and the link should not be broken.

Fishing Gears and Livelihoods of Fringe Communities in the Sundarban

Fisheries and fishes occupied a greater portion of livelihood of people in Bangladesh during the Mughal Empire. Afterwards a large chunk of these people fully tagged their livelihoods to the fisheries even in the mangrove ecosystems of the Sundarban. In 2000, for example, 4000 households carried out fishing activities in the impact zone of the Sundarban (17 Upazilas under Khulna, Sathkhira, Bagerhat, Pirojpur and Borguna districts). Of these households about 35% were shrimp fry collectors, about 33% were fishermen harvesting edible fishes and crustacean, and about 2% were crab or shell collectors (SBCP 2001a).

Shrimp farming started in and around the waterways of Sundarban

By **Zahangir Alom and Rubaiyat Mansur Mowgli**

mangroves in 1980s as a result of a huge demand for shrimps in the international market. So new gear types made with mosquito nets were introduced for shrimp fry collection. This mosquito nets were actually made for fencing the water bodies dug for fish and shrimp farm, but now it is mainly used for the post-larvae collection. With the diversified fish and crustacean population found in the Sundarban, fisherfolk developed various fishing gears. During several field visits from 2006 to 2011 we recorded 24 types of fishing gears including eight post-larvae collection nets. Fishing Gears are mostly used during spring tide to fisherfolk normally return to their homes at the end of spring tide and be with their families during slack tide.

About 25000 registered fishing boats harvest fish and crustacean from Sundarban and a coastal area of the Bay of Bengal. None of the fishing permissions allows shrimp fry collection, so all mosquito nets found inside the Sundarban are illegal according to the laws of the land. Inside the Eastern Sundarban, a total of 145 fish and 33 crustacean species have been recorded that were caught in 16 types of fishing gears operated with different techniques. The annual catch is about 3000 metric tons of fish and crustacean which was 18150 metric tons during the year 2007-2008 (Hossain 2010) . However, a winter fishery is operated in the Dubla Island of eastern Sundarban Reserved Forest during November to March with tens of thousands of fishermen using mostly set-bag nets which are operated in the coast of Bay of Bengal where the annual catch is 15-18 thousand metric tons (SBCP 2003). Extensive use of set bag nets is believed to be responsible for the overexploitation of near-shore fisheries of Sundarban ecosystem. It has been seen that some species such as the commercially valuable Bagda chingri (*Penaeus monodon*), Pangas (*Pangasius pangasius*), Ilish (*Tenualosa ilisha*), Kain magur (*Plotosus canius*) and giant mud crabs (*Scylla serratta*) are particularly overexploited in the Sundarban (Huda 2003 ; Hoq *et al*. 2003) due to lack of knowledge of fishermen about sustainable fisheries and fishing practices. Besides the edible fishes and crustaceans, about 110 million of shrimp fries are collected with eight types of mosquito nets for supplying to the shrimp farms each year. All of these mosquito nets are contributing to huge catch mortality of crustacean and fish fry including zooplankton and phytoplankton. About thousands of

fish and crustacean larvae die against one target shrimp fry. So these nets are a direct threat to the aquatic resources and our protein stocks.

Aquatic resource management is a crucial need at the present time but there is no such effective initiative to develop and implement it. The ignorance of managing the aquatic resource in the Sundarban Reserve Forest is a big setback to the sustainable fisheries and fishing practices. The wildlife sanctuaries and only 18 small creeks are closed for fishing as they are recognized as major breeding grounds within the Sundarban. Besides these, fishing is also closed for some fishes like Ilish (*Tenualosa ilisha*) in October, giant mud crabs (*Scylla serratta*) in January-February, parshe (*Liza parshia*), Pangas (*Pangasius pangasius*), Kain magur (*Plotosus canius*), Golda chingri (*Macrobrachium rosenbargii*) and Bagda chingri (*Penaeus monodon*) at various times of a year and catching of Jatka ilish (size below 15cm) at any state. But these restrictions are often ignored by the fisherfolks.

Inside the Sundarban, Forest Department staff have a very poor knowledge of fisheries laws and none of the fisherfolk knows about them except seasonal closure for ilish and crab, and ban on catching of Jatka ilish (size below 15cm). Most of them also don't know about banned fishing season and areas where fishing is banned. Many of the FD staff are known to be engaged in illegal fishing by allowing the fisherfolk to fish in sanctuaries and in the banned creeks. If they see somebody fishing in banned areas or in closed season they take advantage from him and thus both parties get personal benefit by causing big harm to the fisheries resources as well as to the ecosystem. However, the goal of this article is to give a brief description of the 24 plus fishing gears documented in last few years in the Sundarban and five fishing gears in the adjacent coastal waters.

There were two major types of fishing gears operated in the Sundarban as documented by Wildlife Conservation Society's Bangladesh Cetacean Diversity Project during 2010-2012: (A) Post-larvae collection mosquito nets and (B) Edible fish harvesting nets. These gears are briefly explained here with some specific features including gear specification, operation technique, catch composition, catch-per-unit effort (CPU), target species and bycatch species, and legal status. Recommendation and photographs are placed wherever necessary. In addition, we also have given a brief description on

: Zahangir Alom and Rubaiyat Mansur Mowgli

poison fishing in the Sundarban.

Post-larvae collection nets

All post-larvae collection nets are made of fine mesh nylon mosquito net (usually bright blue). Mesh size is 0.8 to 2.0 mm. The target species for most of these nets are fries of two shrimp species; golda chingri (*Macrobrachium rosenbargii*) and bagda chingri (***Penaeus monodon***), and bycatches include all other crustacean and fish fingerlings, macro vertebrates and invertebrates. But the post-larvae fish shore nets and the flat mosquito nets are used for harvesting fish fries; parshe (*Liza parshia*)). The use of all post-larvae mosquito nets is illegal as per the Bangladesh fisheries act. However, there were eight types of post-larvae collection nets found in the Sundarban which are described below:

1. Post-larvae Set Bag Net (PLSBN) Net jaal: A funnel-shaped mosquito net with a rectangular mouth held open by wooden poles. The funnel length is 5 to 26 meters attached to a cod end where the fries are retained while the mouth circumference is 10 to 27 meters. Most of the cod end is made of same mosquito net but a few are of cloth. The cod end length is 0.4 to 3.1 meter and circumference is 0.5 to 1.0 meter. There is a multifilament thick synthetic rope (sometime called pata plastic or cot nylon) of 0.2 to 2.0 cm in diameter attached to the mouth circumference to allow the net to be tied with stakes or wooden anchor (locally called kakra) driven into the ground to fix to the river bottom and set facing the incoming current. The kakra looks like a tick mark (✓) with an extra narrow cross stick attached at the joining point of two heavy unequal arms (diameter – 9cm) of the kakra. The long arm's length is 1.7 to 4.6 meter and the short arm's length is 1 to 1.5 meter with pointed like plough, and cross stick's length is – 1 meter. During deployment, the long arm of the kakra attached to wings with a multifilament heavy rope and the short arm enter into the river ground where the cross stick lies horizontally parallel to the river ground. If the net deployed close to the shore then wooden poles are fixed to hold the net instead of kakra. Big plastic barrels or drums (120 liters) and containers (30-55 liters) are used as floats attached to both sides of the mouth to keep the net suspended from the surface. The mouth is typically held open by one or two

1.2 to 6m long vertical and 5.6 to 12m long horizontal wooden or bamboo poles and a lazy rope from mouth to the cod end is attached which allows the fishermen to check and collect the fries from the cod end. The net is checked by the fisherman 3-5 times during a full incoming tidal flow. The width and height vary with the tidal height. The net is usually set during low tide and the height increase and width decrease synchronically with the increase of tidal height. Sometime a debris protection net is set at the mouth made with fine nylon twine (number 2-12) with a mesh of 1.2-6cm. Fishermen reported that this nylon made mosquito net is made in India and Bangladesh. There were no PLSBN found during post-monsoon season but were in use during the other three seasons in the village bordering areas to 25km inside the Sundarban (up to Tambulbunia forest petrol post).

2. Post-larvae Box Net (PLBN) *Baxo jaal*: A small mosquito bag net mounted on a rectangular wooden frame that is set at the mid part of the river with long ropes to a small rowing boat by 1-2 persons. The frame size is 1.05 to 1.29m high and 1.7 to 1.96m wide. There are two extra vertical bars attached at the middle part of the frame with equal intervals and four small sticks (50 cm) are attached with both vertical and horizontal bars at each corner. The funnel length varies from 1.8 to 2.1 meter. Typically, 3-4 nets are set on a line tie with 3.7 to 4.6m long thick nylon or plastic ropes to the boat facing incoming tide. Net is being checked after every 15-30 minutes. These nets were only found in the village bordering areas of the Sundarban during dry, pre-monsoon and post-monsoon seasons.

3. Post-larvae Hand-drag Net (PLHDN) *Tana jaal*: This net is structurally the same as the box net and is dragged through shallow water by a person walking ahead of the net. The mouth opening is 0.43 to 2.0m high and 2 to 4m wide. There are no middle vertical bars in the frame but 2 to 4 corner sticks are attached to the frame. The funnel length is 0.9 to 3.3m, sometime a debris protection net (mesh size 1.7 to 4cm, made of multifilament nylon threads) is attached to mouth to prohibit the entry of debris inside the funnel. Dragging ropes are 0.9 to 2.8m long made of multifilament thick synthetic or jute fibers. The net is taken out from the water after every 5-15 minutes during incoming tidal flow. These nets were found during dry, pre-monsoon and post-monsoon seasons only in the village

bordering areas of the Sundarban.

4. Post-larvae Hand-push Net (PLHPN) *Thela jaal*: A small mosquito bag net mounted on a triangular wooden or bamboo frame. Funnel length varies from 0.5 to 2.5 m. The frame is made of two ~1.5 m long vertical bars on both sides and one 1.4 m long horizontal bar at the bottom. Typically a small cross stick (length 70 cm) is attached horizontally to the vertical bars close to the upper corner which used as grabbing bar while pushing the net. The net is pushed or scooped before a person walking in shallow water or drag similar to the PLHDN using pulling ropes. Sometime this net is fixed with bamboo or wooden poles on the shallow edge of the river. The net is pulled out from the water after every 5-10 minutes to collect fries during incoming tidal flow. The catches are collected in a big clay or aluminium pot (*hari*). Target species and bycatch are the same as PLSBN but sometimes it is used for catching small shrimps for use as baits with hook and rod. The catches are sorted on the shore or at home and after sorting all target fries bycatches are dumped on the ground where they die. These nets were mostly found during pre-monsoon season in the village bordering areas of the Sundarban but a few were found about 25km inside the forest to catch small shrimps for was as baits with long-line with multiple hooks and cast net during pre-monsoon and monsoon seasons.

5. Post-larvae Drag Net (PLDN) *Pona Moi jaal*: A mosquito bag net with single or multiple mouth opening attached to a horizontal wooden ladder bar at the upper part to help it float while dragging against the tide by a person grabbing 1.6 - 3.6 meter long pulling rope tied to both ends of the bar. The ladder bar is normally 2.3m long and the funnel length is 2.6m. If cod end is present then usually it is made of the same mosquito net. Each of the mouth openings is called pocket and a number of small hollow circular iron or clay pieces or brick weights are attached to the bottom rope of the pocket to keep it open and sink the net while being dragged. The net is taken out from the water after every 5-15 minutes during incoming tidal flow. Normally it is used to catch shrimp larvae but other small shrimps are also collected for family consumption. This net was found in the mid-eastern part of the Sundarban for the first time during monsoon season in 2010.

6. Post-larvae Fish Seine Net (PLFSN) *Parse Ponar jaal*: About 41 m long and 2.5 m high slightly folded sac like mosquito net which contains more than two plastic bottles / small floats per meter on the top rope and three lead weights per meter at the bottom rope. Top and bottom ropes are made of thick synthetic fiber and are – 6m longer than the net. The net is set from a vessel on the side of a river at a depth of <2 meters, both ends of which are pulled to shore, with 5-6 fishermen grabbing both bottom and top rope standing on the bank. This net is used to catch fish larvae especially Rinomugil corsula and Liza parsia. This is a new fishing gear found in dry season in the Passur river along the Joymoni village bordering the Sundarban.

7. Boat Net (BN) *Rocket jaal*: A small pair of triangular or rectangular mosquito bag nets (the same as PLHPN and PLHDN) mounted on either side of a rowing boat close to the water surface. The boat is anchored and the nets filter the incoming tidal water to catch shrimp fry. The net is very rarely seen in northern borders of the Sundarban.

8. Flat Mosquito Net (FMN) *Khorulla jaal*: A 10-15 meter long and 1.5 meter wide mosquito net fixed to the ground with a weight at one end and the other end attached to the boat making a 100-120 degree fold of one meter net towards incoming tide at the boat side where the fishermen sit. Fish fries congregate at the folding corner and fishermen collect fries with a bowl and filter by a mosquito sweeping net. This net was newly found in the Passur River upstream of Mongla in November 2011. Target species and bycatch are Rinomugil corsula and Liza parsia.

Edible fish harvesting nets

There were 16 types of fishing nets recorded from the Sundarban which are used to harvest edible fishes and crustacean. These gears are described with specification, operation techniques, catch composition (target catch and bycatch), and legal status below:

1. Large Mesh Drifting Gillnet (LMDGN) *Ilish jaal/Chandi jaal/ Bhasha jaal/Fash jaal*: A 146m to 1463m long and 3.3m to 9.1m wide gillnet with multifilament fine nylon twine (commercial twine number 2 and 4), mesh size 8 to 15 cm, that has floats attached to the top rope with an interval of 1.3 to 14.9 meters (mean 6.2m) to

keep it near the surface and brick or clay disks (Chara) are attached to the bottom rope with an interval of 1-11 meters (mean 4.8m), drifting freely near the surface in the water following tidal flow. Sometime heavy metal anchors (up to 15kg/anchor) are also used as sinker. The net is pulled out at 30 minutes to 2 hours intervals, sometimes the interval can be longer than 2 hours depending on fish availability and strength of tide. This net is normally operated by 2-5 fishermen with one small non-mechanized or mechanized wooden boat. The target Species is adult hilsha fish (*Tenualosa ilisha*) and the bycatch include small and median size fishes, crabs, shrimp, dolphins, turtles, snakes etc. During the field survey three species of fishes (e.g., *Tenualosa ilisha, Otolithoides pama and Setipinna taty*) and one species of crustacean were identified from the catches of this net. This net is very harmful for dolphins as many entanglements have been recorded from different areas of Bangladesh and other parts of the world. It is generally used in all big rivers and coastal waters. This net is allowed by the Bangladesh fisheries act. It is found during monsoon and post-monsoon seasons only.

2. Small Mesh Drifting Gillnet (SMDGN) *Poka jaal/False jaal/ Parshe jaal*: A gillnet (~150 m long and ~3 m wide) made with double filament nylon twine (twine's commercial number is 4) and small mesh size (5-6 cm) fixed to the river bottom by heavy weights (brick or iron) attached to the bottom rope at either end of the net. Clay disk are used as sinker on the bottom rope at 4.5 meters interval. This net is set during both incoming and outgoing tide. Floats are attached on the top rope with an interval of 2-7 meters to keep then at the surface. This net is normally operated by two fishermen with one small non-mechanized wooden boat. The target species are juvenile *Tenualosa ilisha* (Jatka illish) size below 15 cm, *Liza parshia* (parshe mach), Gangetic hairfin anchovy *Setipinna phasa* and *Setipinna taty* (falshe mach), and *Polynemus paradiseus* (taposhi) *Arius gagora* (gagra tengra), *Mystus gulio* (nuna tengra), *Clupisoma garua* (Ghaire), *Sillago dimina* (tular dandi) small croakers such as *Otolethoisdes pama, Johnius coitor* etc. Bycatches are crabs, snakes, eel etc. During field survey five species of fishes (e.g., *Arius gagora, Setipinna phasa, Sillaginopsis panijus, Otolithoides pama* and *Polynemus paradiseus)* were identified from the catches of this net. This net was seen to use in big rivers e.g.,

Passur and Baleswar, during monsoon and post-monsoon seasons only. Use of this net is illegal as per the Bangladesh fisheries act.

3. Fixed Floating Gillnet (FFGN) *Vetki jaal/Dhora jaal*: A 50-60m long and about 8m wide gillnet with big mesh size of about 18cm and thick multifilament synthetic twine fixed to the river bottom at meanders or confluences by heavy weights attached to the bottom rope at either end of the net. Sometimes it set across the creek mouth blocking the whole stream (which is illegal). Generally one end of the net is tied to trees on the river bank. Floats attached on the top rope of the net keep it at the surface and bundles of four to six bricks are attached to the bottom rope with an interval of about ten meters. This net is used year round and is set for a full 6 day cycle of spring tide, occasionally during neap tide and is checked at an interval of 12-18 hours to collect entangled fishes. The target species are *Lates calcarifer* (*Vetki/patari/koral*), Pangas (*Pangasius pangasius*), Poma (*Otolithoides pama*) and other croaker species. Bycatches are dolphins, porpoise and sharks of different species. During field survey three species of fishes (e.g., *Johnius coitor*, *Lates calcarifer* and *Macrospinosa cuja*) were identified from the catches of this net. This net was found year round inside the forest.

4. Monofilament Gillnet (MFGN) *Current jaal*: This is similar to fash jaal but the twine is monofilament nylon. This net is found in the creeks or plain water bodies with wooden or bamboo poles. The mesh size is 02 cm meter to 10 cm. The target species are *Tenualosa ilisha* (size below 15 cm), *Otolithoides pama* (poma), *Johnius coitor* (coitor) *Liza parshia* (parshe), *Setipinna phasa* (falshe) and *Setipinna taty* (falshe) *Mystus gulio* (nuna tengra) and *Arius gagora* (gagra tengra) and other small and medium size fishes etc. We saw this net at Kotka and kochikhali of Sundarban set across the small creek's mouth and on open field inundated by rainwater; and two species of fishes e.g., *mystus gulio* and liza parsia were entangled. This net is very harmful to dolphins and fisheries, and use of this net is strictly prohibited throughout Bangladesh in the Bangladesh fisheries law.

5. Set Bag Net (SBN) *Behundi jaal*: Structurally similar to a PLSBN but larger in size with large mesh size and multifilament thicker twine. The net normally has a big mouth circumference from 35 to 78

meter held open vertically by two 3-7 meter long wooden or bamboo poles. The poles are set at the middle part of mouth opening at a distance of 10 to 20 meters in between them (usually about 1/3 of the total width). From the pole to the end of both sides are considered as wings to hard the fish and crustacean to the funnel. The mouth opening can be compressed vertically with the increasing of strength of current and amount of floating debris. The funnel length is 27 to 46 meter which attached to a 1-6 meter long cod end with an average circumference of 0.8-2.6 meter. The net is made of thick multifilament nylon twine and its mesh size 1-5 cm at mouth, 0.5 to 3.0cm at middle and 0.3-4 cm at the end of funnel (that means mesh size decreases chromatically from mouth to the end) and the twine number is 4-12. Cod end mesh size also varies from 0.3-2.5cm and the twine number is 4-9. A rope from the mouth of funnel ties the cod end to facilitate checking and collecting the catch from cod end. All along the mouth circumference and wings a thick rope with diameter of 1-3 cm is attached which is tied to the anchor and floats to keep the mouth open. The net is fixed with stakes, metal pipe or wooden anchor (locally known as *kakra*) driven into the river bottom and is set facing the current. The *kakra* looks like a tick mark (✔) with an extra narrow cross stick attached at the joining point of two heavy unequal arms of the *kakra*. The long arm's length is 3.2 to 4.6 meter and the short arm's length is 1 to 2 meter which point like a plough, and the cross stick's length is 1 meter. During deployment, the long arm of the kakra is attached to wings with a multifilament heavy rope and the short arm enters into the river ground where the cross stick lies horizontally parallel to the river ground. If the net is deployed close to the shore then wooden poles are used instead of kakra. Big plastic barrels or drums (60-200 liters) and containers (30-55 liters) are used as floats attached to the end of wings to keep the net suspended from the surface. The net is pulled out after 5 hours from the start of incoming or outgoing tidal flow. The catch may be checked once or multiple times depending on fish availability. The net is checked by the fisherman 3-5 times during a full incoming tidal flow. The main target species are shrimps, small to medium size fishes and giant mud crabs while the bycatches include other crustaceans and smaller non-edible fishes and invertebrates. During field survey

123 species of fishes and 32 crustacean species were identified from this net. This net is harmful to fisheries and use of this net is strictly prohibited inside the Sundarban. However, it is found year round but mostly in the monsoon and occasionally in dry season.

6. Cast Net (CN) *Khepla/toire/Jhaki/Chatki/Pheka/Dhundi/ Mootth jaal*: A circular and funnel shaped net with pockets and metal weights (iron) around the mouth circumference and a tether (tail rope) in the center. There are different sizes of cast net recorded from the Sundarban and sizes vary from 5.4 to 15.1 meter mouth circumference with 1.4 to 5.0 meter long funnel. The tether can be long up to 7 meter and is made of multifilament nylon threads or plastics and connected to the net by a bundle of fine nylon threads. The main net mesh size varies from 0.8 : 2.5 cm and in most cases mesh size at tail is smaller than mouth. This net is made of multifilament nylon twine (commercial number of twine is 2-8). Along the mouth circumference about 20 cm of the net is folded inside and a series of pockets with weights along the opening border to hold fishes. Pocket sizes vary from 18 X 14cm to 40 X 31cm and are made of little thicker twine than the funnel. This net is repeatedly thrown over the water from the river bank and retrieved using the tether. After harvesting the fishes are kept in a bag or small bamboo basket (*Khaloi*). Mostly the net is operated by women for family consumption and the fish basket is carried by one of her children while catching fishes close to the villages. Sometimes bait ball made of rice and rapeseeds with clay are used to catch *Macrobrachium rosenbargii* and other shrimps while fishing inside the Sundarban. In the bait ball method the balls are thrown into the water near the shore and a few minutes are given to attract the shrimps then the net is thrown from a rowing boat. After harvesting the live M. rosenbargii are kept into a bamboo fish basket floating in the water. Fishermen are often seen to drag this net on the shallow river bank and in the small creeks to catch shrimps. The target species are all edible fishes (>6cm long) especially *Liza parsia, L. subviridis, Plotosus canius, Lates calcarifer, Mystus gulio, Arius gagora, Pangasius pangasius, Acanthopagrus latus, Parapocryptes batoides, croakers,* threadfins and shrimps. During the field survey 18 fish and 15 crustacean species were identified from cast net catches. This is an eco-friendly fishing gear and found year round mostly in the fringe areas of Sundarban.

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7. Long Shore Net (LSN) *Charpata jaal*: Long blocking net attached to wooden poles deployed adjacent to the river bank. This net is made of multifilament nylon twine (commercial number 4 to 6), mesh size is normally in between 0.8 to 2.8 cm, sometimes mesh size on the upper part of the net was found a little bit larger than the lower part. The net length is 100 to 823 meter and height or width is 3.4 to 5.8 meter. The top and bottom ends of the net are attached to a thin rope (diameter 0.2 to 1.4cm). The net is set at the last quarter of the outgoing tide to the beginning of incoming tide when the bottom rope and few inches of net are buried in the ground and anchored with small forked branches of trees. Some tree branches are set to the bank side of the net to attract fish to gather. The upper end of the net is pulled out at high tide (when water becomes steady) and tied with a series of 6 to 7m long narrow wooden poles (usually made of juvenile sundary trees (*Heritiera fomes* called kocha) with an interval of 6 meters making loops with the top rope. As the tide falls fishes and crustaceans are trapped on the landward side of the net where they are harvested. The soak duration is more than 12 hours from the setting of the net to the end of harvesting. The target species are all small to big fishes, shrimps and giant mud crabs. During field survey 77 species of fish and 20 species of crustacean were identified from cast net catches. This net is a big threat to the mangrove dweller threatened bird masked finfoot (*Heliopais personatus*), small-clawed otter (*Aonyx cinerea*) and also to the estuarine crocodile (*Crocodylus porosus*). These are found year round inside the forest.

8. Creek net (CrN) *Khal pata/Khal gora jaal*: It is a small net that looks similar to the long shore net but is slightly pocket shaped set across at the mouth or inside of small creeks during high tide with a series of wooden poles (placed about 1m apart). The fish is harvested after the creek dries at the end of outgoing tide. Mesh size varies from 1.5 to 2.5 cm and twine is multifilament nylon. It is usually 20 to 25 long and 3 to 5 m high. The primary target species are shrimps of different species such as *Penaeus indicus, Metapaenaeus monoceros, Macrobrachium rosenbargii, M. villosimanus, M. idella, M dianu, M. rude* and fishes include *Arius* sp. *Mystus gulio, Acanthopagrus latus, Polynemus paradiseus, Plotosus canius, Parapocryptes batoide, Liza sp, Glossogobius giuris, Coius quadrifiseiatus, Lates calcarifer, Otolethoides*

pama, Johnius coito etc. This net is found to be in use year round but is strictly prohibited for use in sanctuaries and in all banned creeks inside the Sundarban. The user of he net often carries poison for harvesting fishes from small creeks and water bodies inside the forest which is strictly prohibited.

9. Seine Net or Beach Seine (SN) *Kathi jaal* or *Ber jaal*: A 150-300m long and 1.8 to 4.5m wide net set from a vessel in an arc (U shape), both ends of which are pulled to shore by fishermen standing on the bank. Mesh size is 1.2-2.5 cm and made of multifilament nylon twine (commercial number is 4 - 8). Spongy floats contained on the top rope and a thick heavy rope (diameter – 3 cm) are used as bottom rope as sinker. The net is operated by 5-6 fishermen who mostly use in the small rivers or creeks in the Sundarban during outgoing tide. This type of net is mostly found in the coastal beach operated by 6-10 fishermen. The target species are small and median size fishes; croakers, mullets, catfish, needlefishes, ribbonfish, seabass, giant mud crab and shrimps. Found mostly during dry and pre-monsoon seasons.

10. Drag Net (DN) *Moi jaal*: A funnel shaped net attached to a 1.3 to 1.9 meter ladder bar similar to a PLDN but the mouth is divided into 4-25 pocket-like openings (width of each opening is 14:50 cm) with led weight on bottom rope of each opening to keep the mouth open while dragging against tide. Mesh size varies from 0.7 to 1.2 cm and the twine of the net is similar to cast nets (twin's commercial number 2-6). The net is normally used to catch shrimps from the shallow river banks for family consumption. This net can be dragged any time of the day but preferably during the middle of outgoing tide. It is found mainly in the rivers close to the fringe villages of the Sundarban. During the field survey two species of fishes (e.g. *Odontamblyopus rubicundus* and *Stigmatogobius sadanundio*) and seven species of crustacean were identified from cast net catches. The net is found only in dry season.

11. Hand-push Net (HPN) *thela jaal*: A triangular net having similar structure to the PLHPN but made by nylon twine with larger mesh size (2cm) instead of mosquito net. A person sits on the bow of the boat and scoops ahead of him in the water. The net was seen operating for catching small crabs sheltered on floating water hyacinth

on the river and was rarely found. This is found only in dry season on the Passur river.

12. Otter-fish Net (OFN) dhaire jaal or tar jaal: A square or rectangular shaped scoop or lift net (size usually 7m X 5m) used generally with three bamboo sticks; one at the mouth (7m) and others on each side (6m) of the net. Mesh size is less than 1cm and made by thick nylon twine. The net is operated by four fishermen from a rowing boat positioned parallel to the shore at 4 to 5 meter out. Usually two to three otters (*Lutra perspicillata*)are used to chase the fish and shrimps towards the net from the underneath plant shoots and other debris while scooping on the river or creek bank. The target species include shrimps and small and large size fishes specially *Lates calcarifer, Otolethoides pama, Liza pasia, Acanthophagrus latus, Scatophagus argus, Pangasius pangasius* etc. This is a native technique used only by the fishermen from Narail and Khulna districts of Bangladesh. A total of 176 otters of different age and sex class belonging to 46 families were recorded of which 138 adult animals were actively involved in fishing during 2003 to 2005 (Feroz *et al*. 2011). These were only during pre-monsoon and monsoon seasons but there were also records of their use in other seasons.

13. Longline or line with many hooks (LL) ***doriborshi/ donborshi / taana borshi***: A gear consisting of a long sturdy line (length is 411 - 900m) anchored to the bottom at each end with weights and tracking floats on the water surface. A series of short ladder lines (400 to 900 in number, 34 to 50 cm in length) with baited hooks are attached on the main line with an interval of 1m. The hook size is 3 to 5 cm (curved length). Mostly shrimp, eels, fishes and sometimes coconut with rice or flower and mastered seeds and mangrove fruits (Chhoyle) are used as bait. Sometimes slugs are also used as bait. Brick tied with two small wooden sticks is used as anchor and plastic floats, bottles or styrofoam are attached to each end with fine rope to set and locate the long line. Sometimes one end of the mainline is tied to a tree on river bank. The line is usually set at river bottom parallel to the shore. The target species are golda chingri (*Macrobrachium rosenbargii*) and bagda chingri (*Penaeus monodon*), kain magur (*Plotosus canius*), gagra tengra (*Arius gagora*), nuna tengra (*Mystus gulio*), pangas (*Pangasius pangasius*), croakers, Snappers and some other fishes are often caught.

During field survey five species of fishes (e.g., *Arius gagora, Chaca chaca, Clupisoma garua, Johnius coitor* and *Plotosus canius*) and two crustacean species were identified from the catches of this net. This is an eco-friendly fishing gear. Generally the line is pulled out with a minimum interval of 30 minutes. It is found year round.

14. Hook and Rod (HR) *Chhip-borshi*: Conventional angling bamboo or wooden sticks with baited hook at the tip of a monofilament thread. Close to the hook a metal weight (usually nail) is used to sink the line. The rod or stick is normally 1 to 2m long with a diameter of 1-2.4 cm. The hook is made of 3 to 5 cm long needle. Small shrimps are the common bait for this gear. Generally 3-4 gears are operated by a single fisherman from a small rowing boat to catch golda chingri (***Macrobrachium rosenbargii***) and bagda chingri (***Penaeus monodon***). The gear is frequently whipped and the line jerked to attract shrimps and it is checked and pulled out from the water whenever there is any entanglement. During field survey five species of fishes (e.g., *Arius gagora, Coius quadrifiseiatus, Johnius coitor and Macrospinosa cuja*) and five crustacean species were identified from the catches of this gear. This fishing gear is found year round.

15. Crabline (CL) *dundori*: Similar to a conventional long line but without ladder rope and hooks are replaced by metal wires or plastic fibers which tie the bait directly to the sturdy main line with an interval of 1 m. The line is 137 to 685 m long and made of jute or nylon rope. Anchors (brick attached to two small wooden cross sticks) attached to each end to set the gear and plastic floats, bottles or styrofoam are tied with a fine rope to the anchors to locate the crab line. The line is usually set at river bottom parallel to the shore like LL. The target species is giant mud crab (*Scylla serratta*). When the gear is removed crabs cling to the bait. The line is pulled out with a minimum interval of 20 minutes while the crab hold the bait on line with chelate legs. The fishermen collect the crab by swiping the net and store them in a big bamboo basket. From the catch composition it was seen that about 33% crabs are within 70 to 100gms, 20% within 100-140gms, 16% within 40-70gms, 14% within 140-200gms, 8% within 180 to 500gms (female), 5% within 200 to 500gms (male), 3% under 40gms, and only 2% within 140 to 180gms. This net is strictly prohibited inside the Sundarban during January to February

but surprisingly it is mostly found in these two months because of high demand of egg bearing crabs.

16. Crab Trap (CT) *chai*: Boxes (size – 32-40cm x 18-31cm x 14-20 cm) made with multiple narrow bamboo sticks used to catch crabs. Eel or fish are kept as bait inside the boxes. The mouth of the box is made in such way that crabs can enter but cannot get out. The mouth opening is on one side of the box from top to bottom and made with crosses sticks. About 32 to 60 boxes were found to have been attached to a main rope by a ladder rope with an interval of 10 to 15 meters. The target species is mud crab (*Scylla serratta*). Fishermen pull out the trap from water after a minimum interval of 30 minutes. From the catch composition it was seen that about 41% crabs are within 70 to 100gms, 35% within 100-140gms, 18% within 40-70 gms and 6% under 40 gms. This gear is a new invention to the Sundarban introduced in 2009 and mostly found in dry season.

Poison fishing in Sundarban: Poison fishing has been identified as one of the most important causes of the decline in fishery resources in the Sundarban (Debnath 2009). The cast net and creek net fishermen often carry pesticides and during outgoing tide set the net across the small creeks and canals inside the forest and use pesticide illegally to catch shrimp and fish at low tide, particularly in the eastern Sundarban. This practice occurs from June to November, with a peak season from mid-August to mid-October (Debnath 2009). An alternative source reports that the peak season is September to December when rainfall is low (Haque 2003). However, the reliability of this information is questionable. Although some other source e.g. Haque 2003 and IPAC 2010 mention poison fishing, it is largely undocumented in the scientific literature, and information is mostly anecdotal. More research is required to quantify the extent, distribution, drivers and impacts of poison fishing.

With the passage of time fishing gears are being made in different shapes and sizes and new techniques are being applied for catching fish and crustacean in the Sundarban. However, nobody respects the fisheries law, seasonal and area fishing bans. So, fisherfolk should respect the fisheries law and local restrictions and should be careful enough about sustainable fisheries to keep a balanced ecosystem for our future generations.

In addition to the above fishing gears, the following are some fishing operations documented from the costal and offshore waters adjacent to the Sundarban, and also illustrated in various published literatures.

1. Marine set bag net (MSBN) *behundi jal / bendi jal / bada jal*: The marine set bag net (MSBN) is used in coastal waters, at depths of up to 30 m, from the island bases of Sonadia, Mohipur and Dubla (Serajuddin and Rahman 1999). This net is made of thick twine and the mesh size is bigger than that of an ESBN, and is operated by mechanized boats during winter. In addition to juveniles, sub-adults and small shrimp and fish, turtles and stingrays are common bycatch of the MSBN.

2. Stern/Bottom drag trawlers: The minimum mesh size of shrimp trawl nets is 4.5 cm at the cod end, and 60 cm for fish trawl nets. The industrial trawl fishery is only allowed to operate beyond 40m depth (Serajuddin and Rahman 1999), though the fleet normally fishes up to 20 m regardless (Islam 2003). Modern bull trawlers, targeting P. monodon, are causing destruction of deep sea habitats (IPAC 2010). Large-scale industrial trawl fisheries account for about 5% of total marine production (Hossain and Rahman 2010).

3. Trammel net ***fash jaal/****duba jaal*: Bottom drifting gill net with a mesh size of 10-15 cm targeting penaeid shrimp and valuable finfish species. The net is most used along the Teknaf-Cox's Bazaar coast throughout the year, and operated by rowing boat at depths of 10-30 m (Serajuddin and Rahman, 1999). It is less destructive and has lower bycatch than many gears (Das 2009).

4. Shark Net hanger jaal or *kamut jaal*: A gill net made of heavy multifilament nylon twine or synthetic fiber (usually 3-4 threads used together) with mesh size of 25 cm. Plastic floats are attached to the top rope and clay disks (weights) are attached to the bottom rope as sinkers. This net's dimension is more than 2000 meter long and 14 meter wide. This net is normally operated by 8 to 10 fishermen on the sea bottom ~10 meter (4bam) under the water surface in between 20 to 50 km offshore from the Sundarban and usually catches about 1000kg per trip. Primary target species is sharks and the secondary target species include croaker, Indian salmon and Spanish mackerel (Das and Bandupadhya 1999, and SBCP 2001b).

5. Large mesh bottom drifting gillnet ***Nakura*** or *Lakkha jaal*: A gill net made of soft multifilament synthetic fiber (usually 3-4 threads used together) with mesh size of 15-25 cm. Plastic floats are attached to the top rope and clay disks (weights) are attached to the bottom rope as sinkers. This net's dimension is more than 4000 meter long and about 15 meter wide. This net is usually operated by 8 to 14 fishermen on the sea bottom at a depth of 20 meters (10bam) in between 20 to 50 km offshore from the Sundarban. The target species are croaker, Indian salmon and Spanish mackerel, mochan, med, konkan mach etc. (SBCP 2001, and Das and Bandupadhya 1999).

REFERENCE

SBCP (Sundarbans Biodiversity Project), 2001a. Report on socio-economic baseline study on the impact zone of the Sundarbans, Bangladesh Forest Department, Khulna.

Hossain, M. A. R. (2010) Inland fisheries resource enhancement and conservation in Bangladesh. In: Miao W., Silva S.D., Davy B., eds., 2010. Inland fisheries enhancement and conservation in Asia. RAP Publication 2010/22, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.

Huda, M. S. 2003. Preliminary report on the analysis of data collected during the fish stock assessment. Technical Report- Tr. no. 27.Sundarbans Biodiversity Conservation Project, Khulna, Bangladesh. 158pp.

Hoq, E.M., Islam, M.N., Kamal, M. and Wahab, M.A. 2003. Fisheries structure and management implications in Sundarbans mangrove reserve forest, Bangladesh. Indian J. Fish., 50(2): 243-249.

Feeroz, M.M., Begum, S. and Hasan, M. K. (2011). Fishing with Otters: a Traditional Conservation Practice in Bangladesh. Proceedings of 6th International Otter Colloquium, IUCN Otter Spec. Group Bull. 28A: 14 - 21

Debnath, K. 2009. IPAC status report on poison fishing in Sundarbans. Bangladesh: WorldFish/IPAC.

Haque, M. E. 2003. How fishers' endeavours and information can help in managing fishery resources of the Sundarban mangrove forest of Bangladesh. In: Putting Fishers' Knowledge to Work. Haggan, N., Brignall, C. & Wood, L., eds., Fisheries Center Research Reports 11, 1. Victoria, British Columbia: UBC Fisheries Center.

IPAC (Integrated Protected Area Co-management). 2010. Study on the Conservation and Management of Fisheries Resources of Sundarbans. Bangladesh: USAID (United States Agency for International Development).

Serajuddin & Rahman, Q. M. S. 1999. Poverty eradication and sustainable fisheries development in coastal villages of Bangladesh. In: Chong, K. & Madhu, eds., S. R. Report of the Workshop on Smart Partnerships for Sustainability in the

Fishing Industry. Penang, Malaysia 26-28 November 1997. Chennai, India: Bay of Bengal Programme.

Islam, S. 2003. Perspectives of the coastal and marine fisheries of the Bay of Bengal, Bangladesh.Ocean & Coastal Management 46: 736-796.

Hussain, M. G. & M. J. Rahman. 2010. Marine fisheries resources of Bangladesh: Stock status and management issues. In: Hussain, M.G. & Hoq, M.E., eds., Sustainable Management of Fisheries Resources of the Bay of Bengal – Compilation of national and regional workshop reports. Support to BOBLME Project. Bangladesh: Bangladesh Fisheries Research Institute, pp. 37-51.

Das, M. 2009. Impact of commercial coastal fishing on the environment of the Sundarbans for sustainable development. Asian Fisheries Science 22: 157-167.

Das. B and Bandupadhya, A. 1999. Matshya Sangraha Projukti (Fish harvesting techniques), Vol. 2. Bangla Academi, Dhaka.

SBCP (Sundarbans Biodiversity Project). 2001b. Draft fishing gears of the Sundarbans. (eds Bernacsek, G and Haque, E.).Ministry of Environment and Forest, Bangladesh. pp 50.

The Forest and its Flora

It was little before eleven and a dark night in January more than 20 years back. Our boat was moored in front of Harintana coupe office and the surrounding darkness and silence was nerve-racking in cool air. The dark and tall trees seemed creeping from the bank silhouetting against the faintly glowing sky and a chilly feeling ran through the spine generated by the unfamiliar quietude. That was the first night for me in the Sundarban. And I can vividly remember every bit of excitement of that voyage even after all these years.

Etymology

The name 'Sundarban', has no firm indication about its origin, but two school of thoughts exist. One group reckons that it had originated from the *Bangla* term '*Sundor*' and '*Ban*' meaning beautiful and forest

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respectively and so together they form *Sundarban* or Beautiful forest. The second group believes that the name derived from the dominant tree species of the forest, '*Sundri*' (*Heritiera fomes*). Anyway, in reality it's a beautiful forest with lots of *Sundri* trees. Yet, locals call it '*paraban*' or '*badaban*' or simply '*ban*'.

Area

Sundarban consists of 10,200 km^2 area spread over Bangladesh and India. Of which Bangladesh Sundarban extends from sea coast to about 80 kms inland and is bound on the east by the Baleswar River and on the west by the international boundary with India. It lays between latitude 21°30N to 22°30N and longitude 89°E to 90°E with a total area of 6,017 km^2 of which, 4,143 km^2 is land area and 1,874 km^2 is water area comprising river and tidal waterways.

However, even in 1911, it was stretched for about 266 km from the mouth of the Hugli to the mouth of the Meghna, and was bordered inland by three districts: Twenty-four Parganas, Khulna and Bakerganj. The total area including water was estimated to be 16,902 km^2. Between 1873 and 1911, a surge of clearing and establishing settlements rose. During this period, with the progression of cultivation, forested Sundarban shrunk by about 2,608 km^2 from 19,510 km^2 to 16,902 km^2, a decrease of about 13.3 percent. This shrinkage reflected large scale conversion of forestlands to cultivation and settlement, most of it in Bakerganj District rather than in Khulna or 24-Parganas Districts. In Bakerganj District, despite substantial increase in the land area due to accretion (18% between 1793 and 1905), the settled area of the district expanded by 36 km^2 per year at the cost of forested land, a rate three times that of natural accretion. At present, the old Bakerganj District or present Barisal Division has virtually no natural forested area left.

Geology

The geological formation of Sundarban delta assembled through the deposition of silt transported by the Ganges and Brahmaputra rivers from the Himalayas which is not much older than 7,000 years. As a so called '*bird foot delta*', the area is made up of triangulate islands and an intricate network of rivers. In the remote past the tidal swamp of the Sundarban was much landward than the present

location, somewhere to the base of Rajmahal hills, but it moves towards the south as the delta extends towards the bay. This growth of delta associated with various other geomorphological alteration and subsequent hydrological adjustments have set the present location and condition of the forest. Tectonic movement in the late Tertiary period in northwest Punjab had changed the course of all Indoburman rivers and that probably pushed the Ganges to flow in the south-eastern direction. Later a neo-tectonic movement in the 12th Century tilted the Bengal Basin eastward raising the western part of the delta. This change resulted in the initiation of degradation of all the distributaries of the Ganges feeding into Sundarban causing a gradual reduction of freshwater flow into the western part of the delta. This reduction or complete stoppage of freshwater supply to the western Sundarban has its significant consequence on the floristic composition; Sundri was once dominating arborescent species even up to Kolkata but now not even a good healthy population can be found in the western part of Bangladesh Sundarban.

Management

The legend of the Sundarban can be followed to as early as 200-300 AD. The ruins of the settlement built by Chand Sadagar have been located in the Baghmara Forest Block in the Indian part of the forest. Later during the Mughal Empire, Raja Basant Rai hid himself in the Sundarban from the onrushing armies of Emperor Akbar. Some of their buildings later used by Portuguese pirates, salt smugglers and dacoits in 17th century. Evidence of the fact can be traced from the ruins at Netidhopani and other places scattered all over the Sundarban.

During pre-Mughal period (1203-1538), local kings leased the forests of the Sundarban out. Even during the Mughal rule the management system didn't change much and local kings or as they were called, 'Jaigirdars' were leasing the lands out for harvest. However, Sundarban acquired the distinction of being the first mangrove forest in the world to be brought under scientific management. The area was mapped by the Surveyor General of India as early as 1764 after proprietary rights were obtained from the Mughal Emperor, Alamgir II, by the East India Company in 1757. Systematic management of the

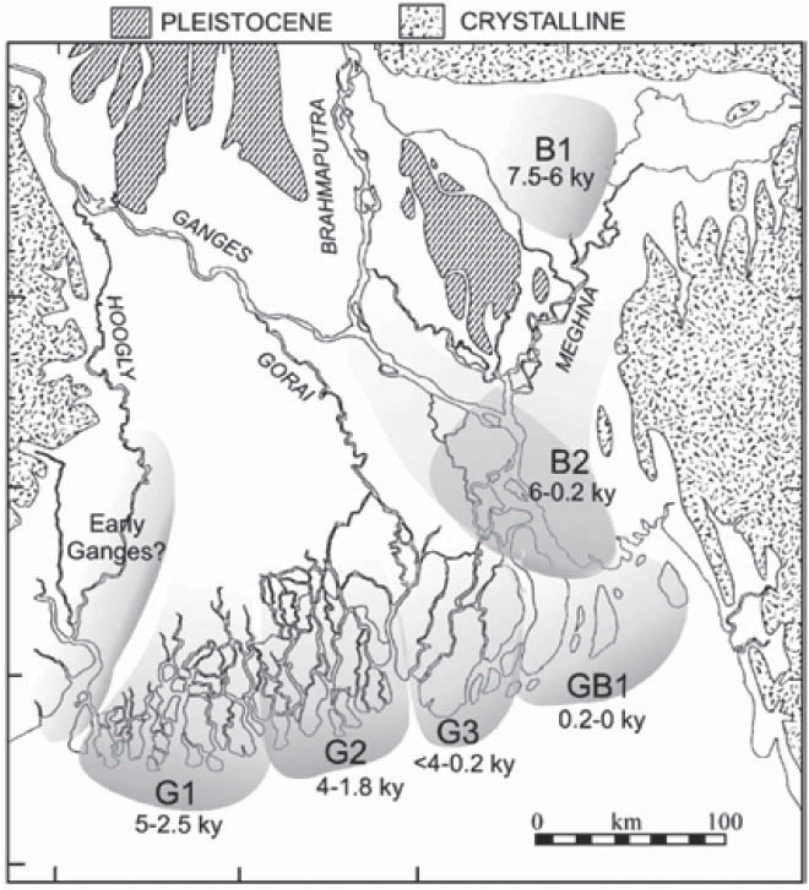


Figure 1: Map of the pathways and timing of the phases of late Holocene growth of the lower delta plain associated with the Ganges (G1, G2, G3), Brahmaputra (B1, B2), and combined Ganges–Brahmaputra rivers (GB1). ky= thousands of years before present. Source: Allison *et al.* 2003.

forest started in 1869 after the establishment of a Forest Management Division in the Province of Bengal, in British India. The Sundarban was declared a reserved forest in 1875-76, under the Forest Act, 1865. A Forest Division was created in 1879 with headquarters in Khulna. The first real management plan was written by R.L. Heinig for the period of 1893-1902. A revised working scheme was prepared by W.F. Lloyd for the period 1903-08. However, the first detailed

working plan was prepared by F. Trafford for the period of 1912-13 to 1931-32. In April 1931, a new plan prepared by Curtis came into force. In 1937, the plan was revised by S. Choudhury for the period of 1937 to 1947. After 1947, the forests were managed under short term plans until 1960. During the late 1950s, a detailed inventory of the forest resources was carried out by Forestal Forestry and Engineering International Limited of Vancouver, Canada. Techniques very new for that time like aerial photography and photogrammetric methods were used for the first time in this part of the world. Based on that inventory, a new working plan was prepared by A.M. Chowdhury for the period 1960-61 to 1979-80. From 1981 to 1985, the Sundarban was managed by extending the A.M. Chowdhury's plan. From 1985 to 1990 an interim set of prescriptions by E.G. Balemforth was used to manage the forest. In 1990 a temporary moratorium on timber harvest was imposed, which is still operational. However, the present forest management is primarily guided by Forestry Master Plan (FMP) completed in 1993.

Floral diversity

Defining mangrove species is truly a complex and difficult work; different authors have put forward different numbers. Chapman (1976) noted 90 mangrove species globally whereas Saenger et al. (1983) recorded 83 species. UNDP/UNESCO (1986) reported 65 species, but Tomlinson (1986) mentions only 48 true mangrove species. Moreover, he acknowledged two types of mangroves- True mangroves – the species with complete fidelity to the mangrove environment, and (2) Minor elements of mangals – not conspicuous in mangrove habitats, rather preferring the peripheral habitats. Many other researchers, Watson (1928), Chai (1982), Mepham & Mepham (1984), and Naskar (1993) have applied the term 'Mangrove associate' as an equivalent to minor elements for the plant found in areas bordering the true intertidal mangrove habitats. Spalding *et. al*. (2010) noted 73 mangrove species, out of which 38 species, he recognized as core mangrove species. Kathiresan & Rajendran, (2005) have reported 69 mangrove species from India.

Based on the available water quantity and quality and characteristics of plant water-relationship, the vascular plants are classified in eight

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major categories, (i) Helophytes, (ii) Xerophytes, (iii) Mesophytes, (iv) Halophytes, (v) Oxylophytes, (vi) Psychoxerophytes, (vii) Lithophytes and (viii) Psammophytes (Warming, 1909). Out of them the first four categories, i.e. Helophytes, Xerophytes, Mesophytes and Halophytes are the major flora in the Sundarban mangrove forest. However, Halophytes occupy the largest share of the true mangrove species. The habitats of halophytes are frequently inundated with tidal sea water which requires them to counter this anoxic condition. Halophytes display selective water absorption quality and can tolerate dissolved salts as they grow on saline soil. They adjust in saline surroundings by osmo-regulatory means to prevail over the toxic effect of dissolve salts. They have succulent, small, evergreen and leathery leaf with thick cuticles and developed water storage and palisade tissues. Mangroves species resemble many of the characters of halophytes and sustain exposure to variance in salinity and the degree of water-logging. However, pneumatophores, knee roots, prop roots, root buttresses and unique viviparous, crypto-viviparous or pseudo-viviparous germination mechanisms are unique and are not available in all halophytes.

Mangrove forests are edaphic evergreen, occurring primarily on muddy shores of tropical coastal areas subject to periodic submergence by tidal waters. Throughout the tropics, they are much alike in their physiognomy – evergreen, closed canopy, floristically pauperate vegetation, although they differ in their structure and floristic composition. The mangroves in the Bay of Bengal, including the Sundarban, belong to the Indo-Malayan group and are regarded as a distinct sub-group.

Because of its floral richness and dominant species composition mangroves in the Sundarban occupy a unique position among the global mangroves. The Sundarban flora is distinguished by the wealth of *Sundri, Genwa* (*Excoecaria agallocha*), *Goran* (*Ceriops decandra*) and Keora (*Sonneratia apetala*). The floras of Sundarban have drawn the attention since 19th Century. In 1895, a comprehensive list of Sundarban plants was presented by C.B. Clarke in his presidential address to the Linnaean Society of London. A collection of the flora of the Sundarban and the surrounding area by Prain (1903) included the plants of swamp forest, grass-savannah, strand vegetation and

the reclaimed areas across the entire expanse of the Sundarban and identified a total of 334 species belonging to 245 genera of Spermatophytes and Pteridophytes. Of these, no fewer than 123 species occur in the present reserve forest of the Bangladesh Sundarban. The working plans prepared thereafter have also taken into account the Sundarban flora (Curtis, 1933). Although a general of changes have taken place in the status of various mangrove species and taxonomic revision since Prain's report, a comprehensive botanical exploration of the Sundarban has never been attempted there after.

Studies of Maiti, (1999), Ghosh *et. al.* (2003), Mukherjee (2004) and Sharma & Naskar (2010) provide an estimate of approximately 180 species under 54 families and 118 genera in the Indian Sundarban. The number would be similar in the Bangladesh part as well. However, the forest canopy reaches a maximum height of about 20 m and in some cases highly stratified. The forest in the eastern and north central part shows higher strata, typical to the tropical rain forest structure. Epiphytes and woody parasitic species are common at the tree crown unlike to the description of mangrove by Amitav Ghosh in ***The Hungry Tide***.

Among the dicotyledonous plants, the tree species are characterized 30 genera of 22 families. Rhizophoraceae is represented by all the 4 known genera and at least 6 species. Avicenniaceae is represented by 3 species, Meliaceae is represented by 3 species, Combretaceae is represented by 2 species and Sonneratiaceae is represented by 2 species. Among the tree species Genwa and Sundri were found to be the most dominant species.

The shrubs or scandant shrubs are distinguished by 12 species belonging to 11 genera under 7 families. The forest is also abundant with climbers. At least 11 species belonging to 6 families have so far been identified. The monocotolydenous herbs are represented by Graminae, Palmae, and Pandanaceae. Besides the rooted plants, the swamp forests species also include the epiphytic and parasitic flora that survive on the rooted trees and do not come into contact with the forest floor. The epiphytes include *Hoya parasitica*, *Dischidia numularia, Derris heterophylla, D. scandens* and *D. trifoliata*. Family Orchidaceae is signified with 13 species. One of the orchids, the Roxburgh's Orchid, scientifically called *Bulbophyllum roxburghii* is

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reported to be endemic to the Sundarban. Among parasites, *Cuscuta reflexa* and *Dendropthoe falcate* are common. Seven epiphytic ferns also reported, including *Lycopodium* sp. and *Psilotu* sp. The Tiger fern (*Acrostichum aureum*), though growing with salt marshes, sometimes form dense patches on river banks and other water logged areas.

Unlike other mangroves, the dominant floral species in the Sundarban is *Sundri* – a member of the Sterculiaceae family. Assemblage of species typical to the Sundarban once extended from the coast of Orissa through the Sundarban, Chakaria, and the Naf estuary in Bangladesh to Tanasserim and in the Irrawaddy delta in Myanmar. Most of the natural vegetation within this distribution range has been cleared for other land use. The near natural vegetation with Sundri dominant species is, at present, limited only to the fresh water dominating eastern part of the Sundarban.

In the Sundarban, three distinct vegetation types have been documented in relation with varying degree of water salinity and freshwater flow.

In the northeast, where freshwater flow is now maximum, Sundri either in pure patches or interspersed with Genwa, Passur (*Xylocarpus mekongensis*) and Kankra (*Bruguiera gymnorrhiza*) are the dominant vegetation type. With Sundri and Genwa some parts are associated with discontinuous distribution of the Dhundal (*Xylocarpus granatum*) and Kankra. Among grasses and palms the *Portresia cocoarctata, Myriostachya wightiana, Imperata cylindrica, Phragmitis karka and Golpata (Nypa fruticans) are well distributed. The Shingra (Cynometra ramiflora*) and Amur (*Amoora cucullata*) grow in more saturated sites as under storey and the Goran in drier sites. Golpata is widespread along the newly formed mudflats along the drainage creeks and riverbanks.

In the south close to the sea with obviously the greatest seasonal variation in salinity levels, Genwa is the dominant woody species. It is often mixed with the Sundri in the backswamps, which receives frequent inundation by the tidal water twice a day. It is also commonly associated with dense understorey of the Goran and sometimes the Passur. In the newly accreted mudflats, the Keora forms pure patches. The Baen (*Avicennia marina*) either grows in mixed patches with Keora or in pure patches in the islands near the sea. The *Rhizophora*

mucronata, Rhizophora conjugata and the Golpata are common along the creeks.

In the western part with more salinity sparse Genwa and dense growth of the Goran is the key vegetation form, with discontinuous patches of the Hantal (*Phonix paludosa*) which grows on the drier ground and riverbanks. Sundri and Passur are found but smaller in size and diameter. As usual in other zones, Keora, and the Golpata are widespread along the drainage creeks and riverbanks.

All plant species show seasonality in leaf, flower or fruit production and the Sundarban is no exception to this. The lean period of freshwater is coincidental with the increase in salinity and also negative precipitation and evapotranspiration values. The dominant plant Sundri and members of Rhizophoraceae are evergreen trees while Genwa and Passur are deciduous trees. Sometime a large part of the Sundarban is suffused in red or pink. This is due to the colour change of the colour of Genwa which turn red at the time of shedding. Some plants were found to shed their leaves twice a year, once during October-November and again during May-July. Passur shed its leaves during the month of March. However, the same species may not shed its leaves in all areas at the same time. This is due to the strength of the stimulus which triggers leaf fall.

Most of the trees in the Sundarban flower during pre-monsoon in the months of March and April, although not variation among individuals does exist within a single population. Fruits are produced after the flowering in the early part of the monsoon. However some species such as Gura (*Kandelia kandel*) and *Bruguiera gymnorrhiza* may flower more than once a year. Sundri trees, in general, fruit heavily in alternate years. It was also observed that many mangrove species flower sporadically during any month of the year and this irregular behavior tends to obscure the existence of a single regular flowering and fruiting season.

Members of the family Rhizophoraceae show viviparous germination and shed their fruits mostly from July to August and may continue up to September to October. Fruit shedding in Baen is completed within a very short period during the month of August. Fruit shedding of Sundri varies from area to area but tends to complete by July and August.

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Local	Scientific name	J	F	M	A	M	J	J	A	S	O
Sundri	*Heritiera fomes*										
Genwa	*Excoecaria agallocha*										
Amur	*Amoora cucullata*										
Golpata	*Nypa fruticans*										
Kankra	*Bruguiera gymnorrhiza*										
Keora	*Sonneratia apetala*										
Passur	*Xylocarpus mekhongensis*										
Baen	*Avicennia officinalis*										
Goran	*Ceriops decandra*										

Flowering time ▬ ; Fruit ripening time ■ ■ ■

Structure and physiognomy

Evergreen species – both trees and shrubs – dominate the Sundarban. However, the vegetation composition is highly mixed and it is rare to find communities that are homogenous in structure and composition over large areas. Apart from certain communities in degraded conditions, the forest is generally closed in structure and stratification is distinct. Even above 70% canopy closure is not uncommon in a healthy condition. Some of the best developed forests are found in the moderate to relatively freshwater areas in the northeast. Under ideal growing conditions, the Sundarban can support lofty evergreen trees of 25-30 m in height.

Trees are found to occur as mixed vegetation and sometimes form monospecific vegetation types. There is a great variation of vegetation, varying from multi-storeyed forest forming closed canopies to scrubby bushes with widely dispersed stunted trees. It is frequently the case that trees in the upper canopy have spreading branches while tree crowns in the lower strata are mostly slender. Species which are light demanders usually form pure stands such as *Avicennia* and *Sonneratia* (Hussain & Acharya, 1994).

Often the emergent stratum is occupied by only Sundri. The canopy is usually irregular and trees are without a single central trunk. Under this the second stratum either consists of pure Sundri or a mixture of Genwa and/or *Kankra*. In this stratum, tree crowns of the canopy are usually tall and narrow and form a continuous layer. The third stratum consists of saplings of the canopy trees and medium sized trees of Amur and Shingra.

In particular areas, this pattern could differ with a complete absence of undergrowth in a dense Sundri forest dominated backswamp. But, in other areas, predominantly in low lying areas or along the riverbank, there is an undergrowth of varying densities, sometimes thick and almost impenetrable with Kewa (*Pandanus* sp.), Bhola (*Hibiscus tiliaceous*), Tiger fern and Hantal.

Forest Types

Forest types are classified predominantly through floristic assemblage based on dominant or co-dominant species. In case of Sundarban Whittaker, (1962) and Karim, (1988), proposed a simplified classification of mangrove vegetation, based on dominance of a single species. Although classified as mono-dominant forest types, these categories of forest vary in their floral assemblage and proportions of species depending on the site condition. The categories are listed below.

1. Grass type: Dhani ghas (*Porteresia coarctata*) and Nol khagra (*Phragmitis karka*) are the dominant in this vegetation type. They are abundant and occur in the newly accreting mud as a distinct zone or may be associated with Keora, Bean, Golpata. Wetlands within the Sundarban possess both Nol khagra and Hogla (*Typha elephantina),* which form extensive patches of marsh vegetation surrounded by dense forest vegetation.

2. Golpata type: This palm occurs along river banks and creeks. A zone of grass, Keora or Bean trees may occasionally be found in front of this zone, along the banks of larger water courses.

3. Baen dominance type: The genus *Avicennia* is represented by three species in the Sundarban of which only *Avicennia marina* was found to cover reasonable sized patches in pure composition in the south with high saline zones. Sometimes it forms mixed vegetation with *Aegicerus corniculatum* and *Aegialitis rotundifolia*. The other two species (*Avicennia alba* and *Avicennia officinalis*) generally do not exist as a dominant species and are found along the river banks and occur in association with other mangrove plants in relatively low saline regions.

4. Keora dominance type: Always on the newly accreting mudflats as pioneer species, this species generally forms monospecific stands

of a few trees to a patch of several hundred meters. *Golpata, Avicennia marina* and Khulshi (*Aeigicerus corniculatum*) are the common associates of this dominance type. Regeneration of Genwa was found to occur under the mature trees of Keora.

5. Genwa dominance type: They occupy a very large part of the Sundarban, and are found in a variety of saline regime. The associate of this dominance type varies from pioneering trees like Keora to late seral species such as Sundri and even *Tamarix indica*. However, Goran is the most common associate of the Genwa in the Sundarban. Hental forms a distinct belt of forest either in pure patches or in association with Genwa in elevated river ridges.

6. Sundri dominance type: Similar to Genwa, Sundri is also found throughout Bangladesh Sundarban and often occurs as mixed vegetation associated with Genwa, Passur, Amur, *Cynometra ramiflora*, Baen and Goran. It is sometimes found as monospecific types in the back-swamps.

7. Kankra dominance type: This type represents one of the most luxuriant attractive vegetations in the Sundarban but is restricted to small north-central part of the Sundarban. The dominant tree, Kankra (*Bruguiera gymnorhiza*), and its umbrella like structure, forms an unbroken canopy along with the major associate Sundri. The other tree species associated with this type are Genwa, Passur and Baen.

8. Goran dominance type: Goran can form an impenetrable scrubby thicket. It occurs as an undergrowth associated with scattered Genwa or Sundri in the eastern part of the forest.

Geomorphology, sedimentation & Topography

Fluvial surfaces are response units to the interaction of stream erosion, accretion and vegetation. Each of these provides a unique habitat representing a potential niche for vegetation development. Geological and tectonic activity, together with past and present drainage patterns has been instrumental in defining the present geomorphology of the Sundarban. Here, at least four morphometric categories could be discernible, i.e., river or stream creeks, mudflats, ridges and back swamps, one grading into the other and responding to the changes in the fluvial process. While the geomorphic process largely determines the development of mangroves in a region,

they are important mainly in producing certain substrate or soil condition and regulating the inundation time and frequency. Analysis of vegetation along the gradient of landform reveal that species assemblage pattern changes with the changing pattern of landform and its position in relation to the elevation from the sea level (Figure. 2). Thus, hydrological factors (sedimentation, drainage density etc) that change the morphometric pattern of the landscape have bearings on the vegetation development in the Sundarban. The Sundarban are low elevated isolated (like islands) landmasses under strong tidal influence. Plants have special adaptation to survive in saline condition using pneumatophores. There are variations of vegetation composition within the Sundarban due to the variation of physical factors: topography, salinity, soil condition and tidal variation. Different ecological niches of the Sundarban and occurring plants are shown in Table 2.

Plants and animals occurring in particular niches are important bio-indicators to identify habitats and monitoring changes due to climate change and destruction of habitats from climatic and anthropogenic causes. These niches are also breeding grounds for particular animals like Gangetic dolphins and Irrwaddy dolphins. Destruction of these habitats will cause damage to niche plants and animals. These bio-indicators and ecological niches should be taken into consideration

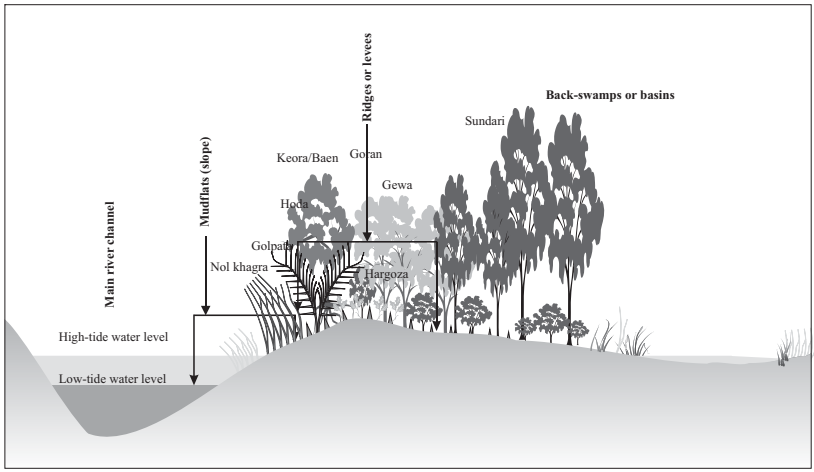


Figure 2. Profile of vegetation along the geomorphic gradient (after: CEGIS 2001)

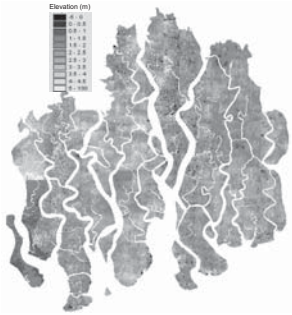
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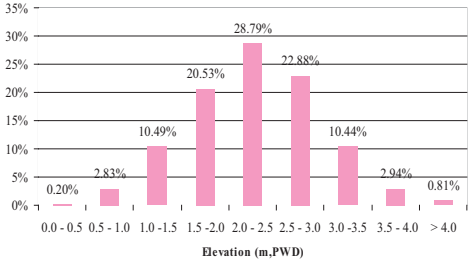
while developing a SRF conservation and management plan.

Table 2. Profile of vegetation along the geomorphic gradient

Ecological Niche	Occurring Plants
Mudflats (slope)	Hodo (*Acrostichum aureum*), Nol-khagra (*Phragmties karka*), Dhanshi (*Myriostachya wightiana*), Golpata (*Nypa fruticans*) and Hargoza (*Acanthus ilicifolius*)
Ridges or levees	Hargoza (*Acrostichum aureum*), Golpata (*Nypa fruticans*), Hantal (*Phoenix paludosa*), Baen (*Avicennia officinalis*), Kakra (*Bruguiera gymnorrhiza*), Keya katta (*Pandonus foetides*), Keora (*Sonneratia apetala*) and Dhundul (*Xylocarpus mekongensis*) and Keora (*Sonneratia apetala*)
Back-swamps or basins	Sundri (*Heritiera fomes*), Dhundal (*Xylocarpus mekongensis*), Genwa, (*Excoecaria agallocha*) Passur (*Xylocarpus mekongensis*), Kakra (*Bruguiera gymnorrhiza*) , Amoor (*Amoora cuculata*), Singra (*Cynometra ramiflora*) and Keya (*Pandonus foetides*)
Main river channel	Golpata (*Nypa fruticans*)
Tidal creeks	Chanda lota (*Dalbergia spinosa*), Gila (*Derris trifoliata*), Abeta (*Flagellaria indica*), Bowali lata (*Sarcolobus globisus*)
Bay or sandy shore	*Ipomoea pes-caprae*, *Paspalum* sp., *Suaeda maritime*, *Cynodon dactylon*

Figure 3. Topography of Sundarban; Source: CEGIS 2006





The topographical distribution of Sundarban varies from 0.5 meter to 4.0 meter with respect to mean sea level as shown in Figure 3. Inside the Sundarban the tidal fluctuation ranges from 1.5 to 2.5 meter. Approximately seventy percent of the land lies between 1.5 to 3.0 meter elevation, which goes under water in regular tidal flooding twice a day. But almost 85% of the land goes under water during high tide in the monsoon season.

Historical changes in vegetation

Geological evidences suggest that the Bengal Basin tilted eastward during the 12th Century because of the neo-tectonic movement. The rise of the western part of the delta separated the ancient branches of the river Ganges from the area, which today comprises the Indian and western part of Bangladesh. This alteration in the course of the main river resulted in a reduction of freshwater flowing into the western part of the delta. This in turn led to accretion at the river mouth and an increase in saline water intruding into the western part of the delta. The lack of freshwater to the western part has had significant effects on the floristic composition of the forests. For instance, according to some studies of fossil pollen, *Sundri* was a dominant arborescent species in the Kolkata region about 5,000 years ago. However, the Indian Sundarban as well as the western part of the Bangladesh Sundarban no longer supports a healthy population of this species, which requires fresh or slightly saline water. Presently, it is dominant only in the eastern part of the Bangladesh Sundarban. On the other hand, more saline tolerant species become dominant in the western part of the Sundarban forest.

Change of vegetation in between 1985 and 1996

The pattern of vegetation succession in the Sundarban depends upon the development stages of the land building process under particular sets of the fluvial regime. Salinity gradients, which in turn depend on the quantity of freshwater flushing from the upstream, also play an important role in shaping the vegetation development. The Sundarban vegetation consists of recurrent patches of vegetation types. Overall, the mosaic formed by these patches represents the equilibrium for the whole ecosystem. It is however argued that the mosaic of forest types represents the serial stages towards an equilibrium condition of vegetation development. Depending on the stresses, both biotic and abiotic, including management conditions there are a number of self maintaining terminal stages of vegetation development which differ from the traditional concept of climax. The most favourable development of vegetation occurs in the freshwater dominating area where the Sundri is the dominant plant. Another extreme condition under the high salinity terminal community is dominated by the Goran, which is a thicket of scrub. In both cases,

grasses and/or trees dominate the initiating and pioneer stage of vegetation development.

The floristic composition of different successions depends upon the species niche and the physical conditions of each specific site. At the present level of information, potential changes in hydrology due to the changing flow of freshwater from upstream could best be understood from a comparison of salinity of the eastern region with that of the western region and its significance on the structural characteristics of vegetation. An attempt is made here to detect the changes in the floristic composition occurring between 1985 and 1996, when the freshwater flow into the Sundarban was gradually decreasing. The data source for calculation was obtained from the forest department as two vegetation maps depicting polygons of different dominant plant communities. The changes, detected by overlapping the two maps, are provided in Table 3.

During this period, major changes have occurred in the Sundri and Genwa dominated areas, as Genwa is gradually replacing Sundri as the dominant tree species. Pure Sundri dominated areas was reduced by about 86 km^2 or about 11 percent of their previous extent, most of which are converted into the Sundri-Genwa and Sundri-Passur-Kankra community. The Sundri-Genwa community also followed a decreasing trend, as it lost 146 km^2 or more than 10 percent of its land to the Genwa-Sundri and Genwa-Mathal community. So the overall shift is from Sundri to Genwa and from Genwa to other more saline tolerant species. A similar trend is also visible even in the higher saline zone where the high saline loving Goran is replacing the Genwa and Sundri. Keora dominated areas have also increased from 37 km^2 to 79 km^2 resulting in an expansion of 43 km^2 or 110 percent. Grass and Bare Ground areas have also increased by about 15 $km.^2$

The general trend during this period indicates the reduction of commercially valuable species like the Sundri and Genwa and increase of less valued smaller tree species. From this change detection exercise, it is evident that the changes that occurred during this period are mostly concentrated in the eastern part of the Sundarban. This might be because of the changed scenario of the salinity regime in the eastern belt due to decreasing freshwater influx from the Gorai River. The vegetation community in the western region seems to be

more stable as the hydrological regime in this area remained stable during the period.

Table 3: Change of area with dominant vegetation types from 1985 to 1996

Vegetation communities	1996	1985	Difference	% area of 85 remaining unchanged in 96	% area of 96 remaining unchanged from 85
Water	4.46		4.46		
Sundri	750.30	836.50	-86.20	72.70	81.05
Sundri-Genwa	1061.70	1208.29	-146.59	66.70	75.91
Sundri-Passur	24.71	21.84	2.88	77.40	68.39
Sundri-Passur-Kankra	73.94	67.32	6.63	85.18	77.54
Genwa and Genwa-Mathal (Coppice)	213.86	193.40	20.46	56.05	50.69
Genwa-Goran	348.96	373.70	-24.74	73.52	78.74
Genwa-Sundri	764.83	597.97	166.86	70.44	55.07
Goran	83.34	85.50	-2.16	65.35	67.04
Goran-Genwa	563.70	571.87	-8.17	86.87	88.13
Passur-Kankra	2.86	9.55	-6.70	15.65	52.36
Passur-Kankra-Baen	25.85	16.77	9.08	78.29	50.80
Baen	11.47	9.28	2.19	32.48	26.28
Keora	79.32	36.61	42.71	75.62	34.91
Grass and Bare Ground	58.91	43.68	15.23	38.63	28.64
Tree Plantation	2.10	3.52	-1.42	31.20	52.26
Sandbar	9.45	3.97	5.49	26.54	11.14

Source: Forest Department

REFERENCES

Allison, M. A., Khan, S. R., Goodbred, S. L. and Kuehl, S. A. (2003). Stratigraphic evolution of the late Holocene Ganges-Brahmaputra lower delta plain. Sedimentary Geology, 155 (3-4) pp. 317-342.

CEGIS, (2006). Impact of sea level rise on landuse suitability and adaptation options. Dhaka

Chai, P.K. (1982). Ecological Studies of Mangrove Forest in Sarawak. Ph.D. Thesis. University of Malaya, Kuala Lumpur.

Chapman, V.J. (1976). Mangrove Vegetation. . J. Cramer, Germany. 447 pp.

Curtis, S.J. (1933) Working plan for the Forests of the Sundarban Division, Vol. I and II, Forest Department , West Bengal, Clacutta.

EGIS II, (2001). Environmental and social impact assessment of Gorai river restoration project. Dhaka.

Ghosh, A., S. Mukherjee, Neera Sen, Manjistha Dasgupta & K. R. Naskar (2003). Floral diversity of mangroves and mangrove associated species in the Indian Sundarban with special reference to distribution and abundance. J. Indian Soc. Coastal agric. Res. 21(1): 53-58.

Hussain, Z. & G. Acharya, (1994), Eds. Mangrove of the Sundarban. Volume two: Bangladesh. IUCN, Bangkok, Thailand.

Karim, A. (1988). Environmental Factors and the distribution of mangroves in Sundarban with special reference to *Heritiera fomes*. Buch-Ham. PhD thesis (unpubl.), University of Calcutta, 222 pp.

Kathiresan, K. & B. L. Bingham (2001). Biology of mangroves and mangrove ecosystems. Advances in Marine Biology, 40: 81-251.

Maiti, G. G. (1999). Monocots of Sunderbans and their present status. In: D. N. Guha Bakshi et. al. (eds.): Sunderbans Mangal, Pp. 400-414.

Mepham, R.H. & J.S. Mepham. (1984). The flora of tidal forests – a rationalization of the use of the term 'mangrove'. South African Journal of Botany, 51: 75-99.

Mukherjee, S. (2004). Ecological investigations on mangroves of the Sundarban Tiger Reserve in West Bengal (India) with special reference to effective conservation through management practice. Ph.D. Thesis. University of Calcutta.

Naskar, K.R. and Guha Bakshi, D.N., (1987). Mangrove swamps of the Sunderbans an ecological perspective. Naya Prakash Publishers, Kolkata.-06.

Naskar, K.R. (1993). Plant Wealth of the Lower Ganga Delta – An Eco-taxonomical Approach. Daya Publishing House, New Delhi, India.

Prain, D. (1903). Flora of Sundarban, Rec. bot. surv. India, 2(4): 231-370.

Saenger, P., E. J. Hegerl & J. D. S. Davie (1983). Global status of mangrove ecosystems. Commission on Ecology Papers No. 3. Gland, Switzerland, World Conservation Union (IUCN).

Sharma, A. P. and Naskar, K. R. (2010). Coastal zone vegetation in India with references to Mangroves and need for their conservation. In: Naskar,K.R. and Bar(eds.) Sunderbans issues and threats. Central Inland Fisheries Research Institute. Kolkata.

Spalding, M. D., Kakinuma, M. & Collins, L. (2010). World Atlas of Mangroves. Earthscan Publications. London and Washington D.C.

Tomlinson, P. B. (1986). The Botany of Mangroves. Cambridge University Press, Cambridge, London, New York.

UNDP/UNESCO. (1986). Mangrove of Asia and the Pacific: Status and Management. Quezon City.

Warming, E. (1909). Oecology of Plants (Engl). Clarendon Press, Oxford.

Watson, J.D. (1928). Mangrove forests of the Malay Peninsula. pp. 1-275. Malayan Forest Records 6. Fraser and Neve Ltd., Singapore.

Whitaker, R.H. (1962). Classification of natural Communities, Bot. Rev. 28(1): 1-160.

The Sundarban Mangrove Forest: Undergrowth Phytodiversity and Ecosystem Health

The Sundarban Mangrove forest is an exceptional ecosystem where some specific ecological factors such as temperature, sea-current, rainfall, salinity stress, wave action, sedimentation, saline water intrusion, fresh water flow, etc., determine the occurrence, development, distribution and association of mangrove floral diversity. Notably, the floral diversity of Bangladesh Sundarban Mangrove forest is very rich compared to other mangrove forest of the world. Although, the association and diversity of plant genetic resources of the Sundarban are remarkably richer than in other mangrove forests of the world, an in-depth floristic exploration of the UNESCO declared World Heritage as inadequate. A few sporadic field surveys on the plant diversity of Bangladesh Sundarban were

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done by Bangladesh National Herbarium (BNH), IUCN, UNDP, ODA and FAO. An extensive field based project, the 'Sundarban Biodiversity Conservation Project' (SBCP) was conducted by IUCN, Bangladesh and the Forest and Environment Ministry of the Government of Bangladesh in 2001 to 2003. In the present paper habitat diversities of different salinity zones have been specified and associated undergrowth plants have been categorized on the basis of salinity zones. Attempts are being made to specify undergrowth plant species that have been adapted and which commonly grow in all the salinity zones as 'Indicator Species'. Key factors for the assessment of ecosystem health of this natural forest have also been discussed.

Habitat diversity of the Sundarban Forest

The whole of Bangladesh Sundarban is broadly divided into two regions, viz. 'Sundarban Mangrove Forest' and 'Sundarban Freshwater Forest'. About 68.5% of the Sundarban forest is covered by forest plants, 30.42% by rivers and canals; and 1.08% by barren and reforested areas (Rahman and Banu, 2003). But on the basis of salinity status, all habitats of the Sundarban have been recognised as three distinct ecological zones (Heining, 1892; Curtis, 1933; Karim, 1994; Siddiqi, 2001; PRDI, Hossain, 2003; Prain, 1903/Rep. 1963, Mohiuddin *et al*, 2007) and these are Oligohaline or Freshwater zone, Mesohaline or Moderately saline zone and Polyhaline or High saline zone. Geographically, the Sundarban forest habitats have been distributed from east to west and three distinct eco-zones, such as East Eco-zone, Middle Eco-zone and West Eco-zone representing Oligohaline, Mesohaline and Polyhaline zones respectively. Important areas belonging to Oligohaline zone include- Mirgamari, Panirhat, Terabeka, Dhabribunia, Tearchar, Pakhirchar, Deemerchar, Kotka, Dublarchar, Jhongra beel etc. Mesohaline areas are Keurabunia, Hodda, Potakata, Dhanshiddirchar, Andarmanik, Kobadak, Chandpai etc. On the other hand, areas under Polyhaline zones are Koikhali, Kolagachia, Dubeki, Puspakathi, Mandarbari, Kalirchar, Danokhali and east side of Raimangal river.

Undergrowth Plant diversity in Bangladesh Sundarban

Bangladesh Sundarban is one of the most unique mangrove

forests of the world with a rich biodiversity. Plant diversity of the Sundarban is broadly classified into two major categories such as: True Mangrove or Halophytic plants and Associated plants, mainly undergrowth species along with some climber, epiphytic and parasitic plants. Mangrove plants grow more or less in the whole Sundarban but their population and association vary in different ecological habitats depending on salinity level. In general, the Oligohaline zone is dominated by Sundari (*Heritiera fomes*), Mesohaline zone by Genwa (*Excoecaria agalloca*) and Polyhaline zone by Goran (*Ceriops decandra*) (Rashid *et al*, 2008).

Undergrowths are those herbaceous and shrubby plants which commonly grow beneath the tall trees in the forest floor. Small trees and their seedlings and saplings are also considered as undergrowth species. A good number of undergrowth plants are grown in the Sundarban along with halophytic plants. But diversity of undergrowth plant species differs in different salinity zones of this forest. Relevant studies (Karim, 1994; Hossain, 2003, Rahman and Banu, 2003; Rashid *et al*, 2008; Mannan, 2010) report that about 75 plant species, under 35 plant families have been recorded as undergrowth in different habitats of the Sundarban (Table-1). But it is exceptionally remarkable that the diversity and association of undergrowth in terms of number and their population are much higher in Oligohaline zone than Mesohaline and Polyhaline zone. Recorded numbers of undergrowth species in Oligohaline, Mesohaline and Polyhaline zones are 68, 22 and 26 respectively, including climbers, ferns and grasses (Figure-1). Among all the representative plant families, the most dominant are the Poaceae, Fabaceae and Cyperaceae, which contained 12, 10 and 6 undergrowth species respectively. It is interesting to note that though many of the undergrowth species are restricted or habituated to grow in specific saline zones, about 10 undergrowth species have been found to dominate and commonly adapted to grow in all salinity zones of Sundarban.

Undergrowth plants in Oligohaline zone

Association of undergrowth diversity is the richest in different areas of this zone due to the presence of fresh water or low level salinity in soil and water. Important plant species include- Dheki lata

(*Stenoclaena palustris*), Golpata (*Nypa fruticans*), Nal ghash (*Eriocaulon procera*), Mutha (*Cyperus rotundus*), Chitki (*Phyllanthus reticulatus*), Bhui amla (*Phyllanthus nirruri*), Nata (*Mucuna monosperma*), Abetee (*Flagellaria indica*), Motmoti (*Clematis arborea*), Vhat (*Clerodendrum inerme*), Malankuri (Eleusine indica), Shonpat (*Crotalaria juncea*), Chagal boti (*Clematis gouriana*), etc.

Undergrowth plants in Mesohaline zone

Some important undergrowth plant species that grow in different areas of this zone are- Shola (*Aeschynomene aspera*), Gul pata (*Nypa fruticans*), Gila lata (*Entada pursaetha*), Nol khagra (*Phragmitis karka*), Hogla (*Typha angustata*), Malia ghash (*Cyperus sp.*), Asam lata (*Mikania cordata*), Chechra (*Scirpus articulatus*), Karoch (*Pongamia pinnata*) and others.

Undergrowth plants in Polyhaline zone

Undergrowth plant species that have adapted to grow in this high saline zone are- Gura (*Kandelia candel*), Dabur (*Cerbera manghas*), Tambul kanta (*Dalbergia spinosa*), Bhola (*Hibiscus tilliaceous*), Kholshi (*Aegiceras corniculata*), Goran (*Ceriops decandra*), Kontikiri (*Solanum xanthocarpum*), Lata Sundari (*Brownlowia lanceolata*), Tora (*Aegialitis rotundifolia*), Chanda lata (*Dalbergia candenatensis*), etc.

Common undergrowth species

Among all undergrowth plants, some are found to grow commonly in all saline zones of the Sundarban. These are- Harguza (*Acanthus ilicifolius*), Tiger fern (*Acrostichum aureum*), Hental (*Phoenix paludosa*), Bandali lata (*Sarcolobus carinatus*), Bawali lata (*Sarcolobus globosus*), Kalialata (*Derris trifoliata*), Keya (*Pandanus foetidus*), Bailla ghash (*Myriostachya wightiana*), Dhanshi (*Porteresia coarchata*) and Anallata (*Vitis trifolia*). These common undergrowth species can be considered as the 'Indicator Species' of Sundarban Mangrove Forest.

Ecosystem health of Bangladesh Sundarban

The Sundarban is the largest intertidal delta in the world and harbors the largest mangrove vegetation (Arabinda *et al*, 2008). This ecosystem is a unique natural wonder of the world and carries a great ecological significance. Healthy condition or ecosystem health status is very important for the association, regeneration,

restoration, conservation and sustainability of biodiversity of any natural ecosystem. The Sundarban ecosystem has been affected by many biotic (mainly, due to human exploitation) and abiotic (mainly, due to natural catastrophes) causes creating severe consequences especially, on its floral and faunal diversity. Due to the present fragile condition of the Sundarban ecosystem, it is very important now to assess and monitor the ecosystem health status of the world's largest mangrove forest for its sustainable management and eco-friendly conservation. Biological indicators are now being used as important tools for the assessment of ecosystem health which reflect community derived environmental values to infer overall ecosystem health status (Hossain, 2003).

Table 1: List undergrowth plant diversity in different salinity zones of Bangladesh Sundarban

Undergrowth species		Salinity zones			Plant family
Local name	Scientific name	Oligo.	Meso.	Poly.	
Harguza, Kotki, Harkuch kanta	*Acanthus ilicifolius*	✔	✔	✔	Acanthaceae
Tiger fern	*Acrostichum aureum*	✔	✔	✔	Acrostichaceae
Tora, Nunia, Dhalchaka	*Aegialitis rotundifolia*	✔		✔	Plumbaginaceae
Kholshi, Halsi, Khalisa	*Aegiceras corniculata*	✔		✔	Myrsinaceae
Shola, Hogra, Banda	*Aeschynomene aspera*	✔	✔		Fabaceae
	Axonopus compressus	✔			Poaceae
Lata Sundari, Sundari lata	*Brownlowia lanceolata*	✔		✔	Tiliaceae
Bet	*Calamus* sp.	✔			Arecaceae
Akonda, Choto akanda	*Calotropis procera*	✔			Asclepiadaceae
Nayan tara	*Catharanthus roseus*	✔			Apocynaceae
Dabur, Dakur, Dhakur	*Cerbera manghas*			✔	Apocynaceae
Goran, Gutiya	*Ceriops decandra*		✔	✔	Rhizophoraceae
Mathgoran	*Ceriops tagal*		✔	✔	Rhizophoraceae
Motmoti	*Clematis arborea*	✔			Ranunculaceae
Chagal boti	*Clematis gouriana*	✔			Ranunculaceae
Vhat, Banjui, Batraj	*Clerodendrum inerme*	✔			Verbenaceae
Kochu	*Colocasia* sp.	✔			Araceae
Kirpa	*Corallina* sp.	✔			Corallinaceae
Shonpat, Shon, Ghoreshon	*Crotalaria juncea*	✔			Fabaceae
Jhunjhuni, Choto Jhunjhuni	*Crotalaria saltiana*	✔		✔	Fabaceae
Shorna lata, Tarulata, Jarbuti	*Cuscuta reflexa*	✔			Convolvulaceae
Durba ghash	*Cynodon dactylon*	✔			Poaceae
Shingra, Singri	*Cynometra ramiflora*	✔			Fabaceae
	Cyperus exaltatus	✔			Cyperaceae
Chumtipati	*Cyperus malaccensis*	✔			Cyperaceae
Mutha, Sadakufi	*Cyperus rotundus*	✔			Cyperaceae
Malia ghash	*Cyperus* sp.	✔	✔		Cyperaceae
Chanda lata	*Dalbergia candenatensis*	✔		✔	Fabaceae
Tambul kanta, Ananta kanta, Chaulia kanta	*Dalbergia spinosa*	✔		✔	Fabaceae
Kalialata, Felialata, Panlata	*Derris trifoliata*	✔	✔	✔	Fabaceae
	Dioscorea sp.	✔			Dioscoreaceae
Barashyama ghash	*Echinochloa crus-galli*	✔			Poaceae

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Undergrowth species		Salinity zones			Plant family
Local name	Scientific name	Oligo.	Meso.	Poly.	
Malangakuri, Malankuri	*Eleusine indica*	✔			Poaceae
Gila lata	*Entada pursaetha*	✔	✔		Fabaceae
Nal ghash	*Eriocaulon procera*	✔			Eriocaulaceae
	Erythrina sp.	✔	✔		Fabaceae
Abetee, Banschand	*Flagellaria indica*	✔			Flagillariaceae
Chitki lata	*Flueggea virosa*	✔		✔	Euphorbiaceae
Horna ghash	*Hemarthria altissima*	✔			Poaceae
Bhola, Bolai, Belapata	*Hibiscus tilliaceous*	✔		✔	Malvaceae
Thankuni, Thulkuri, Brahmobuti	*Hydrocotyle asiatica (Centella asiatica)*	✔			Hydrocotylacea
Chan, Ulu, Chau	*Imperata cylindrica*	✔			Poaceae
Gang lata, Dupati lata	*Ipomoea biloba*	✔			Convolvulaceae
Gura	*Kandelia candel*			✔	Rhizophoraceae
Kripa	*Lumnitzera recemosa*		✔		Combretaceae
Asam lata, Tara lata	*Mikania cordata*	✔			Asteraceae
Nata, Natai, Alkushi	*Mucuna monosperma*	✔			Fabaceae
Bailla ghash, Nalai	*Myriostachya wightiana*	✔	✔	✔	Poaceae
Gul pata	*Nypa fruticans*	✔	✔		Arecaceae
Bono dhan	*Oryza coractata*		✔	✔	Poaceae
Bono dhan, Jhara	*Oryza rufipogon*	✔			Poaceae
Keya, Keya kanta	*Pandanus foetidus*	✔	✔	✔	Pandanaceae
Baranda, Dhanighas	*Panicum repens*	✔			Poaceae
Hental, Hital, Hintal	*Phoenix paludosa*	✔	✔	✔	Arecaceae
Nol khagra, Khagra, Nal	*Phragmitis karka*	✔	✔		Poaceae
Bhui amla	*Phyllanthus nirruri*	✔			Euphorbiaceae
Chitki, Pankushi	*Phyllanthus reticulatus*	✔			Euphorbiaceae
Karoch, Karmuj, Kanji	*Pongamia pinnata*	✔	✔		Fabaceae
Dhanshi	*Porteresia coarchata*	✔	✔	✔	Poaceae
Kash, Khag, Khaisha	*Saccharum spontaneum*	✔			Poaceae
Modhu phal, Choita boroi	*Salacia prinoides*	✔			Celastraceae
Hurmuri, Harua, Urmel	*Sapium indicum*	✔			Euphorbiaceae
Bandali lata	*Sarcolobus carinatus*	✔	✔	✔	Asclepiadaceae
Bawali lata	*Sarcolobus globosus*	✔	✔	✔	Asclepiadaceae
Chechra, Patpate	*Scirpus articulatus*	✔	✔		Cyperaceae
Guri	*Scirpus squarrosus*	✔			Cyperaceae
	Sida sp.	✔			Malvaceae
Kontikiri, Kantakini	*Solanum xanthocarpum*			✔	Solanaceae
Dheki lata	*Stenoclaena palustris*	✔			Blechnaceae
Nimukha, Aknadi, Ghaopatta	*Stephania japonica*	✔			Menispermaceae
Nuna Jhaw	*Tamarix indica*	✔		✔	Tamariaceae
Hogla, Chelpata	*Typha angustata*	✔	✔		Typhaceae
Kunjira, Kunijra	*Urena sinuata*	✔			Malvaceae
Anallata, Amallata, Sonekesar	*Vitis trifolia*	✔	✔	✔	Vitaceae
Mankata, Moin Kanta, Mainphal	*Xeromphis spinosa*	✔		✔	Rubiaceae

Key factors/indicators for assessing ecosystem health

To determine or predict the overall health status of the Sundarban ecosystem, some key biological indicators or factors should be considered. The four major factors are as follows:

1. Diagnosis of ecosystem health symptoms: Identification of vital signs or symptoms which differentiate healthy ecosystem

from the unhealthy or sick one which is the first and foremost parameter to assess the ecosystem health. Symptoms indicative of ecosystem distress are commonly known as 'Ecosystem Level Distress Syndrome' which include reduction of primary productivity, deficiency or excess of nutrients, reduction of species diversity and richness, change in succession pattern, increased instability in population, disease occurrence, increased circulation of pollutants and inability of ecosystem to recover or restore after any agitation. Development or appearance of one of these symptoms should be considered as 'Early Warning Indicator'.

2. Identification of 'Risk Factor/s' that may threaten ecosystem health.
3. Ability of ecosystem to recover after an induced perturbation, and
4. Adoption of necessary treatment or measures, if the ecosystem is found sick.

Conclusion

Plant diversity, especially, the undergrowth vegetation plays a vital role in the conservation and quality control of soil as well as standing plants of any natural ecosystem (Rashid *et al*, 1997). Association of rich undergrowth in any ecosystem is one of the signs of its healthiness. In comparison with other natural forest ecosystems, the level of salinity is the most vital factor for the development and association of undergrowth species in the Sundarban Mangrove Forest. There is a positive correlation among higher diversity indices, ecological habitat distribution and existing present environmental parameters such as fresh water flow, salinity gradient and sedimentation load from the east to the west direction and vice versa (Hossain, 2003). These general trends indicate that the Sundarban phytodiversity is much richer in Oligohaline or low saline zones than in Polyhaline zones. Mangrove plant diversity, especially the undergrowth diversity in terms of species richness in most of the areas decreases sharply, as one gradually moves from fresh water or low saline i.e. eastern and north-eastern and south-eastern Sundarban to high saline zones i.e. western and south western Sundarban (Rashid *et al*, 2008). The rich undergrowth diversity of healthy individual might be indicative of the healthy mangrove forest of low saline zone areas and poor undergrowth diversity as well as their stunted growth might be indicative of all sick

mangrove forest of high saline zone areas. So, it is logically concluded that the importance of in-depth and extensive scientific research is emphasized much on the assessment and continuous monitoring of ecosystem health to safeguard the Sundarban mangrove forest.

REFERENCES

Arabinda, N.C., R. Mondal, A. Brahma and M.K. Biswas. (2008). *Eco-psychiatry and Environmental*

Conservation: Study from Sundarban Delta, India. Environ. Health Insight. 2:61-76.

Curtis, S.J. (1933). Working plan for the forest of the Sundarban division for the period 1931-57. Vol. 2. Bengal Government Press. Calcutta, India.

Heining, R.L. (1892). *Working plan of Sundarban Government Forest*, Khulna and 24-Parganas district. Bengal, Calcutta, Bengal Secretariat Press.

Hossain, A.B.M. (2003). Final Report on The Undergrowth Species of Sundarban Mangrove Ecosystem (Bangladesh). Sundarban Biodiversity Project. IUCN, Dhaka.

Karim, A. (1994). *Mangroves of the Sundarban*. Volume two: Bangladesh. Edited by Z. Hossain and G. Acharya. IUCN, Bangkok, Thailand.

Mannan, M.A. (2010). *Impact of environmental hazard on the plant diversity of Sundarban*, Satkhira range. Ph.D. thesis. Department of Botany, Jahangirnagar University, Dhaka, Bangladesh.

Mohiuddin, M., M.A.T. Chowdhury and I. Sarwar. (2007). *Floristic composition and species distributionIn Sundarban Mangrove Forest community, Bangladesh*. Journal of Biological Sciences. 7(2). 384-388.

Nuruzzaman. (1992). Sundarban at a glance. Khulna. Rahman, M. and Banu. (2003). *Biodiversity in Bangladesh Sundarban- the largest mangrove forest of the world*. ARANYA. Vol. 6 (10-14).

Rashid, S.H.; M.M. Rahman and A.B.M.E. Hossain. (1997). *Ecological studies on the relationship between soil properties and dominant undergrowth species of Chandra 'Sal' Forest at Gazipu*r, Bangladesh. 4(1): 9-14.

Rashid, S.H., R. Böcker., A.B.M.E. Hossain and S.A. Khan. (2008). *Undergrowth species diversity of Sundarban mangrove forest (Bangladesh) in relation to salinity*. Ber. Inst. Landschafts- Pflanzenökologie. Univ. Hohenheim Heft 17, 2007 (41-56).

Prain, D. (1903). *The Flora of Sundarban. Records of Botanical Survey of India.* Periodical Expert Book Agency. (Reprint edition- 1963). Calcutta, India.

Siddiqi, N.A. (2001). *Mangrove forestry in Bangladesh*. Institute of Forestry and Environmental Sciences, University of Chittagong.

Exploited and Hidden Treasures of the Sundarban

15 November 2007: Formed at the Bay of Bengal, the cyclone Sidr surged towards the river Baleshwar – in the southern regions of Bangladesh. But the Sundarban stood like the great wall of China, and took the brunt of the cyclone before it could hit the heavily populated human habitations beyond. The vast range of trees facing the fury of 270 km per hour wind were severely damaged. The forest eventually absorbed the first great thrust of the cyclone, lowered its intensity and tamed the storm considerably. One of the strongest cyclones of the century, Sidr was actually directed towards the capital city Dhaka through its route passing over Morelganj in the district of Bagerhat. Confronted by the Sundarban, the cyclone had to change its

By **Iftekher Mahmud**

course towards India over the district of Mymensingh. The resistance by the Sundarban considerably reduced the cyclone's capacity to cause massive destruction of both human and animal lives and property. Thus the Sundarban played the role of a true mother in protecting Bangladesh from the wrath of the cyclone.

The American space research centre NASA confirms that in terms of the intensity of wind flow Sidr was more powerful than the cyclones of 1970 and 1991 that cruelly devastated part of the country. NASA reports that Sidr at its peak hours blew at the speed of 260 to 280 kilometers per hour. NASA puts this cyclone into a Category 4 – equivalent type of cyclonic storm that has a maximum wind speed of 260 to 280 km/hour.

It have been revealed from the information obtained from Bangladesh Meteorological Department that the 1990 cyclone had a maximum wind speed of 221 km / hour while the 1991 cyclone reached 225 km at its peak hours. When Sidr was at a close proximity of Bangladesh coastal areas, the wind speed within 74 km of the centre of the cyclone was between 220 and 240 km.

A number of climate research organizations of the world, including NASA and NOA, observed on 13 November 2007 the serpentine movement of the Sidr towards Bangladesh. But as the probable route of the cyclone could not be ascertained it was initially thought that the cyclone would either hit the coastal belts of Chittagong or Khulna or would cross the territory of Bangladesh blowing over these areas. On 14 November afternoon meteorological observers found that the cyclone had made an evident move towards the southern belt of Bangladesh.

The meteorologists thought that the cyclone would enter into Bangladesh territory over the districts of Barguna and Patuakhali and by midnight it would reach the central part of the country while it would most likely depart Bangladesh by the morning of 16 November crossing over the districts of Mymensingh and Jamalpur.

However, it was observed that Sidr remained static for an hour from 8 pm to 9 pm over Morelganj. During this time the centre of the cyclone was in the areas of the Sundarban. At 12 o'clock at midnight the storm reached Dhaka and other central parts of the country.

Then on a sudden twist it took a turn towards Narayanganj and left Bangladesh at 2.45 am passing over Comilla and Sylhet.

The local office of Meteorological Department informed that the recorded highest wind speed was 223 km / hour at Patuakhali near the centre of the cyclone. Then the wind speed at Mongla Port was 160 km /hour when it was 111 km /hour at Sandwip. The lower wind speed confirmed that the resistance given at the Sundarban had effectively reduced the strength of Sidr. But the cost of taming the cyclone was quite high.

The Sundarban, spread over an area of 6000 km^2 had about 1000 square km forest damaged totally or partially during this cyclone. The cyclone uprooted and knocked down a huge number of trees. The Sidr hit areas of the Sundarban appeared burnt out, as if a fire had swept over the canopies of the trees.

Keep the Sundarban in peace and let it subsist

Some employees of the forest department and some of their experts came up with the suggestion that the broken trees of the Sidr ravaged Sundarban must be cut and cleared off to allow new plants to grow and develop.

On 29 May the daily ***Prothom Alo*** published a report captioned 'The Sundarban will live if kept undisturbed, experts suggest not to clear off broken trees' – an opinion that was also passed by the editor of this book in the ***Daily Star*** on 5 January 2008 (see it elsewhere in this book). The experts opined that the security system of the forest had broken down and if broken trees were cut off and removed it would led the forest to a total destruction. The plunderers of wood from the Sundarban would soon turn it into a vast denuded field. They also insisted that there was no need for importing new trees inside and planting those to recover the loss the forest suffered. The natural tidal system would bring seedlings to the affected areas from the unaffected parts of the forest and a natural process would take an appropriate care for regeneration of the forest while trees with broken branches and burnt out leaves would surely come up with new foliage in the following monsoon.

Dr. C S Karim, the then adviser to the Caretaker Government for the Ministry of Environment and Forest ignored the suggestions of the Forest Department and accepted the opinion forwarded by

independent experts. He not only prohibited the removal of broken trees but also issued orders of further prohibition on the collection of *Golpata* or any other resources of the forest for the next one year. Within next July the Sundarban proved what a perfect decision that was for regeneration of trees in the devastated part of the forest. The Sundarban got its dark green stature back. Everywhere in Nalian, Dangmari, Katka or Kachikhali green leaves came out of brown trees affected by the Sidr. With chirping of birds and massive movement of deer the true face of the Sundarban appeared to have been restored. Nature conveyed a message that it does not need human help to recover the loss it incurs. The indomitable life of nature proves that nature is far more powerful than a thousand government projects.

Only after one year and a half of the devastating Sidr the southern part of the country was again hit by another cyclonic storm Aila in May 2009. The difference between Sidr and Aila is in the intensity of tidal surges. Aila carried with it a higher tidal surge. Before Aila hit Bangladesh the protective shield of the Sundarban once again stood on its way and reduced the strength of the cyclone and the height of the surge.

An on the spot assessment by Centre for Environment and Geographical Information Services suggests that the tidal surge crossed about 75 km of forest land from the forest camp at Dakope, Khulna to Munshiganj forest camp in Satkhira. The Sundarban eventually lessened the height of the tide by 10 per cent and reduced the strength by 30 per cent. When Aila hit the Sundarban the height of the tidal wave was 15 feet and when it hit the districts of Khulna and Satkhira after crossing such a vast area the height of the waves came down to 10 feet. The taming of the surge by the Sundarban with its forest shield did not allow it to hit Faridpur, Rajbari, Magura and other southern districts. Thus it had considerably lessened the loss of life and property.

The cyclone Gorki that hit Chittagong, Noakhali and Barisal coast on 12 November 1970 killed more than a million people. An examination of the history of cyclone suggests that the strength of cyclone that hit the division of Chittagong in 1991 was less powerful than Sidr but it killed more than a hundred thousand people. Even having a lesser strength than Sidr or Aila the cyclone of 1970 or the one of 1991 caused more loss of lives and properties. The reason is

clear – Chittagong did not have a costal forest as its frontiers were open to the sea. As such cyclones and tidal surges hit coastal habitat directly. While in case of Satkhira and Khulna the Sundarban shielded the areas against any such sudden tidal surge in the sea. If the coasts of Barisal, Chittagong and Noakhali had forest shields of mangrove or coastal forests like that of the Sundarban the scale of devastation would certainly be far less than what had actually occurred.

When natural resources are the intrinsic power of the Sundarban

The people of southwestern belt of the country always remember the visible contribution of the Sundarban in confronting natural disasters like cyclone and tidal surges. While surviving triumphantly even after absorbing the shock and calamities of two giant cyclones and massive surges within a range of three years, the Sundarban did not remain a mere playground of natural beauty – it revealed more of its potentials, more important for the meaningful survival of the coastal population of the country. The hidden strength of the forest came to the forefront as a subject of research and discussion.

A recent study of resources of the forest reveals that during a span of 13 years about 62 per cent areas of the Sundarban witnessed expansion of forest cover in terms of rise in the number of trees, and growth of trees both in height and width. The growth and survival of saplings have also achieved a better record than in previous times.

But the study also suggests that forest resources had declined in 32 per cent of areas of the Sundarban. The reduction in resources has been recorded in areas closer to human habitation while there has been a remarkable increase in resources in areas having rivers and the Bay of Bengal as the frontier. The forest that received the first blow of cyclone and tidal surges and got ravaged to protect human lives and properties became the ultimate victim of human greed as its vital resources are being plundered. Humans have turned out to be the worst enemies of the Sundarban. The surveys specified that the forests adjacent to the human habitations in the districts of Khulna, Satkhira, Bagerhat, Barguna, Patuakhali and Bhola have lost a considerable amount of forest cover and the mindless thinning of forest continues unabated.

Sundarban as a carbon Store

With technical support from the forest services of the United States, Bangladesh Forest Department conducted a survey in the Sundarban on the number of trees and their carbon absorption capacity over a period of five months. The study suggests that trees, herbs, creepers and forest resources of the Sundarban increased by 2 per cent over a period of 13 years. The number of trees closer to the Bay of Bengal and rivers increased by 5 per cent while there was a reduction of trees by 3 per cent in the forest in Khulna, Satkhira, Bagerhat and Barguna.

The experts were concerned about the top dying disease of the Sundari trees for over a decade. But this study has eased their concern with the finding that only 3 per cent of the trees are affected while the rest of the trees elsewhere in the forest enjoy comfortable growth.

Bangladesh Forest Department and US Forest Services led a survey on the 'Determination of Quantity of Carbon: 2009-10 in the Sundarban'. The findings of the Carbon related part of this study were disclosed before the parliament. It has been stated that resources of the forest closer to habitats had markedly reduced. Bangladesh Forest Department had chalked out a joint management programme for protection and development of forest resources in the Sundarban involving people of 97 adjacent villages. Meanwhile the programme started in some villages. Apart from this programme some projects on creating alternative employment have been undertaken with the assistance of development partners. It is hoped that these efforts would be effective in the protection of forest resources.

Rays of hope after the cyclone

The study of the Department of Forest shows that the growth of saplings and their development into healthy trees have significantly increased during the thirteen years of the study period. New saplings grew on an area of 53806 hectares of land in 2009 while the area covered under new saplings in 1996 was 34623 hectares. It needs a special mention here that the number of steady trees like Sundori, Genwa and Bain has increased considerably.

Other resources of the Sundarban

On 4 February 1999 143,000 hectares of lands of the Sundarban were declared as wildlife sanctuary for wild animals and plants. A ban on the extraction of resources from the areas of Kotka-Kochikhali in the east Sundarban, notabete in the west and Nilkamol in the

south was imposed. After the cyclone Sidr in 2007, collection and extraction of forest resources, except Golpata for housing and honey gathering, were prohibited.

The Sundarban enter into carbon market

Another hidden treasure of the forest apart from the inventoried ones which is now being discussed in the international spheres is the carbon absorption capacity of the Sundarban. The trees, creepers and herbs and even the soil of this forest store huge amount of carbon. According to the joint survey of US Forest Services and Bangladesh Forest Department the Sundarban had absorbed 105.06 million metric tons of carbon. The survey was conducted in the Bangladesh part of the Sundarban on 156 spots spreading over 0.6 million hectares of land. Modern technology including GIS was used in the survey. It gave detailed information including the number and pattern of trees. Different kinds of trees in Dakope, Paikgascha, Koira in the district of Khulna, Patharghata and Mongla in Bagerhat, Shaymnagar in Satkhira, Patharghata in Barguna, and Mathbaria in Pirojpur came under the purview of the carbon absorption survey.

The survey ascertained the quantity of carbon in trees, creepers and herbs, and dead and rotten trees and it also measured the quantity of carbon stored in the soil. But Bangladesh is yet to take any initiative to market her carbon resources. The major share of the global carbon business is controlled by two carbon stock markets based in Chicago and London. The large companies of the world sell the emitted carbons of their factories in these markets. The developing countries are the buyers of such emitted carbon. Global carbon businesses are on full swing since 2000 through international carbon markets. India, Brazil, Nepal and some other countries are beneficiaries of different carbon funds. It is known that these two stock markets in Chicago and London yearly transact carbon business worth 2 billion US dollars.

Since 2009 United Nations initiated marketing of emitted carbon of industrially developed countries through REDD (Reduction Emissions for forest Deforestation and Degradation) programme. Under this programme developing countries are given financial assistance. United Nations have initiated a fund collection drive for 740.37 million US dollars to run its programme. Bangladesh will

make efforts to get appropriate share of this fund.

But currently recession is going on in the international carbon market. In 2009-10 the price of carbon was 15 to 20 US dollars per ton. Multinational companies are the buyers of the larger share of the carbon market. The fund is given to absorb the emitted carbon of the companies by other countries through creating additional forest. Trading carbon entails some cumbersome and uncomfortable conditions that might be imposed by the multinationals. It is presumed that such conditions may even be harmful for the Sundarban.

Under CDM - Clean Development Mechanism – the price of carbon per ton was 30 to 40 US dollars. The forestland under REDD (Reducing Emissions from Deforestation and Forest Degradation) was awarded 40 US dollars for conservation of per ton of carbon. Bangladesh has two national committees for CDM and REDD+ initiatives. Bangladesh is yet to formally approach the United Nations or go to the international carbon market to sell the carbon from the Sundarban. The carbon market experts are of the opinion that Bangladesh can fetch funds of thousands of millions Taka by selling the great unrevealed resources of the Sundarban. The REDD+ plus programme of the United Nations has so far received 118.9 million US dollars. Concerned experts think that a large share of Cancun Green Climate Fund may be deposited to REDD+ fund. In that case the fund is likely to exceed billion dollars. As of today 16 countries have received project aid for preservation of forest from this fund.

Despite the huge capacity of the Sundarban to absorb and retain carbon Bangladesh is yet to get access to any of United Nations' funds. People of Bangladesh are patiently waiting to see some tangible results in this direction.

Besides protecting the country against nature's fury the Sundarban is also contributing to the flow of foreign exchange for the country through the export of huge quantity of shrimps and crabs as well as fish and fish products. The Sundarban can earn money for its own protection by selling its carbon absorption capacity in the international markets and protect Bangladesh from cyclones and tidal surges for generations to come.

Climate Change Impact and the Sundarban

Climate change is a reality, which is now evident in the largest tidal halophytic mangrove forest in the world, the Sundarban. In a report of the UNESCO, it is stated that an anthropogenic 45cm rise in sea level (likely by the end of the 21st century, according to the Intergovernmental Panel on Climate Change), combined with other forms of anthropogenic stress on the Sundarban, could lead to the destruction of 75% of the Sundarban mangroves (Colette, 2007). Also an annual temperature rise of 0.4 degrees Celsius predicted in Bangladesh due to climate change will result in greater frequency and intensity of cyclonic storms. These phenomena will result in an increase in salinity and a decrease in the sweet water flow in the Sundarban, which will hamper the mangrove ecosystem in great extent.

By **Ainun Nishat**

Most part of the Sundarban is a UNESCO World Heritage Site and is intersected by a complex network of tidal waterways, mudflats, and small islands of mangrove forests. It is a very important source of forestry and fisheries products that plays an important role in the local and national GDP. The forest also acts as a green barrier, which protects the neighboring inland areas from the heavy destruction of periodical cyclones and tidal surges originating from the Bay of Bengal. Around 0.5 million to 0.6 million people depend directly on the Sundarban for their livelihood (Gain, 2002). The forest is also the niche of about 300 species of trees and herbs and about 425 species of wildlife (BCAS, 1994).

In the Sundarban, conservation is threatened by several external factors and climate change should be viewed as one sources of stress among others. According to the IPCC, sea-level rise is the greatest threat and challenge for sustainable adaptation within South and Southeast Asia. Sea level rise is a continuous natural subsidence in the Sundarban (Sanyal, 2002), and larger changes in sea level have led to mangrove ecosystem collapse. A net sea-level rise of 3.1 mm per year at Sagar and 7.5 mm per year at Hiron point has been experienced recently at the Sundarban (Sanyal, 2002). Already, Lohachara Island and New Moore Island/South Talpatti Island have disappeared under the sea, and Ghoramara Island (under the West Bengal part of the Sundarban) is half submerged (George, 2010). Sea level rise is enhancing salinity intrusion in the area. The adverse effects of increased salinity on the ecosystem of the Sundarban are manifested in the dying of the tops of Sundari trees, retrogression of forest types, slow forest growth, and reduced productivity of forest sites (MPO, 1986).

In addition, surface water temperature has increased 0.5 degree Celsius per decade over the past three decades in the Sundarban (Mitra, 2009). The variations in salinity and rising temperature triggered the variation in pH and dissolved oxygen in the water bodies of the mangroves. Already some parts of the Sundarban showed a decreasing trend of dissolved oxygen concentration. Depletion in dissolved oxygen may cause major shifts in the ecological habitation in the region.

Bangladesh is extremely vulnerable to cyclones and about 10% of the world's tropical cyclones occur in the Bay of Bengal area (Haq, 2010). The Sundarban has been already severely affected by several tropical cyclones. The recent two cyclonic storms (Sidr in 2007 and Aila in 2009) have wrecked a massive destruction in the Sundarban area. About a quarter of the forest was destroyed and according to the researchers, it will take several decades for the forest to regenerate by itself from this catastrophe. All the species were affected by Sidr which led in severely damaging the ecosystem.

The Sundarban has a delicate balance for growth of flora and fauna in association with the fresh water of the Ganges and the salty sea water of the Bay of Bengal. But the balance is now at risk due to the diminishing downstream river flow and increasing siltation. Anthropogenic activities are the major actors to disturb the halophytic forest ecosystem, but climate change events (erratic rainfall, sea level rise, increasing temperature etc.) are aggravating the situation. Freshwater inflow to the mangroves has been considerably reduced since 1974 due to diversion of freshwater in the upstream area by neighboring India through the Farakka Barrage bordering Rajshahi, Bangladesh. If the situation stays the same, then the joint action of sea-level rise, increased evapo-transpiration, and lower freshwater flow in winter will result in increased salinity in the area threatening the conservation of the Sundarban mangroves (Huq, Rahman, Konate, Sokona and Reid, 2003).

Further destruction of the Sundarban mangroves would diminish their critical role as natural buffers against tropical cyclones. The exposure of the region to the effects of climate change impacts will gradually increase, thus it is utmost necessary to conserve the mangroves successfully. In the short term, mangrove habitats should be protected and restored to minimize the impact of flood and cyclonic storms. In the long term, land use zoning map should be created for mangrove habitat to minimize the impact of anthropogenic activities. Also, restoration and rehabilitation of mangrove forests through re-planting selected mangrove tree species along the canals should be facilitated to reclaim land to minimize the adverse impact of sea level rise in the region. Otherwise in the future, substantial areas of mangrove forest will deplete and Bangladesh will lose its largest heritage reserve and natural treasure.

: Ainun Nishat

REFERENCES

BCAS. (1994). *Wetlands of Bangladesh*. Dhaka: Bangladesh Center for Advanced Studies (BCAS).

Colette, A. (2007). *Case Studies of Climate Change and World Heritage*. Retrieved December 23, 2012, from UNESCO: http://unesdoc.unesco.org/images/0015/001506/150600e.pdf

Gain, P. (2002). *Bangladesh Environment Facing the 21st Centur*y. Dhaka: Society for Environment and Human Development (SEHD).

Haq, S. A. (2010). *Impact of climate change on "Sundarban", the largest mangrove forest: ways forward*. 18th Commonwealth Forestry Conference. Edinburgh: CFC.

Huq, S., Rahman, A., Konate, M., Sokona, Y., & Reid, H. (2003). *Mainstreaming Adaptation to Climate Change in Least-Developed Countries (LDCs)*, International Institute for Environment and. Retrieved 12 23, 2012, from IIED: http://www.iied.org/pubs/pdf/full/9219IIED.pdf

Mitra, A. G. (2009). *Observed changes in water mass properties in the Indian Sundarban (northwestern Bay of Bengal) during 1980–2007*. Current Science , 97 (10), 1445-1452.

MPO. (1986). Chapter 7: *Salinity. In M. P. Organization,* National Water Plan (pp. 7.1-7.33). Dhaka: MPO.

Sanyal, P. (2002). *Sea-Level Rise and Sundarban Mangrove*. National Seminar on Creeks, Estuaries and Mangroves – Pollution and Conservation, (pp. 47-50). Thane, India.

Climate Change and Mitigating Role of Sundarban Mangrove Forest

Greenhouse gas emissions are the main anthropogenic cause of global warming and current climate change. Climate change means that the land, the forest, the water resources, animal behaviour, crop production, and other things on earth are going to change. The way we grow food, the types of plants that can live in different areas, the patterns of rainfall and hot and cold weather will all continue to change if we do not halt the process of global warming and climate change. Humans, plants and animals will not be able to survive in areas that get too hot or in places that are flooded because of rising sea levels. If we want to survive on this earth in the future, then we will need to stop activities that are causing climate change and learn

By **Md. Kamruzzaman**

to adapt to new ways of doing things. Although Bangladesh has had an insignificant contribution to the generation of greenhouse gases, adverse effects on climate change are a reality it has to face. In recent times, the country is experiencing more frequent natural calamities, salinity increase, sudden flood and symptom of desertification. The present rate of global warming threatens the survival of entire ecosystems. The mangrove forests, particularly the Sundarban are among the most at-risk ecosystems in the world and are especially vulnerable to sea-level rise. Scientific findings suggest that with one meter sea-level rise, a fifth of Bangladesh will go under the sea. The Sundarban, a habitat of rich bio-diversity and a RAMSAR and also UNESCO World Heritage Site, will be permanently lost.

The impact of climate change – specifically changes in temperature, CO_2, precipitation, cyclones and storms, and sea level, combined with anthropogenic threats – is believed to have some changes in the overall environment of the Sundarban. The impacts of climate change on the Sundarban mangrove forests are diverse. The major impact will be sea level rise and fresh water unavailability. Sea level rise will reduce fresh water available due to salinity intrusion. Both water and soil salinity along the coast will increase with the rise in sea level. Increased salinity will change the habitat pattern of the forest. *Sundari*, the most typical kind of tree in the Sundarban is thought to suffer from top dyeing disease because of increased salinity. Due to salinity ingress aquatic organisms will migrate inward, a 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-Baleshwar river in the eastern part of the forest. The resultant increase in salinisation and accretion of sediments may alter vegetation composition. Impacts on animal communities may also occur due to both, the direct effects of salinity and indirectly through food chain modifications caused by the alterations in the nature and amount of detritus available in the mangrove ecosystem, which is directly a threat to the living bio-diversity. Eventually the species offering dense canopy cover would be replaced by non-woody shrubs and bushes, while the overall forest productivity would decline significantly.

The degradation of forest quality might cause a gradual depletion of the rich diversity of the forest flora and fauna of the Sundarban ecosystem. Natural habitat will be destroyed due to inundation. The Intergovernmental Panel on Climate Change (IPCC) projection suggests that the state of tropical forest ecosystems is likely to get worse due to climate change.

The Sundarban is being degraded due to over exploitation and environmental degradation, exacerbated by climate change. World Wildlife Fund for Nature Conservation (WWF) estimates that due to sea level rise, nearly 7,500 hectares of mangrove forest in the Sundarban is projected to be flooded. Studies have shown that tropical cyclones destroy the mangrove forests to a large extent. For instance, in the recent past, cyclone Sidr has destroyed one-third of the Sundarban. A recent study showed that surface water temperature has been rising at the rate of 0.5ºC per decade over the past three decades in the Sundarban, eight times the rate of global warming rate of 0.06 ºC per decade that makes the Sundarban one of the worst climate change hotspots on the globe. Withdrawal of water from trans-boundary rivers is also increasing the salinity and habitat destruction in the Sundarban. Global warming is expected to accelerate the process of erosion in coastal and estuarine zones either through increased summer flow of monsoon water from the glaciers or by increased tide penetration due to sea level rise. Expansion of commercial shrimp culture, oil and gas exploration will be increasing the vulnerability to higher extent.

Table 1: Fate of the Sundarban with different sea level rise

Sea level rise	Potential impacts
10 cm	will inundate 15% of the Sundarban
25 cm	will inundate 40% of the Sundarban
45 cm	will inundate 75% of the Sundarban
60 cm	will inundate the whole Sundarban
1 metre	will destroy the whole Sundarban

(Adapted from World Bank, 2000)

The Sundarban mangrove forest is playing a significant role in combating the adverse impacts of climate change in Bangladesh. We already know that 'adaptation' and 'mitigation' are the two agreed

: Md. Kamruzzaman

strategies to tackle climate change. The Sundarban is playing a dual role i.e., adaptation and mitigation as these two can be seen as two sides of the same coin. What is good for adaptation is also good for mitigation and vice versa. Adaptation refers to using forests to lessen the effects of climate change. In this sense, forests can be used to protect coastal areas and watersheds against erosion, landslides and storms. On the other hand, climate change mitigation is to reduce emissions of greenhouse gases. IPCC admitted that 20% of anthropogenic emissions are captured by forests. Forest ecosystems capture and store carbon dioxide (CO_2), making a major contribution to the mitigation of climate change. When forests are destroyed, over-harvested or burned, however, they can become a source of CO_2 emissions.

Forests and climate change adaptation are linked in two ways: first, through adaptation for forests, because climate change will affect forests and so they need help to adapt; second, through forests for adaptation, because forests contribute to helping local communities and the broader society adapt to climate change. Forest ecosystems provide services that reduce the vulnerability of communities and broader society to climate change. The value of mangroves for coastal protection has been estimated in some areas to be as much as US$ 300,000 per km of coast based on the cost of installing artificial coastal protection. The Sundarban mangrove forest helps the community to adapt with the adverse impacts of climate change through providing shield against cyclones and storm surges. It supports the community to survive and adapt through providing livelihoods and ecosystem services. The Sundarban forest is an invaluable natural capital and social safety net for the people of Bangladesh in terms of adaptation to climate change. It provides livelihoods for climate vulnerable people living in the coast; refuge the people during disasters and climate shocks. The Sundarban is supporting the coastal zone of the country through conserving and regulation soil, water and microclimate in agricultural lands; regulating water quality and protecting soil from erosion. The cyclone Sidr had done massive destruction of the Sundarban. The Forest Department had stopped extraction of forest products for some time to recover it naturally, which has proved effective for the regeneration of vegetation. This way the Sundarban

has adapted and somehow recovered some damage. This initiative can be termed as adaptation for forests.

The Sundarban has proved itself as a buffer against cyclones and storm surges. The United Nations Environment Programme (UNEP) estimated that mangroves like the Sundarban can reduce 70 to 90% energy from wind-generated waves in coastal areas and reduce the number of deaths from cyclones. It is projected that the intensity and severity of cyclones will be increased in the future. As a result there will be increasing damage of forest quality in the Sundarban. It is therefore adaptation measures are needed to ensure that the ecosystem services provided by the Sundarban forests are maintained under future climates. Regular and continuous monitoring of forest health, undertake forest restoration and rehabilitation can be initiated to protect forest health in the Sundarban.

The Sundarban is also important in terms of climate change mitigation. Conservation and restoration of the Sundarban forests will help carbon sequestration. The forest stores large amounts of carbon (Blue Carbon). The Sundarban acts as the world's largest mangrove carbon sink. Recently the Forest Department has estimated carbon sequestration potential of the Sundarban. According to 'Sundarban Forest Carbon Inventory-2009' prepared by the Forest Department, Bangladesh can get 150 billion taka by selling reserved carbon of the Sundarban. It is estimated that the Bangladesh part of the Sundarban stores 105.06 million metric tons of carbon.

To fight against climate change for Bangladesh, what is indeed most urgently is to conserve the Sundarban and protect it from destruction. This unique forest is to be conserved and both climate change mitigation and adaptation potentials are to be explored properly for future forestry projects. It is sure that climate change will fundamentally affect its composition, functioning and distribution. Different management approaches will be required that anticipate and address the potential implications of climate change whether forests are being managed primarily for conservation, production, protection or other uses. Forests are also a vital part of comprehensive, landscape-scale adaptation responses to climate change. Regardless of climate change mitigation activities implemented today or in the near future, however, historical emissions and inertia in the climate system mean

: Md. Kamruzzaman

that further climate changes are inevitable. Some effects of climate change are already noticeable and there is a need and opportunity to be better prepared for future change. Individuals, societies and institutions should be aware of the impacts that climate change is likely to have and should have strategies in place to adapt to them.

With increased frequency or intensity of storms in the tropics, the coastal protection function of the Sundarban will become more critical over time. As the Sundarban itself is vulnerable to these impacts, its ability to adapt successfully will become increasingly difficult. Since the IPCC reports in 2007, there has been some evidence from global assessments suggesting that observed and projected sea level rises may in fact exceed those reported in IPCC, which would exacerbate the vulnerability of mangroves.

In the Sundarban, productivity is higher than many other mangrove ecosystems due to relatively lower salinity levels because of large volumes of freshwater input from the Ganges-Brahmaputra-Meghna river systems. So, to save the unique forest natural flow of fresh water is also important. Melting of glaciers will reduce fresh water availability in the future. Withdrawal of water from the rivers through dams and barrages is also an existing threat for the Sundarban. There should be joint regional initiatives for protection and conservation of this global heritage for mankind. It should be noted that Bangladesh and India have signed a Memorandum of Understanding (MoU) in 2011 on Conservation of the Sundarban. We are to consider that we are living in the same planet and destruction of the Sundarban will surely worsen the adverse impacts of climate change nationally, regionally and globally.

Dubla Island: The Centre of Dried Fish in Bangladesh

Dubla Island is the south-central part of Sundarban Reserved Forest (SRF) under Sharankhola Range of the Sundarban East Forest Division in Bagerhat district. This island includes Alor Kol, Majher Kella, Office Kella and Meher Alir Char, which cumulatively act as a major hub for coastal fishing in the country. The total area of the island is 73.51 km^2 and the land under human settlement is around 1.64 km^2. The coastal fishing season in the Sundarban officially runs each year from October to the end of February but some *baharders* (owners of the fishing business) extend fishing by one month more i.e. till March. Fisherfolk come from Bagerhat, Chittagong, Cox's Bazar, Khulna, Pirojpur, and Satkhira districts. They build temporary camps in the *char* (island) of the SRF around Dubla. One of the primary jobs

By **Samiul Mohsanin**

that fishers engage after arrival in the island is setting the '*gauze*' or '*kankra*' – anchoring gears that are set at the fishing grounds to mark out fishing territories. The *gauze* is set about 30 km offshore and is used for such operations, while the *kankra* is for nearshore fishing and is set 10km from Dubla Island.

During the first week of arrival, laborers are involved in building a house each for a *baharder*; featuring a kitchen, storage room and a fenced-off fish drying area. A laborers' camp is then constructed and fenced off. This consists of smaller communal houses (12x24 feet). Eleven temporary forest department camps exist within the fishery, which is known as the Dubla Char fishery to monitor fishery activities and collection of revenue.

Fisheries legislation in the nearshore and offshore zone is shrouded in legal ambiguities. A lack of collaboration between the Bangladesh Forest Department (FD) and Department of Fisheries (DoF) has resulted in overlapping bureaucracy and unclear legislation. The FD is responsible for the fisheries of the Sundarban up to 20 km offshore. Regulations of licensing, gears and areas of fishing in marine waters are limited from the 18.29 m depth line to the limit of terrestrial waters. The trawler fleet is not permitted by rules and ordinance to fish at a depth shallower than 40 m, although it has been suggested that they fish up to 30 m and even 20 m. It should also be noted that there is a lack of any harvest policy for fishers engaged in seasonal fishing in Dubla Island.

Fishing operations can be separated into nearshore fishing and offshore fishing. The main hub for nearshore fishing is the village of Alor Kol. This is the largest village on the Island and about 80% of its residents originate from the Sundarban (particularly Bagerhat and Satkhira ranges). The remaining 20% are made up of fishers from Cox's Bazar and Chittagong. Offshore fishing is dominant in the other villages, all of which are much smaller than Alor Kol.

Each fishing operation is organized and overseen by a *baharder* who provides upfront capital and fishing vessels, in addition to hiring staff. Two distinct types of *baharder* exist. The first type orchestrate offshore fishing operations; usually recruiting some 50 fisherfolk to man 4-5 trawlers. The crew of each vessel is typically made up of one Boatman/Captain (*Majhi*), one assistant captain, one engine man, eight

fishers and one cook. In addition, about 30 laborers are hired to work in the fish drying camps. The second type of *baharder* orchestrates near-shore fishing operations. These men usually own just one boat which is smaller in size than those used for offshore fishing. As such, smaller crew (typically one boat captain and four fisherfolk) and fewer laborers (typically 5) are hired. Nearshore fisherfolk travel 1-2 hours (10-30 km) away from the coast. There are two types of boats found at Alor Kol: engine boats/trawlers, which carry 2-3 marine set bag nets (*Bendi/Behundi jal/Bada jal*), and the hand-driven dingy boats, which usually occupy waters 5-10 km offshore, carrying shore seine and beach seine nets (*Kati jal* and *Ber jal*).

During the peak fishing season the following marine species are frequently caught: *Loitta* (Bombay duck), *Churi* (Largehead hairtail), *Suri* (Smallhead hairtails), *Parshe* (Goldspot mullet), *Rupchanda* (Chinese Pomfret), *Phasa* (Gangetic Airfin Anchovy), *Telia phasa* (Goldspotted Grenadier Anchovy), *Ghagra tengra* (Gagora catfish) and shrimp, noteably *Chaka chingri* (Indian White Shrimp), and *Bagda chingri* (Black Tiger Shrimp). As bycatch they get small sized sharks, Stingrays and very rarely saw fishes.

Fisherfolk catch fishes overnight or even at daytime depending on favorable tides. They send back the catch with a carrying boat or fishing vessel. Land laborers receive the fish and start sorting according to different species and groups and then they spread them over long lying plastic sheets on ground. Fish drying also varies according to species. *Loitta* are dried over fence hanging two individuals hooked by the jaws. *Churi* are dried by the same process but tied by the two elongated pointed tails. *Phasa* are dried on abandoned fine meshed nets on the ground. *Parshe* are dried on bamboo mats above the ground. Shrimps are usually dried on plastic sheets on the ground. Fishes are dried in sunlight and the drying process takes about 5/6 days. At night they keep the fishes covered by bamboo sheets (*Chatai*) to avoid dews. After drying dried fishes are stored in plastic sacks. Fishes are sorted in two major groups; edible dried fish and rubbish. Fish traders (middleman) collect dried fishes from *baharders* and deliver them to wholesalers in Bhola district. Fish traders visit the island four times a month (almost every week) during the fishing season and collect fishes from about 25 *baharders* each. Dried fishes

are transported in fishing trawlers (*c.* 8 tons). During the journey they stop over at Mohipur in Potuakhali close to Kuakata. It takes about two days to reach Bhola from Dubla. Fish traders pay all the government taxes at Dubla FD office and cover all the transport costs and dispatch the money between *baharders*. Fish traders make profit on price differences between those of *baharders* and the wholesalers.

Dubla Island is one of the largest centres for dried fish in Bangladesh. Each year government collects about 4.5 core taka revenue from about 17000 tons of dried fishes from the Dubla Island. However, there is no proper handling, cleaning or icing of the fish. Fisherfolks demand ensuring better living, safe drinking water and a temporary doctor (or better, a hospital) to be based on the Island during the five months.

This island is also famous for Rash Mela and the holy bath, a Hindu festival that is being held annually for the last 200 years. Hindus believe that the Rash event is the 'get-together' of Radha and Lord Krishna. The Rash event starts on the rise of full moon in Kartik (Bengali month). In order to celebrate this assemblage, thousands of people visit this area from different parts of the country. A three-day long yearly ritual is a highly exciting event for the tourists from both home and abroad.

REFERENCES

Inventory of Coastal and Estuarine Islands & Char Lands. (2001). Program development office. Integrated Coastal Zone Management. PDO-ICZM Paper No. 06.

Sundarban Biodiversity Conservation Project (SBCP). (2002). Fisheries management for the Sundarban. Khulna: Bangladesh Forest Department, Aquatic Resources Division.

Thompson, B.S., Mohsanin, S., Bladon, A.J., Fahad, Z.H., Hossain, M.A. (2012). *Dubla char fishery of Bangladesh*. Aquatics project report, Wildlife Trust of Bangladesh.

Culture and Livelihood

History

The Sundarban mangrove forest has been in existence for more than a thousand years and the history of human settlements found these from archeological remains in the Sundarban dates back to the Stone Ages. The ancient cult of worshipping trees and animals in the Sundarban as evidenced in the remains certainly shows its antiquity and pre-Aryan cultural traits. Remnants of river ports, temples and archaeological findings from the lower parts of southern Bengal indicate the presence of civilizations almost 3,000 years back (Hussain, 2004). During the Pala dynasty, circa 8th century, this region was referred to as the 'Tiger Coast' (IUCN, 2000). The

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dynamic physical characteristics, changing tides and river courses, along with natural disasters such as cyclones and tidal surges have made it nearly impossible to study the chronology of events in the Sundarban accurately.

In 1757, the infamous *Nawab* Mir Zafar, appointee of English traders made a gift of the 24 Parganas, including the Sundarban to the East India Company. The first surveys of the Sundarban were carried out during 1769-1773 by the British and the results of the surveys led to the delineation of the Sundarban forest (Kolkata University, 2009). The main objective of the British at the time was to reclaim land suitable for human habitation and agriculture and thus began the process of felling of trees and depleting the coastal green belt by the settlers and traders.

The first map of the Sundarban was drawn in 1873 and according to journal records, the mangrove forest is described as "A vast tract of forest and swamp, extending for about 170 miles along the sea face of the Bay of Bengal from the estuary of the Hoogly to that of the Meghna and running inland to a distance of from 60 to 80 miles. The most probable meaning of the name is the 'forest of Sundri' (*Heritiera fomes*), this being the characteristic tree found here…" (Kolkata University, 2009).

The nature of the forest, canals and creeks and the harsh environmental conditions have made the people of the Sundarban willful and strong. The bravery of the people of the Sundarban is recorded in history, as the breeding ground of the farmers' revolution (*Tebhaga Andolan*) that took place in 1945 (Haider, 2004).

Literature

The labyrinth of coastal islands, deadly attacks by tigers, unrest and eviction, and tidal surges are not uncommon in the mangroves. Many literary works depict these hazards and peoples' handling of them. The Sundarban has also lured many historians to investigate its past. The Sundarban was documented in the sixteenth century, by a renowned historian of the Mughal Empire in his book *Ain-i-Akbari* (IUCN, 2000). The famous Bangla novel *Jolgongoler Kabbya* by Sunil Gangopadhay portrays the hardships of the people and how they strive to sustain their livelihoods in the backwaters. *The Hungry*

Tide by Amitav Ghosh is a contemporary novel, premised in the Sundarban and weaves the tale of love between a dolphin researcher and a fisherman. It also depicts political turmoil and a natural disaster with which the novels ends.

Myths and Beliefs

The Sundarban is the abode of many spectacular animals, such as the Bengal tiger, the saltwater crocodile and the venomous King cobra. The Sundarban is mysterious and the entire forest is interspersed with the breathing roots and changing landscapes with the ebb and flow of tides. This inhospitable terrain is also frequented by pirates, who take refuge in the creeks and canals of the forest. The danger and risks associated with the Sundarban are perhaps a blessing in disguise; the presence of deadly creatures has deterred people from over exploitation of resources to some extent.

There is a popular Bangla proverb '*Jole kumir, dangay baagh*', which means that there is crocodile in the waters and tiger on the lands of the Sundarban. In the Sundarban, no one dares to utter the word 'Baagh' (tiger) as they believe that calling the majestic creature by its name would alienate it, as a result of which the tiger may attack them. The tiger is fondly referred to as Mama (uncle), Boro (elder) Mama, Bondhu (friend) and many other interesting titles bred locally.

Out of the shared fears of facing natural disasters and wild animals, Hindu populations worship certain deities; the Muslims also show respect to the same beliefs. Myths and legends about conflict between Dakshin Rai and Bonobibi narrate the introduction of Islam in the region, and the conflicts and eventual compromise for peaceful co-existence in the forest.

The mystic Gunin

The honey collectors, wood cutters, fisherfolk, mollusk shell collectors and animal hunters have traditionally taken the aid of the *gunin* (a traditional healer), before they venture into the forest for harvesting natural resources. The *gunin* is believed to be a mystic, blessed with powers to even chase the tiger away with his *mantra* (a magic spell). The people of the Sundarban have trusted the *gunin* for generations and their mantras have had profound effect on the beliefs of the forest dwellers. Before entering into the creeks and crannies of

the dense forest, the *gunin* recites his mantra. The following *mantra* was collected from a *gunin* that has been translated from Bangla:

Bonobibi Ma (mother)
We have come for your love…
We believe in you…
Please protect us from the tiger!
Pir Gazi is our Baap (father)
Blessed by his powers…
We can fight crocodiles, tigers, boars…
And chase death far away from us!

Deities

The remoteness of the Sundarban has paved the way for a unique culture of the forest dwellers, tailored to the needs of the people. In the course of inhabiting the jungle and harnessing its resources together, people from different faiths came together and paid homage to the gods and goddesses they believe to be their saviours. The exclusive cult alive to this day in the Sundarban includes Islamic icons as well as gods and goddesses of the animist and pagan culture that once prevailed in the Sundarban, before the Aryan and Muslim invasions.

There are many legends that have been passed down from generation to generation and ballads sung by fisherfolk till this day, about the deities of the Sundarban forest. Dakshin Rai, Bonobibi and Gazi Shaheb are all related to respecting the tiger and unquestionably the tiger is most respected by the people of the Sundarban who depend on the forest for their livelihoods. The tiger cult of the Sundarban is indigenous to southern Bengal and homage to the tiger god Dakshin Rai is paid usually under the shade of a banyan, *peepul*, wood apple or *neem* tree.

Legends and narratives about Bonobibi, sister of Shah Jangali reveal that she was sent to the Bhati (erstwhile name of the Sundarban) to rule the region. She met with a violent confrontation with the tiger god Dakshin Rai, the tyrant ruler of the forest. After the conflict, a truce was declared and a compromise agreement was reached where Bonobibi was entrusted with the control of 18 *bhati* and Dakhsin Rai was endowed a considerable part of the forest. The Bonobibi is worshipped every year on the first day of the Bangla month Magh (January-February). Pir and Gazi Shaheb are also some revered

figures all over the southern Bengal, including the Sundarban. These myths and stories symbolize the religious and cultural syntheses that took place in the Sundarban over time.

Festivities: Rash Mela

Rash Purnima Utshob also known as *Rash Mela* or *Dubla Mela* is the largest festival to take place inside the Sundarban, during the full moon of the month of *Ôgrohaeon* (November) in Bengali calendar. Every year thousands of devotees and tourists gather at *Dubla Char*, an island that provides refuge to thousands of seasonal fishermen engaged in fish drying and processing. People from various walks of life, different faiths and sects participate in this fair; while the devotees seek purification from their sins by bathing in the rising tide waters. This spectacular display of devotion can be witnessed at the last dawn of the festival, when the full moon sets. Devotees sit in rows with offerings placed in front of them on the sandy beach of the southwestern part of Dubla Island known as *Alor Kol*. Traditionally each devotee places the offering (in small amounts, usually food items, such as dry fish, fruits, or food grains) on a green coconut, places the coconut in front of him or her on the sand, sits down to pray and awaits the rising tide to fetch the offering. The rising tide washing away the offering is taken as the sign of acceptance by the divine powers and hence, fulfillment of the devotees' prayers.

The Forest Dwellers

Because of its unique geographical position and reserve of natural resources – the Sundarban has always attracted a range of people, traders and speculators. Most of the early settlers of the Sundarban were migrants with varying ethnic and religious backgrounds. While the majority of the populations living in and around the Sundarban are fisherfolk, honey collectors and wood cutters, indigenous communities such as the Manda also inhabit the periphery of the Sundarban. Mandas are Hindus and followers of the goddess Kali. They were traditionally hunters and gatherers, but have now become landless and marginalised, a minority group with dwindling population.

Lives and Livelihoods

The Sundarban provides livelihoods for honey and wax collectors, fisherfolk, crab hunters, woodcutters, shell collectors, roof thatchers and mat weavers. About 95 percent of the people living in the Sundarban throughout the year are engaged in fishing and wood cutting (CCEC, 2004). These people live in boats and makeshift huts, without their families and devoid of any medical care and any basic facilities.

Water transport (boats) is the only mode of communication through a large number of rivers, rivulets and creeks. These are no approach roads. In recent times mechanised engine boats are used to commute through the Sundarban. The forest products are usually transported to markets using traditional wooden country boats of various sizes and shapes.

The Forest Industries

Fish processing and trading is the major industry of the Sundarban and involves millions of people, who come from other parts of the country during the peak season. Every year, fish are dried and processed from the Bangla months of Kartik-Falgun (corresponding to December-January) in the islands of Dubla, Kochikhali and Mandarbaria. White fish caught by the fisherfolk throughout the year are also sent to *aroth* or growth centers by various traders and merchants to other areas of Bangladesh.

The Sundarban forest is exploited for a range of forest products, of which the most important ones are timber, thatching material, industrial raw material and fuelwood. Genwa pulp is used for making match sticks and matchboxes, newsprint paper and hardboards. Wood from Goran trees are used as pillars for making houses and as fuelwood.

Honey and bee wax are important resources that cater to the needs of the whole country. One of the most important non timber forest products is the *golpata* (*Nypa fruticans*) leaf, widely used for thatching of household roofs, boats and bio-fencing.

Chingri Poona: Shrimp fry collection

The demand for shrimps has dramatically risen in the global market since the 1970s. While shrimp exports fetch lucrative foreign

earning, it has led to conversion of adjoining forested areas to shrimp farms locally known as *ghers*. Collection of shrimps is seen extensively in the creeks and rivers along the boundaries of the Sundarban. Although it is banned within the reserve forest, fry catchers often come into the prohibited zone. Hordes of women and children collect shrimp fries from the mangrove ecosystem indiscriminately. This is a matter of major concern as the fry collectors keep only the shrimp fries and dispose off the rest of the seeds of all other fish varieties, referred to as *shada mach* (white fish) in the Sundarban.

Mouali: The honey collectors

Honey is a commercially important resource of the Sundarban and the honey every year meets more than half the country's demands. Honey gathering in the Sundarban is a traditional livelihood of people living within the proximity of the forest. Honey collection is a seasonal occupation commencing on the first day of April. Every year on that day honey collectors gather with their boats at the Burigoalini Forest Station in Satkhira district. They obtain permission for the seasonal collection of honey from the local forest office. The beginning of the season is marked with a small ceremony held by local forest authorities in the presence of dignitaries and the honey collectors, followed by a prayer offered for the success and the safety of the honey collectors. After the prayer, honey collectors return to their boats and wait for the formal opening of the season signaled with a gun-shot. At noon, the signal ushers a magnificent boat race among the honey collectors, who venture out to reach the best locations to be claimed for their exploration.

On reaching the shores of a potential honey comb-filled area, six members (usually each boat houses 8 members during honey collection) disembark and go into the forest in search of the precious honey. Two of the honey collectors stay on board and blow a horn at regular intervals to broadcast the boat's location. The six member team search the forest on foot, looking for the tell tale signs like a travelling bee, or bee droppings, or even a honey comb if they are fortunate. They follow the bees to the beehive and smoke the bees out using Tiger Fern (*Acrostichum* sp.) and Hental (*Phoenix paludosa*) leaves. It is the traditional sustainable practice of the honey collectors

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of the Sundarban to cut only a portion of the beehive, to ensure that the Giant Asian Bees (*Apis dorsata*) can return and rebuild the same hive.

Usually honey collection takes place in the western part of the Sundarban forest, which is mostly dominated by the nectar producing flowering trees like Goran (*Ceriops decandra*), Khalsi (*Aegiceras corniculatum*), and Keora (*Sonneratia apetala*). The colour and the taste of the honey depends on the nectar that bee collects from; for example honey from only *Khalshi* nectar has a translucent color, the honey from *Goran* nectar has a dark golden color, and range of light to dark golden depending on the mix of nectar from different flowers.

Jele: The fisherfolk

Although the daily routine of the honey collectors and wood cutters is similar, the lives of fisherfolk or jele are entirely dictated by the tidal regime. About one-third of the Bangladesh Sundarban is water, criss-crossed by numerous rivers and *khals* (canals). The waters of the Sundarban are rich in biodiversity and habitat for fish and aquatic resources; they serve as the fishing grounds for the forest communities. The fisheries resources are mainly exploited by seasonal and artisanal fisherfolk and include fishes such as *loitta*, *rupchanda*, *churi*, shrimps, crabs, mollusks, shells, etc. Fisherfolk make up almost half of the population of the Sundarban. Hilsa fishing is practiced by thousands of fishermen in the rainy season, especially in the Boleshwar, Passur and Shibsa rivers.

There are also nomadic fisherfolk who come mostly from the villages located at the fringes of the Sundarban like Shoronkhola. Seasonal fisherfolk also travel from far off places like Chittagong during the harvesting seasons. These marginal fisherfolk are tormented by pirate attacks and often spend sleepless nights, guarding their gears. They encounter the vagaries of nature and usually have traditional knowledge for survival, like avoiding venomous snakes.

There are *tarjali* fishermen, who fish in the tidal creeks with the help of pet otters. This is a specialized fishing technique and these fishermen are less prone to tiger or crocodile attacks. Other fishing gears or jals (nets) used in brackish water fishing are pata jal, bindi jal, ilish jal, hook and line fishing and the use of fine mesh nets for

shrimp fry collection. Some fishermen with small *dingi nouka* (country boats) fish inside the creeks and catch prawn and crabs.

Bawali: The wood cutters

Woodcutters, Golpata (*Nypa* palm) collectors and the grass-cutters of the Sundarban are generally known as the *Bawali*. However most of the Bawalis or wood cutters have lost their traditional livelihoods and have migrated to other professions, because of a moratorium placed on logging in the Sundarban since 1989. The *Gunin Bawalis* are possibly the handful of the remaining wood-cutters in the forest. *Gunins* the local guides to the forest and shamans who are known to posses traditional sustainable harvesting methods of the forest products, also work as guides to others and ward off tigers and other evil spirits of the forest using their talismans and chants. In winter, the grass-cutters and the *Golpata* harvesting *Gunin Bawalis* continue to practice their traditional livelihood, while in other seasons they seek alternative employment opportunities.

Jongra Khota: The shell collectors

The Jongra Khota or shell collectors are a near extinct class practicing a traditional livelihood of the Sundarban. The shell collectors collect large *Telescopium telescopium* and other kinds of shells from the shores of the Sundarban forest and carry them back to their villages. They then crush the shells and sell the powder to others, to produce fertilizers and as feed for poultry.

Mangroves: The green sentinels

Mangroves not only provide livelihoods to millions of people, they also have important roles in stabilizing the biosphere, regulating the atmosphere, sifting out pollutants from water, preventing erosion and facilitating land accretion. The mangrove trees are uniquely adapted to the regular movement of the tides and are therefore able to withstand stronger forces of wave and wind energy that occur with cyclones and tidal surges. Depending on their ecological health and coverage of trees in the forest, mangroves can absorb more than half of the energy of the waves, acting as physical buffer against the elements and the shore. The Sundarban is recognized as a buffer against storm-tidal surges that would otherwise have wreaked havoc to the low-

lying deltaic lands of Bangladesh. Scientists are of the opinion that destruction of coastal mangroves will lead to large-scale flooding of coastal areas if the sea level continues to rise because of climate change. The Sundarban mangrove forest is the sanctuary for endangered and spectacular species of birds and a spawning ground for important marine fish and mollusks. The mangroves are protecting the coast of Bangladesh like green sentinels and it is our duty to protect this World Heritage Site through conservation, responsible tourism and education.

REFERENCES

Kamal, S, *Sundarban: Poems and Photos of an Enchanting Journey*, 2006

Poribesh Shikkhay Sundarban, Center for Coastal Environmental Conservation (CCEC), 2004

Hussain, Dr. Z, *Mangroves of the Sundarban: Management of Forest Resources,* Volume 2: Bangladesh, IUCN 1994

Haider, M A K, *Sundarban Bhabna*, 2004 (book in Bangla)

Marginal Life, *Literature and Culture of Sundarban*, Kolkata University, October 2009 (book in Bangla)

Sundarban: A Photoreal Sojourn, IUCN Bangladesh Country Office

Gupta, R S, *Mangroves: soldiers of our coasts*, TERI India, 2010

Akhter, M, *Remote sensing for developing an operational monitoring scheme for the Sundarban Reserved Forest*, Bangladesh', Doctor of Natural Science thesis, Technische Universität Dresden

Shams, S B, Mukta, ZH, Mahapatro, M, Uddin, SA, Tutu, A-uA, Ara, S & Hassan, R 2004, *To Enter Again the Sweet Forest: A qualitative perspective of People's Livelihood in the Sundarban,* Action Aid, Dhaka

Combating Cyclones: The Intangible Values of the Sundarban

The reserved forest part of the Bangladesh Sundarban extends over 5,777.56 square kilometres (km^2) of which 1,757.24 km^2 is water. There are three Protected Areas in the SRF, which constitute the core area of the World Heritage Site as declared in 1997. The total area of the World Heritage Site is about 1,400 km^2 including 490 km^2 of water.

Management of SRF

Management of the Sundarban mangroves under a set of written management prescriptions through selection felling was initiated during 1893-94, through a ten-year management plan written by R. L. Heinig. Later W. F. Lloyd increased the felling cycle to 40 years during 1903-08. Sir Henry Farrington's management plan, applied

By **Junaid K. Choudhury & Shimanto Dipu**

during 1906-12 enhanced girth limits of trees to be felled. F. Trafford prepared the next management plan for the period 1912-32. S. J. Curtis formulated a detailed management plan for the Sundarban suggesting rotations, felling cycles and minimum exploitable girth for major species including "yield calculations". By 1937 it was realized that the existing infrastructure was not able to adopt such elaborate prescriptions. On this realization, S. Choudhury revised the management plan, which was in force till 1960.

Forestal Forestry carried out a detailed scientific inventory of the Sundarban mangroves and published the report in 1960 which indicated that the average net merchantable volume from trees over 12.7 cm and above was 53.62 M^3 per hectare (Forestal 1960). Based on this inventory A. M. Choudhury prepared the management plan of the Sundarban for the period 1960-80.

The Overseas Development Administration of the United Kingdom conducted the second detailed inventory of the Sundarban. The report, published in 1985, clearly reflected depletion of the growing stock to the tune of 41.9 and 34 percent of stems per hectare in case of trees with DBH (Diametre at Breast Height) of 7.5 cm and above, for Sundri and Genwa respectively. The regeneration was reported satisfactory (Chowdhury *et. al.* 1994).

Canonizado and Hussain prepared an integrated forest management plan for the Sundarban in 1998. This management plan, supposed to be implemented during 1998 to 2010, suggested a 20-year felling cycle. Annual Allowable Cut (AAC) of 54,000 M^3 was prescribed including improve felling and extraction of Top Dying Sundri (TDS). For Genwa, the AAC prescribed was 53,000 M^3. But because of the imposition of the moratorium by the Government, these management prescriptions were not implemented. At present only Non Timber Forest Products (NTFPs) are being harvested, that too at a very small scale.

Value of the Sundarban

Like any other forests, the Sundarban provides two types of benefits, namely tangible and intangible. Till a couple of decades back, only the tangible benefits of the Sundarban used to be treated as its value. Though the intangible benefits of the Sundarban are

being perceived for the last 20 years or so, the value (especially the monitory values) of such intangible benefits has hardly been brought to light. There are many intangible benefits that we get from the Sundarban. The gross major intangible benefits are:

- Benefits of carbon-sink.
- Benefit of livelihood support to about 1 Million people.
- Benefits of ecosystem and biodiversity.
- Benefits of combating cyclones and tidal surges.

In general though it is accepted that the Sundarban provides the above benefits, their value in terms of money, is yet to be determined. An attempt has been made here to assess the monitory benefits of the Sundarban in combating cyclones, that too limited only to the lives saved, since data needed for assessing the total value are not available.

Methodology

Briefly the methodology used is as follows:

- Data on cyclones that hit Bangladesh since 1960 to 2009 were collected from meteorology department of the Government of Bangladesh.
- Cyclones of equal strengths that hit non-Sundarban (No forest) and the Sundarban coast were identified.
- Damages caused by these cyclones have been compared.
- Due to the non-availability of complete data on total damage, only the death toll could be compared.
- Using expected life span and per capita income the gross benefits have been assessed.
- The yearly revenue expenditure of the government for the salaries and other expresses has been used as the cost, since that is what the government spreads for the protection of the Sundarban.
- Using the above the NPV (Net Present Value) has been calculated.

Valuation

The protective value of the Sundarban can be assessed as the difference of causalities and losses between two cyclones of almost equal strengths, of which one is passing over the Sundarban and the other passing over the non-Sundarban area. From the information collected from the Meteorological Department, Government of

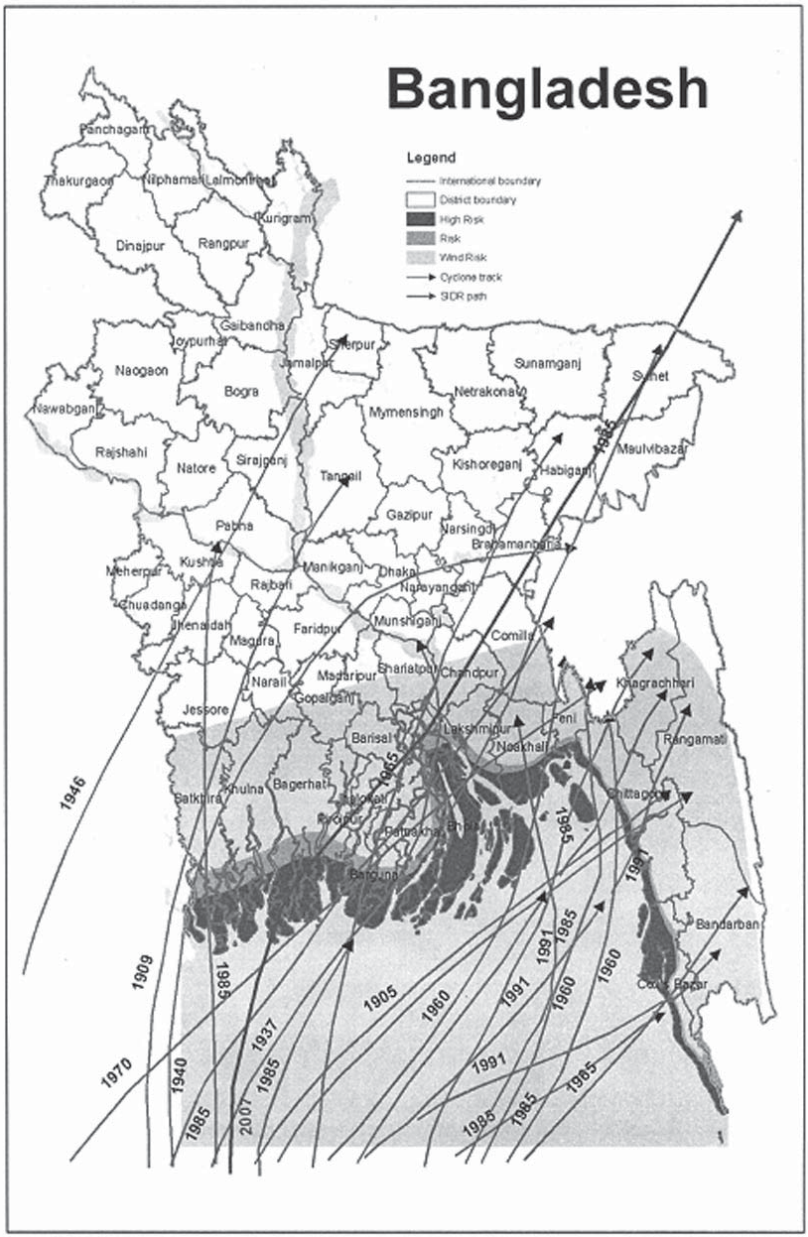


Fig. 1 Major Cyclonic Storms from 1960 to 2009

Bangladesh on the cyclones (see fig 1) that hit Bangladesh since 1960, given in Appendix A, indicates that the cyclone that lashed the Greater Chittagong District (non-Sundarban) area on November 12, 1970 had a speed of 224 Km per hour and had a death toll of 0.5 million lives, while another cyclone, Sidr, having a speed of 210 to 230 Km per hour, hit the Sundarban first and then passed over the human habitations on November 15, 2007, had a death toll of 3,363.

These two cyclones were almost of equal strength. Even if we ignore the loss of materials and properties that these two cyclones have caused, since the relevant data are not available, the death toll in leeward side of the Sundarban was less by (500000-3363=) 496637 number.

Assuming the followings (which are very conservative)

- Life span of people = 55 years
- Per Capita Income = 500 USD
- Average age of the people died = 20 years (Most of the people died were children, women and old people).
- One USD = 80 Taka.

  Based on these assumptions the following have been derived.
- Had there been no death each would have lived for another (55-20=) 35 years on an average.
- And each would have contributed (35 x 500=) 17500 USD during these 35 years.
- Thus these 496637 persons would have added to the nation's economy to the tune of (496637*17500=) 8,691,147,500 USD say 8,700 Million USD, which is equal to (8700 x 80=) 696000 Million Taka i.e. 696 billion Taka.

Thus the contribution of the people that died would have been 696 Billion Taka, which can be treated as revenue (V_t) or income or savings only with respect to the lives.

Every year the Government of Bangladesh spends about 0.13 billion Taka[1] (total allocation to Sundarban as revenue budget, see Appendix B) for the protection of the Sundarban.

1 Average of last 7 years (2006 to 2012)

The formula that we use to calculate the NPV (Net Present Value) is as under;

NPV = $V_t * e^{-ht} - V_o$

where

V_t = Revenue in t-th year
e = 2.712
h = Interest rate
t = Numbers of years
V_0 = Present value of investment

For this given case

V_t = 696 Billion Taka
e = 2.712
h = 0.06 since forestry is long term business the interest rate used is very low and in this case we are using 6%
t = 3 since it is found from the cyclone data that every 3 year a major cyclone passes over the Sundarban.
V_0 = 0.13 billion Taka, the amount that the Government spent for the protection of the Sundarban.

Thus the NPV comes to 581.1135 billion Taka say 581 billion Taka in every 3 years, which means that the yearly intangible value of the Sundarban only with respect to lives saved is 193.6 say 194 billion Takas.

Conclusion

It appears from this simple valuation that the intangible benefit of the Sundarban in saving life alone from cyclones every year is worth 194 billion Taka. Do we ever think of this immense benefit that the Sundarban is rendering to the nation every year, while we destroy these forests not only by directly removing the trees, but also by causing circumstances such as setting of coal fired power plant nearby, enhancing water pollution by allowing navigation routes through Sundarban, withdrawal of fresh water by putting barrages up stream, so on and so forth?

REFERENCES

ADB, 1993. *Forestry Master Plan, Vol. I-III.* Development Bank (TA No.1355-BAN) UNDP/FAO BGD/88/025. Government of Bangladesh, Ministry of Environment and Forest.

ADB, 1996. *Final Report on Forestry Sector Study, Vol. I & II.* Government of Bangladesh, Ministry of Environment and Forest, Fountain Renewable Resource Ltd. (UK) and Desh Upodesh (Bangladesh) Ltd.

ADB, 1997. *Draft Final Report on Biodiversity Conservation in the Sundarban Reserved Forest.* Vol. I-II, Asian Development Bank (PPTA NO.2724-BAN), Government of Bangladesh, Ministry of Environment and Forests, Forest Department.

Balmforth, E.G 1985. *Preparation of Interim Felling Prescriptions for the Sundarban Forest.* BGD/79/017, Assistance to the Forestry Sector, UNDP/FAO, Rome, Italy.

Baten, S.A. 1960. *Working Plans of the Sundarban Forest Division (1960-1980).* Vol. III, East Pakistan Government Press, Dacca.

Chaffey, D.; Miller, F.R. and Sandom, J.H. 1985. *A Forest Inventory of the Sundarban, Bangladesh.* Main Report and Appendices, ODA.

Choudhury, A.M. 1962. *Working Plan of Sundarban Forest Division : 1960-61 to 1979-80.* Volume-I & II, East Pakistan Govt. Press, Dacca.

Community Based Adaptation to Climate Change Through Coastal Afforestation in Bangladesh. GEF/UNDP funded project (July 2008 to June 2012).

Curtis, S.J. 1933. *Working Plan of Sundarban Forest Division : 1931-1951.* Vol. I&III, Calcutta Bengal Government Press, India, 1933.

FAO. 1995. *Draft Report on Integrated Resource Management Plan of the Sundarban Reserved Forest*. Vol. I & II, FO: DP/BGD/84/056, Integrated Resource Development Plan of the Sundarban Reserved Forest, Dhaka, Bangladesh.

FD. 2010. *Bangladesh Tiger Action Plan*. Forest Department, Dhaka, Bangladesh.

Forestal, 1960. *Inventory 1958-59, Sundarban Forest*. Origin: Forestal Forestry and Engineering International Ltd.; Canada.

FSP. 2001. *Guidelines for the Development of Conservation Area Facilities*. Forest Department, Dhaka, Bangladesh.

Grepin, G. 1995. *Draft Final Report on Mangrove Ecology*. FAO/UNDP Project BGD/84/056 Integrated Resource Development of the Sundarban Reserved Forest. Khulna, Bangladesh.

Hassan, M. M. and Mazumder, A.H.; Islam, A.T.M.N and Hossain, A.T.M.E. 1990. Soil hydrology and salinity of the Sundarban in relation to top dying, regeneration and survival of Sundri (*Heritiera fomes*) trees. In Rahman, M.A.; Khandakar, K.; Ahmed, F.U.; Ali, M.O. (edited): *Proceedings of the seminar on Top Dying of Sundri (Heritiera fomes) trees,* August 11, 1988. Bangladesh Agricultural Research Council, Dhaka.

Heining, R. L. 1892. *Working Plan of the Sundarban Government Forests*, Khulna and 24 Paragans Districts Bengal.

Hossain, Z. and Acharya, G. 1994. *Mangroves of the Sundarban*. Volume II;

Bangladesh. The IUCN Wetlands Program, IUCN, Thailand.

Karim, A. 1988. *Top Dying Sundri Trees: An ecological view point.* In, Rahman, M.A.; Khandakar, K.; Ahmed, F.U.; Ali, M.O. (edited): Proceedings of the seminar on Top Dying of Sundri (*Heritiera fomes*) trees, held on August 11, 1988. Bangladesh Agricultural Research Council, Dhaka.

Karim, A. 1995. *Draft Report on Mangrove Silviculture*, Vol-I, FAO/UNDP Project BGD/84/056, Integrated Resource Development of the Sundarban Reserved Forest, Khulna, Bangladesh.

Katebi, M.N.A. and Habib, H. 1987. *Sundarban and Forestry in Coastal Area Resource Development and Management,* Part-II, CARDMA, BRAC Printers, Dhaka.

Latif, M.A, Rahman, M.F., Das, S. and Siddiqi, N.A. 1992. Diameter increments for six mangrove tree species in the Sundarban Forests of Bangladesh. *Bangladesh Journal fof Forest Science,* Vol 21 (1 & 2):7-12.

Masson, J.L. 1984. *Technical Report: Integrated Development of the Sundarban Reserved Forest.* TCP/BGD/2309 Technical Report. FAO-1994.

MOL, 2007. Inception Report of the Coastal Land Use Zoning Project.

ODA. 1985. *A Forest Inventory of the Sundarban*, Bangladesh. Main Report. Land Resources Development Centre, Surbition, England.

SEALS. 2010. Development Project Proposal, Forest Department, Government of Bangladesh.

USFS. 2010. *Carbon Assessment Report*. USAID, Bangladesh.

Appendix A

List of Major Cyclonic Storms from 1960 to 2009 with a brief account of loss and damage

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph.	Tidal Surge Height	Central Pressure (mbs)	Loss/ Damage
1	2	3	4	5	6	7
11.10.60	Severe Cyclonic Storm	Chittagong	160	15	-	People Killed = 3000
31.10.60	Severe Cyclonic Storm	Chittagong	193	20	-	People Killed = 5149 70% buildings in Hatiya blown off, 2 large Ocean liners thrown on main land, 5-7 vessels capsized in Karnaphuly river
09.05.61	Severe Cyclonic Storm	Chittagong	160	8-10	-	People Killed = 11468
30.05.61	Severe Cyclonic Storm	Chittagong(Near Feni)	160	6-15	-	Damage report not available.
28.05.63	Severe Cyclonic Storm	Chittagong-Cox's Bazar	209	8-12	-	People Killed = 11520 Home stead lost = 1000000
11.05.65	Severe Cyclonic Storm	Chittagong-Barisal Coast	160	12	-	People Killed = 17279 In Barisal 14193 people were killed

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph.	Tidal Surge Height	Central Pressure (mbs)	Loss/ Damage
05.11.65	Severe Cyclonic Storm	Chittagong	160	8-12	-	People Killed = 873 No. of salt beds damaged = 10000
15.12.65	Severe Cyclonic Storm	Cox's Bazar	210	8-10	-	Great loss of lives Fisherfolk missing = 1000
01.11.66	Severe Cyclonic Storm	Chittagong	120	20-22	-	People Killed = 850
23.10.70	Severe Cyclonic Storm of Hurricane intensity	Khulna-Barisal	163	Mode-rate	-	No heavy damage report received.
12.11.70	Severe Cyclonic Storm with a core of hurricane wind	Greater Noakhali District	224	10-33	-	People Killed = 200000 (officially) = 500,000 (unofficially) The entire belt from Khulna to Chittagong and off-shore islands experienced hurricane wind for about 9 hours. A great number of animals were also killed.
28.11.74	Severe Cyclonic Storm	Cox's Bazar	163	9-17	-	People Killed = 20 People wounded = 50 People missing = 280 Cattle killed = 1000 No. of dwelling perished = 2300
10.12.81	Cyclonic Storm	Khulna	120	7-15	989	People Killed = 72
15.10.83	Cyclonic Storm	Chittagong	93	-	995	People Killed = 43 Fisherfolk missing = 100
09.11.83	Severe Cyclonic Storm	Cox's Bazar	136	5	986	Fisherfolk missing = 300
24.05.85	Severe Cyclonic Storm	Chittagong	154	15	982	People Killed = 4264 People missing = 6805 Affected area = 1906 sq. miles People affected = 1310935 Damaged to crops in acres =132860 House damaged fully = 90915 House damaged partly = 34611 Livestock lost = 135033 Road damaged = 40 miles Embankment damaged fully = 53 miles Embankment damaged partly = 189 miles Trees damaged = 1200

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Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph.	Tidal Surge Height	Central Pressure (mbs)	Loss/ Damage
29.11.88	Severe Cyclonic Storm with a core of hurricane wind	Khulna	160	2-14.5	983	People Killed = 6133 (Bangladesh & India) People missing = 6000 Deer killed = 15000 Bengal Tiger killed = 9 Cattle heads = 65000 Crops damaged = 940 Crores(Taka) Fishing equipments = 15 crores (Taka)
18.12.90	Cyclonic Storm (crossed as a depression)	Cox's Bazar Coast	115	5-7	995	Damage report not available
29.04.91	Severe Cyclonic Storm with a core of hurricane wind	Chittagong	225	12-22	940	People Killed = 138882 People wounded = 1390540 No. of affected districts = 19 No. of affected Thana = 102 No. of affected Municipalities = 9 No. of affected Population = 10798275 Damage to crops fully = 133272 acres Damage to crops partly = 882705 No of house destroyed fully = 819608 No of houses damaged partly = 882705
02.05.94	Severe Cyclonic Storm with a core of hurricane wind	Cox's Bazar-Teknaf Coast	278	5-6	948	People Killed = 188 Affected unions = 64 Affected families = 98169 Affected people = 416000 Totally damaged dwelling houses = 45000 Partially = 62677 Cattle & livestock = 7890 Crops lost (totally) = 21167 acres Crops lost (partially) = 33862 acres Salt beds damaged = 7527 acres Shrimp Project damaged = 5017 acres Barrage damaged = 126 kms Roads & Highways damaged = 350 kms Forest Resources damaged = 2530051 trees Educa. & other Religious Institu. damaged = 725 Bridges damaged = 150
25.11.95	Severe Cyclonic Storm	Cox's Bazar	140	10	998	Damage report not available

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph.	Tidal Surge Height	Central Pressure (mbs)	Loss/ Damage
19.05.97	Severe Cyclonic Storm with a core of hurricane wind	Sitakundu	232	15	965	People Killed = 155 People wounded = 9663 People affected = 2835472 Families affected = 541586 Districts affected = 10 Livestock killed = 3118 Houses damaged (fully) = 112160 Houses damaged(partly) = 99557 Crops damaged (fully) =19173 acres Crops damaged (partly) = 78160 Roads damaged (fully) = 53 kms Roads damaged (partly) = 162 kms Betel vines damaged = 60000 acres Shrimp Projects affected =600 acres Embankment damaged = 6 kms Bridge & Culverts damaged =165 Fishing Trawlers damaged = 26 Educational & Religious Institutions damaged = 1480 Cyclone Shelters damaged = 718 Salt washed away = 60000 maunds
27.09.97	Severe Cyclonic Storm with a core of hurricane wind	Sitakundu	150	10-15	-	People Killed = 78 People missing = 222 People affected = 2015669 People wounded = 2396 Family affected = 374583 Loss of cattle heads = 3196 Housed damaged (fully) = 51435 Housed damaged (partly) = 163352 Crops damaged (fully) =16537 acres Crops damaged (partly) =72662 Bridge & Culverts damaged = 85 Educational & Religious Institutions damaged = 475 Roads damaged (fully) = 218 kms Roads damaged (partly) = 2379 kms Embankment damaged = 280 kms

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Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph.	Tidal Surge Height	Central Pressure (mbs)	Loss/ Damage
20.05.98	Severe Cyclonic Storm with core of hurricane winds	Chittagong Coast near Sita Kundu	173	3		People Killed = 14 People wounded = 100 Fisherfolk missing = 100 House damaged = 10,000 Ships damaged = Two ships collided and one was damaged Micro-Wave Link = Mocro-Wave Link at Singira was damaged at 0005 UTC on May 20,1998. Trawllers missing at Chittagong = 32 Coasters/Tankers of BIWTC blown away over land = 13 Police Camp damaged (Fully) = 12 Police Camp damaged (Partially) = 03
17.10.99	Severe Cyclonic Storm of Hurricane intensity	Orissa Coast	-	-	-	No causalities was reported in Bangladesh
25.10.99	Severe Cyclonic Storm of Hurricane intensity	Orissa Coast	-	-	-	No causalities was reported in Bangladesh
28.10.2000	Deep Depression (Probably Cyclonic Storm)	Sundarban coast near Mongla	50-60 kph	2- 4 ft	-	People killed =3 Fisherfolk reported missing = About 250 Houses reported damage = 3,000
16-10.2001	Severe Cyclonic Storm	Andhra coast	65 - 85 KPH	-	996	Weakened into a depression
2002 12.11.2002	Cyclonic Storm	Sundarban coast near Raimangal river	65-85 kph	5 - 7 ft	998	People killed = 2 Fisherfolk reported missing = About180 Houses reported damage = 100
20.5.2003	Cyclonic Storm	Myanmar coast	65-85 kph	3 - 5 ft	-	Weakened into a depression No causalities was reported
16.12.2003	Severe Cyclonic Storm	Andhra coast	98-115 kph	-	992	No causalities was reported
19.5.04	Cyclonic Storm	Cox's Bazar – Akyab Coast	65-90 kph	2 - 4 ft	990	26 small boats with fisherfolk were reported missing
2007 15.11.2007	Severe Cyclonic Storm with a core of Hurricane Winds "SIDR"	Khulna-Barisal coast near Baleshwar River	210-230 kph (223 Km/hr at Patuakhali)	15-20 ft	942 hPa	People died: 3363 People missing: 871 Family affected: 19,28,265 People affected: 85,45,470 Houses damaged: 14,49,157 Crop damaged: 20,77,226 Trees destroyed: 40,65,316

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph.	Tidal Surge Height	Central Pressure (mbs)	Loss/ Damage
27.10.2008	Cyclone 'Rashmi'	Khulna-Barisal coast (near Patharghata)	Hatiya, Patuakhali, Mongla, Barisal 83 km/hr each.	-	992	
18.04.2009	Cyclone "BIJLI"	Chittagong-Cox's Bazar coast (near Chittagong)	-	-	988	Total Death: 04 (Source: control room of Ministry of Food and Disaster Management)
25.05.2009 Afternoon to evening	Cyclonic Storm "AILA"	West Bengal-Khulna (Bangladesh) Coast (near Sagar Island)	92 kph (at Khepupara)	04 - 05 ft.	987	Total Death: 190 People Injured: 7103 Family Affected: 9,48,621 People Affected: 39,28,238 Houses Damaged: 6,13,778 Crops Damaged: 3,23,454 acre

Source: Meteorological Department, Govt. of Bangladesh.

Appendix B

Yearly net grant in Taka given to Sundarban by the Government

Year	Sundarban West	Sundarban East	Sundarban Total
2005-06	47580349	87506517	135086866
2006-07	54897971	44339038	99237009
2007-08	58302189	48012954	106315143
2008-09	65315207	57879698	123194905
2009-10	69181412	62133443	131314855
2010-11	83842669	78173796	162016465
2011-12	88857419	82330247	171187666
		Total	928352909
		Average	13,26,21,844.1

Source: FD Government of Bangladesh

Threats to the Bangladesh Sundarban

Threats to the Bangladesh Sundarban are diverse and pervasive. Many of these threats are already in place while some others are impending. Did anyone imagine a coal-fired power plant on the shoulder of our Sundarban? Most probably not. Now it is an awful reality. We may even see some more harrowing projects in and around our Sundarban in the near future.

The Sundarban is the largest single block of tidal halophytic mangrove forest on the planet. Advantageously, Bangladesh holds a greater part of this magnificent world heritage in its territory. Recognising the importance and uniqueness of the Sundarban, UNESCO declared three wildlife sanctuaries as a World Heritage Site in 1997. It is well understood that the Sundarban is critical to

By **Md. Abdul Aziz**

the well being of Bangladesh as it provides significant economical, societal and environmental benefits. Despite its high productivity and provisions of many benefits, the Sundarban ecosystem is however facing an array of ongoing and potential threats for its long-term survival.

Ecologists know that the Sundarban fragile ecosystems, a blend of aquatic and terrestrial, are inseparably webbed through multiple biotic and abiotic interlinking components: the tiger, the supreme predator and the tertiary consumer, sits at the top of the trophic level; one of most important primary consumers, the deer which is the major prey of tigers and lastly the producers, the green plants that are so deeply rooted into the soil, the habitat. However, these three vital ecosystem components are at a great risk due to a wide variety of extrinsic and intrinsic threats. The endangerment of our Sundarban has been also reflected in the "Bangladesh Vision 2021" report of the Bangladesh Academy of Science where concerns have been raised about the gradual degradation of mangroves. Recommendations made in the section of its Science, Technology and Development clearly states that "encroachment into the mangrove forest should be stopped and exploration of its resources, if at all permitted, should not be allowed to exceed their sustainable limits (Rashid, 2002)." A study carried out jointly by the Bangladesh Forest Department, Wildlife Trust of Bangladesh and the Zoological Society of London in line with the Bangladesh Tiger Action Plan 2009-2017 identified and ranked a total of 23 threats which are known to have potentials to cause serious stresses to the three major ecosystem components of the Sundarban – the tigers, the spotted deer and their habitats (Aziz *et al*., 2011. This analytical report identified these threats, of which four are linked to tigers, two to deer, and 17 to the habitat of the mangrove forests. Among the high-ranking threats, tiger poaching, deer poaching, sea level rise, upstream water extraction or divergence, wood collection, and fishing and harvesting aquatic resources have been categorised as the most active and potential threats. Medium-ranking threats include stray tiger killing, tiger and prey disease, invasive species, river pollution, mineral and gas extraction, storm and tidal surge, melting Himalayan glaciers, temperature change and sea acidification. The lower category threats of the extensive list are

the inbreeding depression of tiger population, plant disease, housing and commercial infrastructure, livestock grazing, Non-timber Forest Products (NTFP) collection and forest fire. The following sections provide evidential supports including some background description of the major threats focusing on the above mentioned three broader ecosystem components.

Tiger Poaching

The Bangladesh Sundarban is known to support the world's largest contiguous population of the Bengal tigers with the highest density in the world (Barlow, 2009). Studies show that this has been only possible due to having a healthy population of the prey species, mainly the spotted deer. In the Sundarban ecosystems, the tiger is the top predator and often termed the keystone species, umbrella species as well as the flagship species. However, this supreme predator is under serious threats due to poaching and indiscriminate illegal killing for meat, skins, bones and other body parts. Although the Wildlife (Preservation and Protection) Act 2012 has made hunting for most of the wildlife species illegal, hunting or poaching in the Sundarban remains a major threat to this Critically Endangered national animal.

Tiger poaching in the Bangladesh Sundarban, which had been unnoticed and purposively denied by the authority since long, has recently seen a boom and come to wider national and international attention. On 16 February 2010, law enforcing agencies held a poacher with three tiger skins and four skulls, including many kilograms of bones from a remote village of Sarankhola close to the Sundarban. This is the first time in Bangladesh such a huge quantity of poached tigers have become public. This seizure overthrows the long lasting denial that no tiger poaching exists in our Sundarban. All concerned have much worry that this seizure of heavy poaching should not be the only misdeed in case of our Sundarban tigers. It is, however, the entry point of a black hole whose exit is far and wide.

We came to know another recent story of tiger cub poaching. On 11 June 2012, the Bengal tigers of our Sundarban all of a sudden made their appearance in Dhaka city! Not even adults, three newborn tiger cubs managed to travel a long way from our Sundarban to the

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capital city. Three cubs were rescued from a house of established wildlife traffickers located at Shyamoli as reported in the local media.

It was unfortunate, out of imagination and worrying! At least to me being a wildlife biologist and activist of wildlife conservation. I am sure we are heading to a tigerless country if the current trend of tiger loss from the Sundarban forest continues. Our symbol of pride, source of courage and heritage of Bangladesh the Bengal tiger and its habitats are at the hands of poachers, pirates and inept managers. It is high time to act in this situation and reverse this trend of tiger removal from the forests if we want to leave the last chance for our future generations to seeing tigers in the wilderness of the Sundarban. Otherwise our tigers will only remain protected in history, on stamps or on the logo of Bangladesh Cricket Team!

Tiger poaching is a cosmopolitan phenomenon; more or less common to all tiger range countries of the world. Available data show that currently up to two tigers are being poached from the Sundarban each year (Ahmad *et al*., 2009). Scientists apprehend that majority of the incidents remains undetected due to the covert and illegal nature of this activity. One of the major reasons behind this poaching is that tiger parts have been integral elements of the traditional Asian medicine (Nowell and Ling, 2007).

Stray tiger killing is a medium level threat for our Sundarban tigers. Records show that up to three stray tigers are killed each year by local villagers when tigers stray in to the villages (Barlow, 2009). For many reasons, some tigers come out of the forests and stray in to the fringes villages located at the northern boundary of the Sundarban.

Deer Poaching

Poaching of spotted deer from the Sundarban is rampant. However, we all know that the spotted deer plays a pivotal role in Sundarban terrestrial ecosystem. It has been the main prey animal for our tigers. Unrestrained poaching of this important wildlife could push our Bengal tigers in peril. It has now become an unfortunate reality. Poaching of deer is widespread in and around the Sundarban. Large numbers of deer are being poached every year by professional poachers; however, opportunistic hunters, fishermen, woodcutters and other resource collectors do this illegal practice as their secondary

or leisure activity. Prey depletion is a serious threat to any tiger population, which has been occurring in the Bangladesh Sundarban too (Ahmed *et al*., 2009).

Blower (1985) noted that there is an extensive illegal hunting and trapping of deer, not only by fishermen and woodcutters but also reportedly by naval and military personnel from Hiron Point in Sundarban South Wildlife Sanctuary. A community based interview study carried out by the Jagrata Juba Shangha in 2003 concluded that deer population in the Sundarban is declining mainly due to poaching. To do so, snaring, among others, has been a common method used by hunters. An FD record shows that between 1981/82 and 1986/87 a total of 118 offences was recorded and over 3,300 m of nets used for deer trapping were removed from the forests. A recent study on the scale of deer poaching by Mohsanin *et al*. (2012) suggests that a large number of deer have been trapped from the Sundarban each year, which amounted to about 11,000 deer per year. It is thought that depletion of this vital prey animal through poaching and hunting must have a greater impact on population dynamics itself and on the tiger population at the end.

Sea Level Rise

The impact of Sea Level Rise (SLR) as a result of global climate change could be catastrophic to the Bangladesh Sundarban including the country's whole range of low lying coastal belts. For the Sundarban habitat, SLR has been noted as a serious threat, with current predictions suggesting substantial loss of habitat over the next 50 years (Agrawala *et al*., 2003). A World Bank (2000) report predicts that an increase of 25 cm SLR by 2050 will inundate 40 percent of the Sundarban. The entire Sundarban is low lying and has a mean elevation of only about 1 m above sea level. Although the estimates of SLR vary according to different authors, some current estimates are more than 1 m by 2100 (Hansen, 2007). Another analysis by Loucks *et al*. (2010), without taking sedimentation rate into account, presages that SLR may inundate more than 70 percent of the terrestrial habitats of the Sundarban in the next 100 years.

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Upstream Water Extraction or Divergence

Biophysical and ecological variables of the Sundarban including ecosystems are highly complex. Functioning of this highly intricate ecosystem is directly linked to the intermixing of freshwater flow from upstream and the contiguous marine tidal water. Any perturbation in the freshwater flow disturbs the whole process of nutrient flow and also the "envelope" of the physicochemical environment (Karim, 2004). Since 1975, the pattern of the flow from the Ganges at Hardinge Bridge has changed due to the diversion of water at Farakka Barrage in India, 17 km upstream from the Bangladesh border. As a result, the minimum daily flow has decreased by 43 percent (Karim, 1994). Again on its courses, there has been further loss of freshwater due to increasing upstream water use driven by a burgeoning human population (Wahid *et al.*, 2007). On the other hand, more than 125 polders have been constructed in the south-west region along the upper catchment areas of the Sundarban between 1969 and 1970 to control saline intrusion into the agricultural fields. So far, 3,700 km earth embankments have been constructed at the upper reaches of the rivers flowing through the Sundarban (Karim, 1994). At the end, decreased freshwater flow increases salinity, particularly in the dry season, which could change vegetation patterns. This vegetation changes would have wider consequences on ecosystems including the distribution of tigers, prey and other wild animals (Ahmad *et al.*, 2009).

Wood collection

The Sundarban terrestrial habitat has been degraded over time, probably in part due to harvesting trees beyond the replenishment capacity of the forest, including both legal and illegal extraction (Iftekhar and Saenger, 2008). Wood collection is considered a contributing factor to the degradation of habitats in terms of forest cover, species diversity, and ecosystem functioning (Karim, 1994; Siddiqui, 2001). Over-exploitation of mangroves due to harvesting trees beyond the replenishment capacity of the forest has been documented elsewhere (ODA, 1985). It is estimated that Genwa, *Excoecoria agallocha* has been depleted by 40 percent and Sundari, *Heritiera fomes* by 45 percent due to a combination of wood cutting

for saw timber and fuel wood as well as disease (Chaffey, 1985; Iftekhar and Islam, 2004). Available data show that average stand density of the forest has been reduced by 87 percent and that of *Heritiera* and *Excoecoria* has been declined by 84 percent and 95 percent respectively during period of 1926/28-1995. It is possible that the systematic felling of trees with highest growth might have reduced genetic quality in spite of banning *Heritiera* in 1989 (Iftekhar and Islam, 2004).

Fishing and harvesting aquatic resources

A wide range of fishery and other aquatic resources such as fishes, crabs, prawns and shrimps have been the mainstay for millions of people living in and around the Sundarban since time immemorial. Collections of these resources are widespread and intense in the Sundarban waterways. As a result, fishery of the Sundarban has come under tremendous pressure in recent years, and extraction of these aquatic resources is thought to have gone beyond its sustainable limit; even more serious issue relating to fishing is that huge quantity of non-target aquatic species is being destroyed by both permitted and non-permitted fishers. It is known that 0.25 million fisherfolks go to the Sundarban every year for fishing.

A relatively recent emerging issue relating to fishing is "fishing with poison" in the waters of the Sundarban. Fishing with poison is a new technique introduced by some of the greedy fishermen in to the Sundarban. Although detailed information on the scale and scope of this devastating fishing activity is unavailable, it is however clear that fishing with poison has significantly increased over the last 3-4 years. Available information and personal observations indicate that poison fishing takes place over the whole Sundarban with relatively high frequency in the creeks of Chandpai and Sarankhola forest ranges. It is alarming to note that most of the fishers carry fish poison while they go to the Sundarban for fishing; however, they use the poison only when catch is not satisfactory as report says. Some fishers also opined that "getting abundant catch within a shortest possible time and with less effort" is the guiding principle behind this illegal fishing practice. A preliminary study carried out under Integrated Protected

Area Co-Management mentioned 58 percent reduction of fisheries production in the Sundarban during the last 40 years. The fishers believe that their fish catch has declined 40 to 50 percent during the last 10 years. Some community people also say that the intensity of poison fishing is increasing nowadays due to low catch; poison fishing along with water pollution might have caused this reduction of fishery resources in the Sundarban.

Fish and other aquatic resources play a critical role in the food chain of the Sundarban ecosystems that ultimately affects the birds, and some of the mammals which feed directly on the fish. The communities living in the Sundarban Reserve Forest (SRF) impact zones believe that fishing with poison is highly detrimental to fisheries and livelihoods and the Sundarban would probably have no fish in the next 5 to 10 years. At the end, the reduction of fisheries due to poison fishing will ultimately increase the pressure on forest resources. Even the most serious damage is that poison applied for target species kills all other aquatic organisms including eggs, larvae and broods in the waterways where poison is applied.

In the end, our Sundarban will only be benefitted if management and conservation efforts are taken to eliminate or substantially reduce these threats. We may come across many unknown threats in the future we never had imagined before. Now the fate of our Sundarban rests on our shoulders whether or not we sincerely want to protect this magnificent forest for the generations to come. Or we will compromise this unique resource in the name of so-called development for our national interest. One such development project, the establishment of a Coal-fired Power Plant at Rampal in Bagerhat near the Sundarban, has emerged as an imminent threat. Could our Sundarban really withstand the consequences of such reckless decisions made in the name of development needs and national interest? I am almost sure we will lose in the end.

REFERENCES

Agrawala, S., T. Ota, A. U. Ahmed, J. Smith and M. van Aalst. 2003. *Development and climate change in Bangladesh: focus on coastal flooding and the Sundarban.* OECOD, France.

Ahmad, I.U., C.J. Greenwood, A.C.D. Barlow, M.A. Islam, A.N.M. Hossain, M.M.H. Khan and J.L.D. Smith. 2009. *Bangladesh Tiger Action Plan 2009-2017. Bangladesh Forest Department, Ministry of Environment and Forests,* Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Aziz, M.A., A.C.D. Barlow, C.J. Greenwood, and M.A. Islam. 2011. *Prioritising threats to improve conservation strategy for Sundarban tigers of Bangladesh.* Oryx (in press).

Barlow, A.C.D. 2009. *The Sundarban tiger: Adaptation, population status, and conflict management.* PhD Thesis, University of Minnesota.

Biswas, S.R., J.K. Choudhury, A. Nishat and M.M. Rahman. 2007. *Do invasive plants threaten the Sundarban mangrove forest of Bangladesh?* Forest Ecology and Management, 245:1-9.

Blower, J. 1985. Sundarban Forest Inventory Project, *Bangladesh: Wildlife conservation in the Sundarban.* Project Report No. 151, Overseas Development Administration, Land Resources Development Centre, Surbiton, UK, 39 pp.

Chaffey, D.R., F.R. Miller and J.H. Sandom. 1985. *A forest inventory of the Sundarban, Bangladesh.* Main report, Overseas Development Administration, England, 196.

Hansen, J.E. 2007. Scientific reticence and sea level rise. Environmental Research Letters 2.

Huda, M.S. and M.E. Hauqe. 2001. *Current Status of Winter Fishery in Dublar Char and Options for Improvement,* Sundarban Biodiversity Conservation Project. Project Report No. 37, Ministry of Environment and Forests, Government of Bangladesh, Dhaka.

Iftekhar, M.S. and M.R. Islam. 2004. *Degeneration of Bangladesh's Sundarban mangroves: a management issue*. The International Forestry Review, 6:123-135.

Iftekhar, M.S. and P. Saenger. 2008. *Vegetation dynamics in the Bangladesh Sundarban mangroves: a review of forest inventories.* Wetlands Ecological Management, 16: 291□312.

IUCN Bangladesh. 2003. *Conservation Monitoring of Sundarban Biodiversity. Biodiversity Health Status Workshop Proceedings*, IUCN Bangladesh Country Office, Dhaka, Bangladesh.

Jagrata Juba Shangha. 2003. *Human-wildlife interactions in relation to the Sundarban reserved forest of Bangladesh*. Report No. 78, Sundarban Biodiversity Conservation Project, Department of Environment and Forests, Dhaka.

Karim, A. 1994. *Environmental Impacts. In Mangroves of the Sundarban*, Volume II: Bangladesh, Z. Hussain and G. Acharya (eds.), IUCN, Bangkok, pp 203-219.

Karim, A. 2004. *Implications on ecosystems in Bangladesh. In M. M. Q. Mirza (ed.). The Ganges Water Dispersion: Environmental Effects and Implications*, Kluwer Academic Publishers, Netherlands, pages 125–161.

Loucks, C., S. Barber-Meyer, M.A.A. Hossain, A.C.D. Barlow and R.M. Chowdhury. 2010. *Sea level rise and tigers: predicted impacts to Bangladesh's Sundarban mangroves*. Climate Change, DOI 10.1007/s10584-009-9761-5.

Miah M.G. and M.N. Bari. 2001. *Agricultural Practices and their impact on the ecology and biodiversity of the Sundarban area of Bangladesh,* Technical Project Report of UNESCO, BSMRAU, Gazipur, Bangladesh.

Mohsanin, S., A.C.D. Barlow, C.J. Greenwood, M.A. Islam, M.M. Kabir, M.M. Rahman and A. Howlader. 2012. *Assessing the threat of human consumption of tiger prey in the Bangladesh Sundarban.* Animal Conservation. doi:10.1111/j.1469-1795.2012.00571.x

Nowell, K. and X. Ling. 2007. Taming the tiger trade. TRAFFIC, East Asia, Hong Kong.

Overseas Development Administration, 1985. *A forest inventory of the Sundarban, Bangladesh,* Main Report. Land Resources Development Centre, Surbiton, England.

Rahman, H.A., A.C.D. Barlow, C.J. Greenwood, M.A. Islam, I.U. Ahmed. 2010. *Livestock depredation by tiger on the edge of the Bangladesh Sundarban. A Technical Report.* Wildlife Trust of Bangladesh.

Siddiqi, N.A. 2001. Mangrove Forestry in Bangladesh. Institute of Forestry and Environmental Sciences, University of Chittagong.

Wahid, S.M., M.S. Babel and A.R. Bhuiyan. 2007. *Hydrologic monitoring and analysis in the Sundarban mangrove ecosystem, Bangladesh.* Journal of Hydrology, 332:381-395.

World Bank. 2000. *Bangladesh: Climate Change & Sustainable Development*, Report No. 21104 BD, Dhaka.

Tourism: An Emerging Threat to Sundarban Ecosystem

The World Heritage Site of the Sundarban consists of three wildlife sanctuaries, namely Sundarban East (in Bagerhat district), Sundarban West (in Satkhira district), and Sundarban South (in Khulna district). The total area of the World Heritage Site is about 1,400 km^2, of which 490 km^2 is water.

Entry into any part within the territory of Sundarban Reserved Forest, without prior permission from the Forest Department, is legally prohibited. Previously none other than the resource harvesters, namely fisherfolk, wood cutters, fuel-wood collectors, honey collectors, etc. used to seek and get entry permit for some such specific activities for a given time as shown on their permits. Till 1987, that was the prevailing situation.

By **Junaid K. Choudhury**

Breakthrough

Sundarban has no road network and is completely devoid of any type of human settlement. The only mode of movement is water crafts, which used to be manually plied, extremely slow moving wooden boats. Although it has water everywhere, all of that are saline and unfit for human use not only for drinking but also for other general use such as for cooking, washing etc. On top of that the Sundarban had crocodiles in its water bodies, venomous snakes and tigers on its land sites. All these, which in the past, used to be viewed as serious hazards, have rightly turned out to be the most important elements of recreation to the tourists at present.

As against such inaccessible surroundings, the Sundarban possesses a heavenly scenic beauty coupled with the usual sounds of birds, monkeys, deer, etc. The Sundarban being a site of heavenly beauty, with the passage of time and advancement of water transportation facilities, started to attract tourists, not for harvesting any resource, but for enjoying its scenic beauty. Till 1987, the Forest Department on behalf of the Government had no general arrangement to formally allow tourists to enter Sundarban for the purpose of recreation. The breakthrough occurred when an executive order was issued by the Government vide their Office Order number 66 dated 1 January 1987, allowing the visitors to enter the Sundarban in lieu of a fee. The fee per person per day was Taka 4 for those entering on board motor launches and Taka 2 for those entering by country boat. This is how tourism started in the Sundarban. With the passage of time, the fees got enhanced, at present over 20 private companies take tourists to the Sundarban and the nomenclature got transformed from simple 'tourism' to 'ecotourism..

Tourism intrusion

As the tourists are allowed formally to enter the Sundarban on payment of a fixed entry fees, just for the purpose of recreation, a new window for the Forest Department (FD), the Government of Bangladesh got unveiled for earning revenue. At this stage the FD started to take steps to encourage ecotourism, primarily to earn revenue and at the same time to enhance the livelihoods of the

Sundarban dependent people living around Sundarban by providing training to enable them to be good tourist guides.

At Kotka and Kochikhali there are Forest Rest Houses wherein the general tourists are hardly allowed to stay overnight. Initially however, the tourists used to go to Kotka-Kochikhali (Sundarban East Game Sanctuary) area only, for 3 to 4 days on board motor launches. This is quite expensive. To bring down the costs of visits to Sundarban within the reach of common people, the FD developed a tourist spot at Koromjal during 2003 and another at Harbaria in 2005. These tourist spots can be visited in a day and can be reached very easily from Mongla port by motor boats at small expense. At present, every day hundreds of visitors flock to these tourist spots. Any visitor now can take a day's trip to Koromjal and/or Harbaria to get a firsthand sightseeing experience of the Sundarban. With the passage of time tourists are now interested to go to every possible spot within the Sundarban.

FD, having an inbuilt mind-set of earning revenue for the Government, stretched this window of tourism to enhance the revenue earnings. At present since the FD is allowing the visitors to go anywhere within the Sundarban, the tourists are intruding everywhere and anywhere within the Sundarban. Private companies have grown like mushrooms to facilitate Sundarban tourists. Some of the private entrepreneurs have started buying land adjoining the Northern boundary of the Sundarban and building cottage type guest houses to attract more and more tourists to the Sundarban. At present, on every holiday, hundreds of tourists are going to Kotka, Kochikhali areas, using loudspeakers all the time of their stay, landing here and there, abusing pristine locations in the name of picnic, throwing trashes all over and so on. The tourism industry has thus started intruding into the Sundarban. Uninterrupted continuation of such situation, very shortly, will pose a serious threat to the Sundarban ecosystems.

In the light of these problems it is worthwhile to mention that IUCN in one of its recent (2011) studies identified nine items as major threats to the Sundarban ecosystems, which are:

- Overexploitation of resources
- Extraction of poles for fixing fishing nets at every trip of fishing

- Top dying of Sundri
- Poaching
- Poison fishing
- Impact of alien invasive species
- Forest fire
- Tourism pollution and
- Poor regeneration

It can be seen that this list has "Tourism pollution" as one of the major threats to Sundarban ecosystems.

Ecotourism

The present day emphasis is not on "tourism" but on "ecotourism". In 1999, the International Ecotourism Society defined "Ecotourism" as "responsible travel to natural areas that conserves the environment and improves the well-being of local people". Ecotourism is a happy mix of conservation, communities, and sustainable travel. This means that those who implement and participate in ecotourism activities should follow the following ecotourism principles:

- Minimize impact.
- Build environmental and cultural awareness and respect.
- Provide positive experiences for both visitors and hosts.
- Provide direct financial benefits for conservation.
- Provide financial benefits and empowerment for local people.
- Raise sensitivity to host countries' political, environmental, and social climate.

In view of these the question is: are we on the right track?

Analyses of prevailing scenario

Though the tourists are visiting Sundarban officially for the purpose of recreation since 1987, the data on these are not easily available. The data about the number of tourists entering the Sundarban and the revenue earned thereby during the last 10 years are as follows:

Year	Number of tourists visited Sundarban	Revenue earned in lakh Taka
2000-2001	5150	0.95
2001-2002	59369	11.38
2002-2003	50595	17.41
2003-2004	48828	13.66
2004-2005	71202	21.86
2005-2006	94214	32.87
2006-2007	96002	29.66
2007-2008	85188	27.46
2008-2009	99427	44.20
2009-2010	116990	64.20
2010-2011	207930	86.22
Source: Forest Department, Government of Bangladesh		

Analyses of these data reveal the followings:
With the passage of time the number of visitors has increased. The different types of regressions tried, resulted R^2 as under.

Type of Regression	R^2
Linear	0.7668
Exponential	0.6253
Logarithmic	0.7766
Power	0.6256
Moving Average	0.6256

Of the above analyses, for the purpose of projections, the use of the linear trend will be most suitable. Projection over a long period will be erroneous. Thus attempts have been made herein to project the required for the year 2020. The linear equations have been used for the purpose of estimating the number of visitors and revenue per visitor in year 2020.

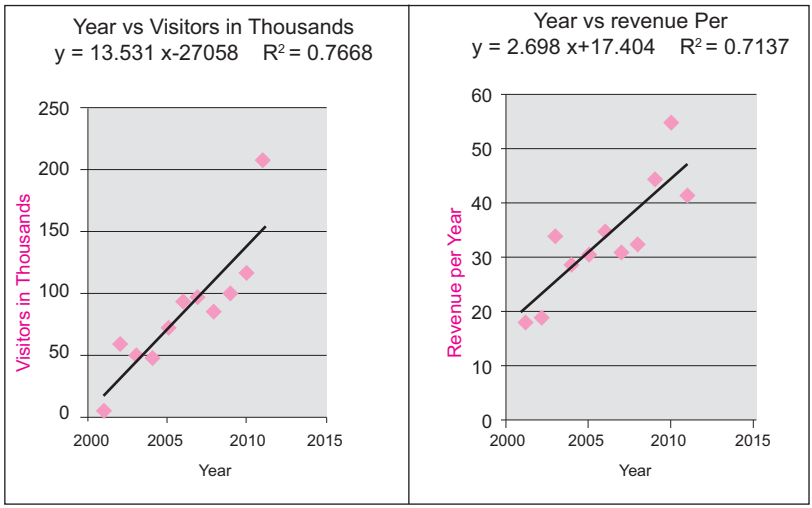
The graphic presentation of the data is as under.

Using equations; $y = 13.531x - 27058$ for estimating the number of visitors and $y=2.698x + 17.404$ for estimating the revenue per visitor. It is found that in year 2015 and in 2020 there will be 207000 and 275000 visitors respectively. The revenue per visitor in 2015 and 2020 will be Taka 35 and Taka 71 respectively. Since the revenue is realized on the basis of the citizenship of the visitor, such as local or

foreigner, and the equipment such as still camera, movie camera etc. that they carry, we have estimated the revenue per visitor as well. This will be the scenario if the existing trend prevails.

Discussion

In connection with the ecotourism in the Sundarban and its future it has to be borne in mind that the number of tourists per year needs to be kept within the carrying capacity of the area so that the ecosystem



is not jeopardized. The tourists at present are causing different types of pollution of which throwing of trashes all over, noise by using loud speakers, sound of the generator and lighting up all the night, etc. are the major ones. For the purpose of sustainability the following are urgently required.

The yearly carrying capacities of each of favourite sites should be assessed and limit the visitors at that level should be limited, may be on first come first serve basis. Advance sale of visitors' permits may be introduced.

The activities of the tourists must be strictly regulated to ensure "zero" pollution, especially with respect to trashes, sound and light.

The entry fee per tourist needs to be adjusted every year depending on spots to be visited and demand, to ensure the best possible revenue for the Government and at the same time enhance the facilities to the tourists.

At present there are no tourism rules or pollution control rules for the Sundarban Reserved Forests. It is learnt that the FD has initiated the process and a draft on this is waiting for its formalities at the office of the Chief Conservator of Forests. Framing of rules alone will be of no benefit unless these can be implemented properly. Proper implementation will require enhancing the number of FD staff and building their capacity.

Conclusion

It is high time that we took well throughout steps in this regard and as early as possible. Otherwise, tourism will ruin the pristine and beautiful ecosystems of the Sundarban.

REFERENCES

Aziz, M. A., I. U. Ahmad, T. K. Dey, A. Hossain, Md. Islam, Md. A. Islam, T. Child, C. J. Greenwood, A. C. D. Barlow. 2010. *Bangladesh Tiger Action Plan: Threat Assessment 2009-2017*. Bangladesh Forest

IUCN: 2011, Biodiversity conservation study.

Khan, M. M. H. 2011. T*igers in the mangroves: research and conservation of the tiger in the Sundarban of Bangladesh*. Arannayk Foundation, Dhaka, Bangladesh.

New Age, 2011. *Forest biodiversity: our common future* by Mohammed Abdul Baten and Muhammad Selim Hossain (30.05.2011).

Prain, D. 1903. *Flora of Sunarban*.

Ecotourism website: http://www.ecotourism.org/what-is-ecotourism

The Sundarban: A Tourist Paradise

The Bangladesh Sundarban is spread over Dakope, Paikgasa, Koira, Shyamnagar, Mongla, Morelganj, and Sharankhola in the district of Khulna, Bagerhat and Satkhira. Situated at the shores of the Bay of Bengal, the forest is surrounded by three rivers – the Hariabganga, the Raimangol and the Baleshwar in the west.

Bangladesh Sundarban covers about 4.2 per cent area of Bangladesh and accounts for 44 per cent of the total forest land of the country. It covers a total area of 6017 km^2 . The land area of the forest is 4143 km^2 (about 68.85 per cent of the Sundarban) when water covers an area of 1874 km^2 (31.15 per cent).

The reserved forest of the Sundarban is under the administration of the Khulna Circle of the Forest Department. The circle is divided

By **Gazi Munsur Aziz**

into two divisions – Sundarban West and Sundarban East having their offices in Khulna and Bagerhat respectively. The whole of the Sundarban is again divided into four ranges. Although the Sundarban covers an area of 6,01,700 hectares of land three wildlife sanctuaries have been declared covering 1,39, 698 hectares. On 6 December 1999 the UNESCO commission of the United Nations declared Nilkomol area of the Sundarban as the 522nd World Heritage Site. It covers 23 percent of the total forest area. The wildlife sanctuaries are the Sundarban east, west and south The distances of these places from Khulna by river are 65, 75 and 80 km respectively. Of these sanctuaries Katka, Kachikhali, Jamtala, Manderbaria, Harbaria, Nilkamol, Hiron Point, Dublar Char and Karamjal are places of interests and open to visitors.

Karamjal

This is the breeding centre for wild animals inside the Sundarban. The Sundarban east division of Forest Department created this breeding centre at the estuary of Karamjal canal. The breeding centre has separate breeding arrangements for crocodile, deer, monkey and other animals. Karamjal is 5 km from Mongla Port by river and it takes only 45 minutes to reach there. It is one of the major gateways to enter the Sundarban. Taka 10 is charged from each visitor at the entrance, a video camera can be carried paying an extra taka 100. Foreign tourists are to pay an entrance fee of taka 200 and an additional taka 200 is charged for carrying a video camera. The breeding centre provides opportunities to watch crocodiles and their babies. Deer and monkeys can be seen from a close distance. There is a museum that shows skeletons of Bengal Tiger, deer, heads and various eggs of crocodiles and specimen of different animals. There is a watch tower and a boardwalk through the forest that gives a great opportunity to walk in the forest.

Sometimes tigers roam around these places. Therefore, a fearless walk along the forest needs some support of the Forest Department. On paying a charge two armed guards can be hired to walk alongside the visitor. The restaurant at Karamjal offers tea, coffee and different kinds of food to the visitors. Permission of the Forest Department has to be obtained to enter into deep forest by smaller boat fitted with

an engine that is nothing but an improvised water pump extensively used in the country with a temporary roof or canopy or small launch. The department charges taka 1100 for each vehicle and provides two armed guards with the visitors. If one intends to visit Karamjal or travel inside the Sundarban one has to arrange a launch or engine fitted boat from Mongla Ferry Ghat. Such launches or canopied engine boats are always available at the Ghat. Taka 500 would be required to pay for the boat for a few hours journey. Some 20 to 25 people can travel together in such boats or launches. Even smaller launches are available to get inside the forest. Although Karamjal is a place worth seeing it does not have arrangements for comfortable stay at night. Pashur Motel at Mongla Ferry Ghat offers accommodation for night when smaller and shabby hotels might be available in the main Mongla Town.

Katka

It is an important place to visit. This sanctuary in the Sundarban east is 150 km away from Khulna city and 100 km from Mongla Port. This place offers rare opportunities to watch tigers and spotted deer. One can visit this place from Mongla and Khulna Forest Ghat on hired engine fitted boat, speed boat or launch. There is a watchtower here. The place is laden with birds. Katka has places to take rest but it does not have arrangements for overnight stay. However, if tourists have a big launch with forest department's armed escorts they can spend the night in the launch itself. This is once in a lifetime experience that no tourist should miss.

Kachikhali

In the eastern sanctuary of the Sundarban this tourist spot is 14 km east to Katka and very close to the shore. Visitors can see tiger, deer, crocodile, monitor lizards and many other animals. Many shorebirds can be observed in the mudflats and grasslands during winter. Visitors can take rest here but cannot stay overnight due to lack of facilities.

Jamtala

This sanctuary in the Sundarban east is nearer to Katka. Standing on the watchtower one can enjoy the scenic beauty of the forest from

: Gazi Munsur Aziz

different perspectives. It does not have arrangement for food and lodging.

Nilkamol or Hiron Point

This place of the sanctuary is to extreme south of the Sundarban. By river Hiron Point is 130 km from Khulna and 80 km from Mongla. Raj Gokhra snake, otter, spotted deer, and tiger may appear while you are on a visit to this spot. Facilities for night halt are not available.

Dublar Char

Another fascinating place Dublar Char is 25 km southwest form Katka and 35 km southeast from Nilkamol. This place is also called the fisherfolks' village or dried fish village. A good number of fisherfolks of the Sundarban live in this village and engage themselves in drying fish. Every year Rash Mela is organized on the full moon night in November. This fair is being organized for the last 200 years or so. The tradition and the fame of the fair draw thousands of tourists and pilgrims from home and abroad. Rash Mela runs for three consecutive days. It ends with pilgrims' bath in the sea on late hours of moonlit night. This place also lacks proper facilities for food and lodging.

Mandarbaria

In the western sanctuary of the Sundarban, Mandabaria is an isolated island at the southwest end of the forest. It is difficult to reach here from Khulna or Mongla. One can however reach here from Dublar Char or Nilkamol by launch or speedboat. Visitors are likely to see dolphin, King crab or Horseshoe Crab, and breeding places of different kinds of crab and tortoise. There is no arrangement for night halt.

The Sundarban Museum

This museum is at the main road of Mongla town. A local non government development worker Subash Biswas established this museum. He started collecting specimens for this museum from 1986. The museum has different kinds of photographs and specimens of wild and aquatic animals, trees, algae, orchid and many other articles of interest. It also accommodates specimens of tools and articles used by local people. Articles reflecting local and folk culture and tradition have found their places in this museum. It is open for all visitors.

How to reach the Sundarban

By road

Any visitor from Dhaka wishing to see the Sundarban must go either to Khulna or Mongla Ferry Ghat. Air conditioned and general bus services of transport companies like Sohag, Hanif, Eagle, and A K Travels ply from Motijheel, Arambagh, Shyamoli, Kallayanpur and Gabtoli to Khulna are available from morning to midnight. Air conditioned bus services charge from Tk. 1250 to Tk. 1500 while non air conditioned ones charge Tk. 480 to Tk. 580 for journey up to Khulna. Local busses are available for onward journey to Mongla. Bus fare from Khulna to Mongla is Tk. 40 to Tk. 50. Bus services specially Sundarban, Poarjatok, Banoful ply from Sayedabad to Khulna, Bagerhat and Mongla from morning to midnight and charge a fare of Tk 300 to 350. All these rates are subject to seasonal changes.

Contact phone

Sohagh Transport – 9344477. Eagle Transport – 7194212. Hanif Enterprise – 7194007.

Train

One can reach Khulna by train. Sundarban and Chitra Express trains leave Dhaka everyday at 7 am and 7 pm respectively. Train fair for chair coach is Tk 230. Contact phone : 9331822 Dhaka Railway information.

Air travel

One can fly from Dhaka to Jessore and take a bus ride up to Khulna and then take the local bus to Mongla. .Air fare is between Tk 5000 to Tk 5500. Contact phone : for Khulna 731020, 761020

Where to stay and dine

Khulna city offers a few standard hotels for room and board. They include Royal Hotel, Hotel Tiger Garden, and Hotel Castle Salam. For single room occupying hotels charge Tk 1500 and while for double bed occupying the charge is Tk 1600 to 3500.

Contact phones

Hotel Royal 721638-9; Hotel Castle Salam 730341; Hotel Tiger Garden 722246.

Tourists willing to stay at Bagerhat will find hotel accommodation at Bagerhat district headquarters. For overnight stay hotels will charge from Tk 200 to Tk 250.

Mongla offers comfortable accommodation for overnight stay in Motel Pashur of Bangladesh Parjatan Corporation. Here single/double accommodation costs Tk 650 to Tk 800. The motel has arrangement for food.

Contact phone

Motel Pashur, Mongla, Bagerhat 04662 75100 Tourists may like to stay at Hotel Singapore, Hotel Bangkok and some other hotels at Mongla town. These hotels will charge Tk 350 to 400 for twin beds in a room and Tk 280 to 300 for a single room accommodation.

Contact numbers for Parjatan Corporation: 8833229, 8834600

Package tour programme to the Sundarban: Bangladesh Parjatan Corporation and other private tour operators offer different packages to visit the Sundarban. Tourists may like to accept such offers for safe and comfortable visits to the Sundarban. A three to four day package tour will cost a tourist Tk 9000 to 10000.

Contact

Bangladesh Parjatan Corporation Headquarters, 83-88 Mohakhali Commercial Area, Dhaka. Phone : 8833229, 8834600.

Apart from such packages, tourists may like to form a team to visit the forest. Launch, engine fitted boat and speedboat will be available at Khulna or Mongla Ghat. Tourists may venture to hire these water transports and decide to visit Sundarban on their own. It will lessen the expenditures. On hired launch, engine boat or speedboat tourists may enter the Sundarban through the river Pashur. Then they can obtain permission to enter into forest from Dhangmari or Chandpai range of the forest department. The department will charge an entrance fee of Tk 50 plus VAT per person per day. But foreigners would be required to pay Tk 750 plus VAT.

Sundarban at a Glance

The Sundarban is important both from ecological and economic perspectives. The importance of the Sundarban is associated with its rich biodiversity and ecosystem production and service functions. The government and non-government organizations have carried out quite a number of survey and research and implementation projects in the area, but whatever information is available are mostly on higher plants as lower group of plants has been neglected. Information on the composition of flora and fauna, occurrence and distribution of species occur only in sporadic literature. The fauna has been studied by a reconnaissance survey. Detailed surveys on the population status of animals have seldom been carried out. Most of the researchers' focus was on mammals, birds and reptiles. Recently there have been

By **Shimanto Dipu**

some studies on fish. Little information however is available on the planktons that lie at the base of the food chain for wide range of aquatic fauna of economic importance. The service values and ecosystem functions had not received due attention. Productive roles of biodiversity and ecosystem functions of Sundarban ecosystems are linked with livelihoods of local people that ultimately influence the political economy of the local landscape although the functions of this complex ecosystem are less understood (IUCN,2012).

Total Area

6,000 square kilometres.

Species Diversity

334 plants, 24 shrimp, 250 fish, 14 amphibians, 87 reptiles, 356 birds and 49 mammals, 34 algae, 7 crabs, 16 Lichens, 1 Bryophyta, 21 Pteridophyta, 122 Angiosperms, 5 Cyanobacteria, 43 Fungi, 237 Ichthyo fauna, 38 Crustacean fauna, 34 Molluscan fauna, 240 Insects.

Forest Types

Tidal swamp forests, Saline water type mixed forests, brackish water type mixed forests palm swamp type.

Floral Status

There are 334 plant species in Sundarban and they have the capacity to with stand estuarine conditions and saline inundation on account of tidal effects. *Excoecaria* sp., *Heritiera* sp., *Ceriops* sp., *Phoenix* sp., *Sonneratia* sp., *Avicennia* sp., *Rhizophora* sp., *Xylocarpus* sp., *Bruguiera* sp. etc are the main major floral elements.

Faunal Status

There are about 506 species of wildlife found in Sundarban. The Main Species are Bengal Tiger, Estuarian Crocodile, River Terrapin (*Batagur baska*), Olive Ridley Turtle, Gangetic Dolphin, King Crabs (Horse shoe), Fishing cat, Spotted Deer, Wild boar, Water Monitor, Masked Finfoot, etc.

Man-Animal Conflict

Occasional killing and eating of human beings inside Sundarban sometimes become problematic. This happens when tigers attack villagers entering the forest or by when tigers stray into human habitations and attack people.

History of Sundarban

The Sundarban is the name given to a beautiful forest or a forest in which the Sundari tree (Heritiera fomes) grows. At the early stages of the history of the area, the entire Bengal basin was submerged under the sea and sedimentation from the Ganges-Brahmaputra river systems created a landmass, which is today's Bengal Delta. The first Sundari trees presumably first took root below the Rajmahal Hills, establishing the northern extent of the Sundarban in history.

Early History

The Sundarban, as we know it today, has a fairly recent history. Much of the present tidal delta only stabilized as late as 5^{th} – 7^{th} century AD. When India collided and penetrated into the Eurasian plate in the middle Eocene, all of what later became the largest delta in the world, covering 65,000 km^2, lay below sea level. The formation of the lower delta plain started during the middle Holocene and most of the presently occupied area of 10,017 km^2 in India and Bangladesh was formed over the course of the last 6,000 years.

First inhabitants

The Bengal Delta was originally occupied by vast stretches of grassland filled with saline marshes and tropical wetlands containing one of the worlds' largest stretches of biodiversity-rich forests – the Bengalian Rainforest. These forests were one of the richest wildlife areas of the world, holding elephants, tiger, gaur, leopards, wild buffaloes, three species of rhinoceros, seven species of deer and a wide variety of other fauna.

The first human settlers, who may have been the 'Veddoids', appear to have arrived in the delta by 5^{th} Century BC, though the first archeological evidence of human civilization dates to around 400-300 BC.

Civilization flourished in the delta during the reign of Asoka (273-232 BC) and in subsequent Hindu periods. The indigenous inhabitants were the 'Pods' and the 'Chandals' who were fishing tribes. The process of human settlement continued unabated till the11^{th} century, when shifting river channels and epidemics seemed to have forced settlers to abandon the area for a while.

Sultanate years

Post 1200 AD, and beginning with the reign of the Bengal sultanate (1204-1575), the history of the Sundarban is one of continuous conversion of forest tracts to wet-rice cultivation under the influence of pioneers professing an Islamic Sufi identity. By the mid-fifteenth century, the reclamation process had brought the southern extent of cultivation to the edges of south Jessore and northern Khulna.

Mughal years

The process of bringing virgin forest under cultivation continued unabated in the Mughal era (1575-1765). During this time the Ganges changed course from the original Hugli channel to combine upstream with the Brahmaputra. As a result, most parts of the 24 Parganas Sundarban faced increased salinity and this gradually affected the flora and fauna of the area. The era also witnessed devastating cyclones, like the one in 1584, which is reported to have claimed about 2,000,000 living creatures.

At the end of the mogul rule, settlers had successfully pushed back the northern boundaries of the Sundarban forests to the very edges of Kolkata.

British era

The British East India Company set up their headquarters at Calcutta in 1757 at the edge of the Sundarban. The forests at that time stretched uninterrupted for 19,200 km^2 and retained much of their splendor and diversity.

British rule started in India in 1765 and over the next century the British Government would relentlessly pursue a policy of deforestation and extension of cultivation in the Sundarban.

In 1928 the British Government assumed proprietary rights to the forest and, in 1830, began leasing out tracts of the forests for reclamation – a process which continued until 1875-76. This period saw a great decline in the diversity of large mammals. Increasing regular revenues from the so-called Sundarban 'waste land' was the main inspiration behind the all out attack on the forests which were 'covered over with impenetrable forests, the hideous den of all descriptions of beasts and reptiles'.

Conservation steps

The first call to preserve the forests was made by Dr. Brandis, the Conservator of Forests in Burma 1862. Based on his recommendations, additional reclamation grants were stopped, but deforestation continued, irrespective. By 1873, 5,100 km^2 of forests had been converted into agricultural land and the Sundarban area forest cover had been effectively reduced to about 14,100 km^2.

It is only post 1873-1874, when faced with dwindling forest produce, the rulers started reviewing the policy of transformation of all available wetland forest to taxable agricultural land in the Sundarban. The economics of exploitation had changed in the last century and forest produce had become scarce and more valuable than agricultural produce. No longer was it considered profitable to clear the forests for cultivation as much greater revenues could be collected from farming the forest itself.

In 1875-1876 the government declared un-leased forest reserved, and placed them under the jurisdiction of the Forest Department– a move which created today's Sundarban forest.

A variety of wildlife still survived till the latter part of the 19th century despite the rapid depletion of habitat. Hunter records "Tigers, leopards, rhinoceros, wild buffaloes, wild hogs, wild cats, barasinga, spotted deer, hog deer, barking deer, and monkeys are the principal varieties of wild animals found in Sundarban" in 1875. But the events of the next few decades led to the near complete destruction of the grasslands and rainforests, which coupled with the increase in salinity spelt the death knell for the Javan rhinoceros, leopard, wild buffalo, swamp deer and hog deer – all of which were either teetering at the brink of extinction or were lost forever from the Sundarban by the turn of the century. The tiger, wild pig and spotted deer survived the mass species extinction because they had learned to adapt to a life in the deep tidally active mangrove forests spread. This was land unfit for cultivation and difficult to access and exploit.

Encroachments continued despite reservation and 1,200 km^2 of the protected forest were deforested over a ten-year period ending

in 1903-04. The 'Lloyd Plan' and the 'working plan' of Mr. Heinig covering the period 1903-04 to 1907-08 were the basis of forest administration until 1913. But these steps did not reverse or reduce reclamation.

The first real conservation step in the Sundarban was taken with the implementation of Trafford's working plan which was drawn up in 1911 and was in effect for two decades 1912-13 to 1931-32. No land lease was allowed and the whole forest was declared as Reserve Forest. In 1926, boundaries of the remaining forest were fixed.

But this was too little too late. The nature and extent of the Sundarban forest area and the mix of its fauna had changed forever by then. What was left for the wildlife of the Sundarban were island based tidal forests towards the south of the Sundarban – a habitat not suitable for sweet water dependent grazers like wild buffalo, rhino, swamp deer. They were simply pushed over the edge and into extinction. Overall, during the course of a century from 1880 to 1980, about 8,270 km^2 of wetlands, and woodlands were lost forever in the Sundarban.

From the early 30's of the 20^{th} century, the Sundarban forests were managed using Curtis's working plan which focused on scientific harvesting. This plan was in effect when partition divided the administration of the Sundarban between East Pakistan (now, Bangladesh) and India. Both countries continued to protect the area after independence.

Post independence

Bangladesh's economic dependence on the revenues from the Sundarban and the ability of their forests to regenerate swiftly meant that they could continue with a policy of harvesting the produce. The Indian forests in the 24 Parganas by then had been seriously denuded by years of felling and the lack of adequate fresh water. India was also not dependent on the revenues from the produce of the Sundarban and as a result commercial felling reduced and even completely stopped in many parts of the forest. However, the pressure of humanity had its last say on the Indian Sundarban in 1963 and 1973 when refugees from East Pakistan (and Bangladesh)

were allowed to clear reserve forests for agriculture and settle in areas like Jharkhali and Herobhanga islands.

In 1973, management of a large portion of the Indian Sundarban was passed on to Sundarban Tiger Reserve, which was established in 1973 under "Project Tiger. At the same time, the management of Bangladesh Sundarban began to be regulated under the provisions of Bangladesh Wildlife (Preservation) Order, 1973.

In the last 25 years India consolidated its share of the residual 4,265 km^2 of natural mangrove forests of the Sundarban through a series of initiatives. In 1977, it declared Sundarban a Wildlife Sanctuary and elevated parts of it to the status of a National Park on 4th May 1984. UNESCO inscribed the Indian Sundarban on the World Heritage List in 1987 and the entire Indian Sundarban area was recognized by UNESCO as a Global Biosphere Reserve in 2001.

Salinity of Sundarban

Salinity is a single most important problem in the Sundarban and its impact area (Miah and Bari 2001). SRDI (1997) reported that, soil salinity levels in south of Khulna and Bagerhat towns ranged between 8 to 15 dS/m during the low flow season. Some non-saline zones in southern Sundarban like Kachua, Mollahat and Fultali began to increase in salinity levels after the post-Farakka barrage period and it observed the low flow regimes in dry seasons from 1980s (Agrawala *et al*., 2003). Upstream fresh water reduction and saline water intrusion in shrimp farms are seen to be responsible for increases of salinity. It is also linked with climate change. In addition of sea level rise reduced fresh water flow will increase salinity level of Sundarban (Agrawala *et al*., 2003).

Cyclone

During the last 135 years, more than 45 cyclones have crossed the coastal belt of Bangladesh, of which 13 have passed through the Sundarban. In last 10 years, several cyclones have crossed through the Sundarban; the most devastating one,cyclone Sidr occurred on 15 November 2007 during the night. The velocity of the wind was 220 to 240 kilometers/hour. More than 3,000 people died and thousands injured. Nearly 20,000 families and 90,000 people were affected by *Sidr* and damage to property, houses and crop was enormous.. The

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other important cyclone was *Aila* that occurred on 25 May 2009, mainly in the western part of the Sundarban. The saline water entered into a large area, damaging crops and shrimp/fish farms.

Hydrology

The hydrology of the Sundarban is quite complex and is dominated by the freshwater flows from the Ganga, Brahmaputra and Meghna rivers, which exhibit very high seasonal variation in their discharge, and tides which range from 2m to 5.94 m high. Tidal influence extends to more than 50 km inland from the shoreline and surges increase considerably during the cyclonic storms. A total of 14.45 sq.km land was accreted and 74.73 sq. km. land was eroded in the Sundarban from 1972 to 1991 (Planning Commission 1993).

Annex 1: Checklist of Fauna

Status Code

V – Very Common
C – Common,
U – Uncommon, and
R – Rare;
CR – Critically Endangered globally
EN – Endangered globally, and
VU – Vulnerable globally;
r – Resident (breeds in Bangladesh)
w – Winter Migrant (does not breed in Bangladesh)
s – Summer Migrant (breeds in Bangladesh), and
v – Vagrant (does not normally breed in Bangladesh)

Table 1: Status and distribution of mammals (Phylum: Chordata, Class: Mammalia) in the Sundarban

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
	Order: Rodentia **Family: Sciuridae**			
1	*Callosciurus pygerythrus*	Hoary-bellied or Irrawaddy Squirrel	Badami Kathbirali,	C (VU) (Does not occur in the Indian Sundarban)
	Family: Muridae			
2	*Bandicota bengalensis*	Lesser Bandicoot-Rat	Dhari/Baro Idur	V
3	*Bandicota indica*	Greater Bandicoot-Rat	Dhari/Baro Idur	V

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
	Musc musculus	House Mouse	Nengti Idur	V
4	*Nesokia indica*	Short-tailed Bandicoot-Rat	-	R?
5	*Rattus norvegicus*	Brown Rat	-	R?
6	*Rattus rattus*	House Rat	Idur	V
7	*Vandeleuria oleracea*	Asiatic Long-tailed Climbing Mouse	Gecho Idur	V
	Family: Hystricidae			
8	*Hystrix indica*	Indian Crested Porcupine	Shojaru	R
	Order: Carnivora **Family: Viverridae**			
9	*Paradoxurus hermaphrodites*	Asian Palm Civet	Gandhagakul or Nongar	C
10	*Viverra zibetha*	Large Indian Civet	Baro Bagdash, Huicha, Wiamphoi (Ma)	C
11	*Viverricula indica*	Small Indian Civet	Chhoto Bagdash	C
	Family: Felidae			
12	*Prionailurus bengalensis*	Leopard Cat	Chita Biral	U
13	*Felis chaus*	Jungle Cat	Ban Biral	V
14	*Prionailurus bengalensis*	Fishing Cat	Mecho Biral	C (VU)
15	*Panthera tigris*	Tiger	Bagh	R (EN)
	Family: Herpestidae			
16	*Herpestes auropunctatus*	Small Indian Mongoose	Choto Benji or Nakul	V
17	*Herpestes edwardsii*	Indian Gray Mongoose	Baro Benji	C
	Family: Canidae			
18	*Canis aureus*	Golden Jackal	Shial	V
	Family: Mustelidae			
19	*Amblonyx cinereus*	Oriental Small-clawed Otter	Dhaira Ud, Ud Biral or Bhodor	C
	Order: Soricomorpha **Family: Soricidae**			
20	*Suncus murinus*	Asian House Shrew	Chika, Chhunchey	V
	Order: Chiroptera **Family: Pteropodidae**			
21	*Cynopterus sphinx*	Greater Short-nosed Fruit Bat	Kola Badur	V
22	*Pteropus giganteus*	Indian Flying Fox	Baro Badur	V
23	*Rousettus leschenaultii*	Leschenault's Rousette	Chhoto Kola Badur	V
	Family: Emballonuridae			
24	*Saccolaimus saccolaimus*	Naked-rumped Pouched Bat	-	U
25	*Taphozous longimanus*	Long-winged Tomb Bat	-	U

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Sl No	Taxon and Scientific Name	English Name	Local Name	Status
26	*Taphozous melanopogon*	Black-bearded Tomb Bat	Dariwala BChamchika	U
	Family: Rhinopomatidae			
27	*Rhinopoma hardwickei*	Lesser Mouse-tailed Bat	Idur-leji Chamchika	R?
	Family: Megadermatidae			
28	*Megaderma lyra*	Greater False Vampire Bat	Boro Daini Chamchika	C
	Family: Rhinolophidae			
29	*Coelops frithi*	East Asian Tailless Leaf-nosed Bat	Lejhin Chamchika	U
30	*Hipposideros galeritus*	Cantor's Roundleaf Bat	Patanak Badur	U
31	*Rhinolophus lepidus*	Blyth's Horseshoe Bat	Ghorakhurakriti Chamchika	U
	Family: Molossidae			
32	*Tadarida aegyptiaca*	Egyptian Free-tailed Bat	Lombaleji Chamchika	R?
	Family: Vespertilionidae			
33	*Hesperoptenus tickelli*	Tickell's False Serotine	Tikeler Chamchika	C
34	*Kerivoula papillosa*	Papillose Woolly Bat	Ul-dehi Chamchika	R?
35	*Kerivoula picta*	Painted Bat	Rongila Chamchika	R?
36	*Pipistrellus ceylonicus*	Kelaart's Pipistrelle	Kelerter Chamchika	R
37	*Pipistrellus coromandra*	Indian Pipistrelle	Chamchika	V
38	*Pipistrellus dormeri*	Dormer's Pipistrelle	Dormarer Chamchika	R?
39	*Pipistrellus tenuis*	Least Pipistrelle	Lister Chamchika	U
40	*Scotophilus heathi*	Greater Asiatic Yellow Bat	Bora Holdey Chamchika	R
41	*Scotophilus kuhlii*	Lesser Asiatic Yellow Bat	Chhoto Holdey Chamchika	R
	Order: Primates **Family: Cercopithecidae**			
42	*Macaca mulatta*	Rhesus Macaque	Banor	V
	Order: Cetartiodactyla (Cetacea) **Family: Platanistidae**			
43	*Platanista gangetica*	Ganges River Dolphin	Shushuk/Shishu, Hucchum	V (EN)

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
	Family: Phocoenidae			
44	*Neophocaena phocaenoides*	Finless Porpoise	Pakhnahin Shishu	U
	Family: Delphinidae			
45	*Tursiops truncatus*	Common Bottle-nosed Dolphin	Botolnak Shishu	V
	Family: Monodontidae			
46	*Orcaella brevirostris*	Irrawaddy Dolphin	Mohonar Shushuk / Iraboti Shishu	V
	Order: Artiodactyla **Family: Suidae**			
47	*Sus scrofa*	Wild Boar	Buno Shukar	C
	Family: Cervidae			
48	*Axis axis*	Chital	Chitra Harin	C
49	*Muntiacus muntjak*	Barking Deer	Maya/Ruru Harin	C (Does not occur in the Indian Sundarban)

Source: Hussain and Acharya (1994), Khan (1986, 2010), Khan (2005) , Sahgal et al. (2007) and Biodiversity Conservation plan for Sundarban, IUCN(2012)

Table 2: Status and distribution of the Birds (Phylum: Chordata, Class: Aves) in the Sundarban

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
	Order: Galliformes **Family: Phasianidae**			
1	*Coturnix chinensis*	Blue-breasted Quail	Cheena Boter	R, r
2	*Gallus gallus*	Red Junglefowl	Bon Morog/ Murgi	V, r
	Order: Anseriformes **Family: Dendrocygnidae**			
3	*Dendrocygna bicolor*	Fulvous Whistling-duck	Baro Sarali	C, r
4	*Dendrocygna javanica*	Lesser Whistling-duck	Choto Sarali Hans	V, r
	Family: Anatidae			
5	*Anas acuta*	Northern Pintail	Lenja Hans	V, w
6	*Anas clypeata*	Northern Shoveler	Pantamukhi Hans	V, w
7	*Anas crecca*	Common Teal	Patari/Peri Hans	V, w
8	*Anas Penelope*	Eurasian Wigeon	Lalshir	V, w
9	*Anas platyrhynchos*	Mallard	Nilshir Hans	C, w

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Sl No	Taxon and Scientific Name	English Name	Local Name	Status
10	*Anas poecilorhyncha*	Spot-billed Duck	Pati/Metey Hans	V, r
11	*Anas querquedula*	Garganey	Narkeli/t/Giria/ Hans	V, w
12	*Anas strepera*	Gadwall	Piong Hans	V, w
13	*Anser anser*	Graeylag Goose	Rajhans	U, w
14	*Anser indicus*	Bar-headed Goose	Shir-dora Rajhans	U, w
15	*Aythya baeri*	Baer's Pochard	Boro Bhuti Hans	U? (VU), w
16	*Aythya ferina*	Common Pochard	Bamunia Hans	C, w
17	*Aythya fuligula*	Tufted Duck	Kalo Hans	V, w
18	*Aythya nyroca*	Ferruginous Pochard	Bhuti Hans	C, w
19	*Netta rufina*	Red-crested Pochard	Moulvi/ Rangamuri Hans	C, w
20	*Nettapus coromandelianus*	Cotton Pygmy-goose	Bejori/Bali/ Alakadra Hans, Bherar Dhosh, Re Ba (Ma)	C, r
21	*Tadorna ferruginea*	Ruddy Shelduck	Chokha Chokhi	V, w
22	*Tadorna tadorna*	Common Shelduck	Shah Chokha/ Shachka	V, w
23	*Sarkidiornis melanotos*	Comb Duck	Nakta Hash	R, w
	Order: Turniciformes Family: Turnicidae			
24	*Turnix suscitator*	Barred Buttonquail	Sadharan Lawa, Gulu, Nagor Batoi	C, r
	Order: Piciformes Family: Picidae			
25	*Micropternus brachyurus*	Rufous Woodpecker	Lal Kaththokra	V, r
26	*Chrysocolaptes lucidus*	Greater Flameback	Brihodakar Sonalipith Kaththokra	V, r
27	*Dendrocopos canicapillus*	Grey-capped Pygmy Woodpecker	Choto Kaththokra, Duanthelak (G)	V, r
28	*Dendrocopos macei*	Fulvous-breasted Woodpecker	Jarad Kaththokra	V, r
29	*Dinopium benghalense*	Black-rumped Flameback	Sonali Kaththokra/ Kathkhutalu/ Kurailla,	V, r
30	*Dinopium javanense*	Common Flameback	Bormi Kaththokra	U, r
31	*Jynx torquilla*	Eurasian Wryneck	Metho Kaththokra	C, w

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
32	*Picumnus innominatus*	Speckled Piculet	Khudey Kaththokra	R, r
33	*Picus canus*	Gray-headed Woodpecker	Sabuj Kaththokra	U, r
34	*Picus chlorolophus*	Lesser Yellownape	Haludgharwala Kaththokra	U, r
35	*Picus flavinucha*	Greater Yellownape	Haludgola Kaththokra	V, r
36	*Picus viridanus*	Streak-breasted Woodpecker	Dora-book Sabuj Kaththokra	U, r
37	*Picus xanthopygaeus*	Streak-throated Woodpecker	Dora-gola Sabuj Kaththokra	R?, r
	Family: Megalaimidae			
38	*Megalaima asiatica*	Blue-throated Barbet	Bora Basnat Bouri or Dhonia/ Beghbou Basantabouri,	V, r
39	*Megalaima haemacephala*	Coppersmith Barbet	Choto Basantabouri/	V, r
40	*Megalaima lineata*	Lineated Barbet	Baro/Gorkhod/ Beghbou	V, r
	Order: Upupiformes **Family: Upupidae**			
41	*Upupa epops*	Common Hoopoe	Hudhud	V, w
	Order: Coraciiformes **Family: Coraciidae**			
42	*Coracias benghalensis*	Indian Roller	Nilkantha	V, r
43	*Eurystomus orientalis*	Dollarbird	Pahari Nilkantha	R, v
	Family: Alcedinidae			
44	*Alcedo atthis*	Common Kingfisher	Chhoto Machhranga	V, r
45	*Alcedo meninting*	Blue-eared Kingfisher	Nilva-kan Chhoto Machhranga	U, r
	Family: Halcyonidae			
46	*Halcyon pileata*	Black-capped Kingfisher	Mathakalo Machhranga	V, w
47	*Halcyon smyrnensis*	White-throated Kingfisher	Sadabuk Machhranga,	V, r
48	*Pelargopsis amauroptera*	Brown-winged Kingfisher	Badami or Thormochra Machhranga	C, r
49	*Pelargopsis coromanda*	Ruddy Kingfisher	Lal Machhranga	U, r

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Sl No	Taxon and Scientific Name	English Name	Local Name	Status
50	*Todiramphus chloris*	Collared Kingfisher	Sabujav Machhranga	V, r
	Family: Cerylidae			
51	*Ceryle rudis*	Pied Kingfisher	Pakhra Machhranga	C, r
	Family: Meropidae			
52	*Merops leschenaulti*	Chestnut-headed Bee-eater	Patkilematha Suichora	V, r
53	*Merops orientalis*	Green Bee-eater	Suichora, Banshpati	V, r
54	*Merops philippinus*	Blue-tailed Bee-eater	Nil-lej Suichora	V, s
	Order: Cuculiformes **Family: Cuculidae**			
55	*Cacomantis merulinus*	Plaintive Cuckoo	Sorgom	V, r
56	*Cacomantis passerinus*	Grey-bellied Cuckoo	Metepet Papia	R, s
57	*Clamator coromandus*	Chestnut-winged Cuckoo	Lalpakha Kokil	U, v
58	*Clamator jacobinus*	Pied Cuckoo	Papiya	V, s
59	*Cuculus canorus*	Eurasian Cuckoo	Gaiyak Kokil	U, v
60	*Cuculus micropterus*	Indian Cuckoo	Bou-kotha-kou	V, s
61	*Cuculus saturatus*	Oriental Cuckoo	-	R, v
62	*Eudynamys scolopacea*	Asian Koel	Kokil, Kalo Kokil	V, r
63	*Hierococcyx varius*	Common Hawk Cuckoo	Chokhgelo, Darji Akha (G)	V, r
64	*Phaenicophaeus tristis*	Green-billed Malkoha	Sabuj kokil or Ban Kokil	C, r
	Family: Centropodidae			
65	*Centropus sinensis*	Greater Coucal	Kankua or Baro Kanakukka	V, r
	Order: Psittaciformes **Family: Psittacidae**			
66	*Psittacula krameri*	Rose-ringed Parakeet	Tia	V, r
67	*Psittacula roseata*	Blossom-headed Parakeet	Lalmatha Tia or Hiramon Koiridi Teya	R, r
	Order: Apodiformes **Family: Apodidae**			
68	*Apus affinis*	House Swift	Ababil,Batashi	V, r
69	*Cypsiurus balasiensis*	Asian Palm Swift	Talchata, Talchorai	V, r
	Order: Strigiformes **Family: Tytonidae**			
70	*Tyto alba*	Barn Owl	Laxmi Pencha	V, r

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
	Family: Strigidae			
71	*Asio flammeus*	Short-eared Owl	Bhramankari Pencha	R, w
72	*Athene brama*	Spotted Owlet	Khuruley Pencha/Kutorey Pencha	V, r
73	*Bubo coromandus*	Dusky Eagle Owl	Bhooma Pencha	R, r
74	*Ketupa ketupu*	Buffy Fish Owl	Badami Bhutum Pencha	U, r
75	*Ketupa zeylonensis*	Brown Fish Owl	Bhutum / Hutum/Kudum Pencha	C, r
76	*Ninox scutulata*	Brown Hawk Owl	Ku/Kal Pencha, Ku-pokh	V, r
77	*Otus bakkamoena*	Collared Scops Owl	Nim Pencha, Nim-pokh	C, r
78	*Otus sunia*	Oriental Scops Owl	Kalo-dagwala Nim-pokh	U, r
79	*Strix leptogrammica*	Brown Wood Owl	Boner Bora Pencha Duang (G)	R, r
	Family: Caprimulgidae			
80	*Caprimulgus asiaticus*	Indian Nightjar	Desi Ratchora	R?, r
81	*Caprimulgus macrurus*	Large-tailed Nightjar	Banshkopani Ratchora/ Dinkana	V, r
	Order: Columbiformes Family: Columbidae			
82	*Chalcophaps indica*	Emerald Dove	Sabuj/Bansh/ Ghughu	V, r
83	*Columba livia*	Rock Pigeon	Jalali/Jongla Kobutar	V, r
84	*Streptopelia chinensis*	Spotted Dove	Tila Ghughu	V, r
85	*Streptopelia decaocto*	Eurasian Collared Dove	Raj Ghughu, Dhobal or-	C, r
86	*Streptopelia orientalis*	Oriental Turtle Dove	Ram Ghughu	U, r
87	*Streptopelia tranquebarica*	Red Collared Dove	Lalchey Ghughu/Jongla Ghughu	V, r
88	*Treron bicincta*	Orange-breasted Green Pigeon	Komolabook Horial/ Harikol	C, r
89	*Treron phoenicoptera*	Yellow-footed Green Pigeon	Botkol/ Haludpa Horial	V, r
90	*Treron pompadora*	Pompadour Green Pigeon	Choto Harial, Mouwa	R, r

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Sl No	Taxon and Scientific Name	English Name	Local Name	Status
	Order: Gruiformes **Family: Gruidae**			
	Family: Heliornithidae			
91	*Heliopais personata*	Masked Finfoot	Golboner/Baila Hans	U (EN), r
	Family: Rallidae			
92	*Amaurornis phoenicurus*	White-breasted Waterhen	Dahuk	V, r
93	*Fulica atra*	Common Coot	Kaalo Koot	V, w
94	*Gallicrex cinerea*	Watercock	Kora, Bon Kora	C, r
95	*Gallinula chloropus*	Common Moorhen	Jolmurgi	V, r
96	*Gallirallus striatus*	Slaty-breasted Rail	Khemir, Kheni	U, r
97	*Porphyrio porphyrio*	Purple Swamphen	Kalim, Kaiem	V, r
98	*Porzana fusca*	Ruddy-breasted Crake	Ranga Ulti, Boidor, Pitha Kag	U, r
99	*Rallina eurizonoides*	Slaty-legged Crake	-	R?, w
	Order: Ciconiiformes **Family: Scolopacidae**			
100	*Actitis hypoleucos*	Common Sandpiper	Cha Pakhi	V, w
101	*Arenaria interpres*	Ruddy Turnstone	Pati Lal pa	C, w
102	*Calidris alba*	Sanderling	Balubelar Chapakhi	C, w
103	*Calidris alpina*	Dunlin	Bankathont Chapakhi	R, v
104	*Calidris canutus*	Red Knot	Lalchey Chapakhi	R, v
105	*Calidris ferruginea*	Curlew Sandpiper	Gulindathonti Chapakhi	C, w
106	*Calidris minuta*	Little Stint	Bamon Chapakhi	C, w
107	*Calidris ruficollis*	Red-necked Stint	Lalcheygharwala Chapakhi	V, w
108	*Calidris temminckii*	Temminck's Stint	Teminker Chapakhi	U, w
109	*Calidris tenuirostris*	Great Knot	Bora Chapakhi	U, w
110	*Gallinago gallinago*	Common Snipe	Metey Chaga, Kadakhucha	V, w
111	*Gallinago megala*	Swinhoe's Snipe	Ban Chaha	C, w
112	*Gallinago stenura*	Pintail Snipe	Chaga, Kadakhucha	V, w
113	*Limicola falcinellus*	Broad-billed Sandpiper	Kadakhucha/ Chaga/ Chegga	U, w
114	*Limnodromus semipalmatus*	Asian Dowitcher	Lomba-thont Chaha	R, w

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
115	*Limosa lapponica*	Bar-tailed Godwit	Kalo-lej Jourali	R, w
116	*Limosa limosa*	Black-tailed Godwit	Dora-lej Jourali	V, w
117	*Numenius arquata*	Eurasian Curlew	Baro Gulinda	V, w
118	*Numenius phaeopus*	Whimbrel	Choto Gulinda	V, w
119	*Tringa nebularia*	Common Greenshank	Sabujpa Pi-oo/ Gothra	V, w
120	*Tringa ochropus*	Green Sandpiper	Sabujavo Chapakhi	C, w
121	*Tringa stagnatilis*	Marsh Sandpiper	Jalar Chapakhi/ Chhoto Gothra	V, w
122	*Tringa totanus*	Common Redshank	Lal-pa Pi-oo	V, w
123	*Tringa glareola*	Wood Sandpiper	Tila Chapakhi	V, w
124	*Xenus cinereus*	Terek Sandpiper	Ulttothonti Chapakhi	U, w
125	*Calidris pygmeus*	Spoon billed Sandpiper	Chamuch Thuto Batan	CR,w
	Family: Rostratulidae			
126	*Rostratula benghalensis*	Greater Painted-snipe	Rongila/Chaga	C, r
	Family: Jacanidae			
127	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	Jol Moyur/Neo	C, r
128	*Metopidius indicus*	Bronze-winged Jacana	Jolpipi, DolPipi	V, r
	Family: Burhinidae			
129	*Esacus recurvirostris*	Great Thick-knee	Bora Shila Batan	U, r
	Family: Charadriidae			
130	*Charadrius alexandrinus*	Kentish Plover	Jiria	R, w
131	*Charadrius dubius*	Little Ringed Plover	Choto Jiria	V, r/m
132	*Charadrius hiaticula*	Common Ringed Plover	Kalo-book Jiria	R, v
133	*Charadrius leschenaultii*	Greater Sand Plover	Balu Batan	C, w
134	*Charadrius mongolus*	Lesser Sand Plover	Majhari Batan	V, w
135	*Haematopus ostralegus*	Eurasian Oystercatcher	Shamukbhoji Batan	R?, w
136	*Himantopus himantopus*	Black-winged Stilt	Kala Pa thengi	U, w
137	*Pluvialis fulva*	Pacific Golden Plover	Batan/Sona Batan	V, w
138	*Pluvialis squatarola*	Gray Plover	Bara Batan	C, w
139	*Recurvirostra avosetta*	Pied Avocet	Khowaz	R, w
140	*Vanellus cinereus*	Grey-headed Lapwing	Dhushar-matha	C, w
141	*Vanellus indicus*	Red-wattled Lapwing	Lal Pa titi	V, r
	Family: Glareolidae			
142	*Glareola lacteal*	Small Pratincole	Balu Batan	C, r
143	*Glareola maldivarum*	Oriental Pratincole	Udoyee Batan	R?, v
	Family: Laridae			

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Sl No	Taxon and Scientific Name	English Name	Local Name	Status
144	*Chlidonias hybridus*	Whiskered Tern	Phokdahori Gangchil	V, w
145	*Larus brunnicephalus*	Brown-headed Gull	Badami matha ganchil	V, w
146	*Larus cachinnans*	Yellow-legged Gull	Holud pa ganchil	U, w
147	*Larus heuglini*	Heuglin's Gull	Heuglin ar Ganchil	C, w
148	*Larus ichthyaetus*	Pallas's Gull	Palasi ganchil	C, w
149	*Larus ridibundus*	Black-headed Gull	Kalamatha Ganchil	C, w
150	*Stercorarius parasiticus*	Parasitic Jaeger	Porojibi Jigar	R, v
151	*Sterna albifrons*	Little Tern	Pati Panchil	V, r/m
152	*Sterna bengalensis*	Lesser Crested Tern	Choto Jhuti Panchil	U, w
153	*Sterna bergii*	Great Crested Tern	Boro Jhuti Panchil	U, w
154	*Sterna caspia*	Caspian Tern	Caspian panchil	U, w
155	*Sterna hirundo*	Common Tern	Pati Panchil	U, w
156	*Sterna nilotica*	Gull-billed Tern	Motathoti Panchil	V, w
	Family: Accipitridae			
157	*Accipiter badius*	Shikra	Pati Shikre	V, r
158	*Accipiter virgatus*	Besra	Bosra Shikre	U, r
159	*Aquila clanga*	Greater Spotted Eagle	Boro Guti Eagle	U (VU), w
160	*Aquila hastata*	Lesser Spotted Eagle	Choto Guti Eagle	R? (VU), r
161	*Buteo buteo*	Common Buzzard	Pati Tisabaj	R, w
162	*Circaetus gallicus*	Short-toed Snake Eagle	Khato angul Shap Eagle	R?, r
163	*Circus aeruginosus*	Eurasian Marsh Harrier	Puber Pankapashi	V, w
164	*Circus melanoleucos*	Pied Harrier	Pakra Kapashi	R, w
165	*Elanus caeruleus*	Black-shouldered Kite	Kala Ghar Chil	C, r
166	*Gyps bengalensis*	White-rumped Vulture	Shakun, bangle Shakun	U (CR), r
167	*Haliaeetus leucogaster*	White-bellied Sea Eagle	Sagar/Sindhu Eagle/Dhola pet Eagle	V, r
168	*Haliaeetus leucoryphus*	Pallas's Fish Eagle	Kura/Koral Eagle	U (VU), r (Restricted to northern Sundarban)
169	*Haliastur indus*	Brahminy Kite	Sankha Chil	V, r

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170	*Hieraaetus pennatus*	Booted Eagle	Butpa Eagle	R?, w
171	*Ichthyophaga ichthyaetus*	Gray-headed Fish Eagle	Dhusor matha mach Eagle	C, r
172	*Milvus migrans*	Black Kite	Bhuban Chil	V, r
173	*Pandion haliaetus*	Osprey	Machmural	U, w
174	*Pernis ptilorhynchus*	Oriental Honey-buzzard	Madhu Chil, Madhubaj	C, r
175	*Spilornis cheela*	Crested Serpent Eagle	Tilaj Nag Eagle	V, r
176	*Spizaetus cirrhatus*	Changeable Hawk Eagle	Shikre Eagle	C, r
	Family: Falconidae			
177	*Falco amurensis*	Amur Falcon	Amur Shahin	R, v
178	*Falco chicquera*	Red-necked Falcon	Lal ghar Shahin	R?, r
179	*Falco peregrines*	Peregrine Falcon	Peregrine Shahin	U, w
180	*Falco subbuteo*	Eurasian Hobby	Eurasian Tikashahin	R, v
181	*Falco tinnunculus*	Common Kestrel	Pati Kestrel	V, w
	Family: Podicipedidae			
182	*Podiceps cristatus*	Great Crested Grebe	Baro Duburi	R, w
183	*Tachybaptus ruficollis*	Little Grebe	Choto Duburi	V, r
	Family: Anhingidae			
184	*Anhinga melanogaster*	Oriental Darter	Shap-pakhi, Goyar	U, r
	Family: Phalacrocoracidae			
185	*Phalacrocorax carbo*	Great Cormorant	Baro Pankouri	C, r
186	*Phalacrocorax niger*	Little Cormorant	Choto Pankouri	V, r
	Family: Ardeidae			
187	*Ardea cinerea*	Gray Heron	Dhupni Bok	
188	*Ardea goliath*	Goliath Heron	Daito Bok	R, v
189	*Ardea purpurea*	Purple Heron	Lalche Bok	C, r
190	*Ardeola grayii*	Indian Pond Heron	Kana Bok	V, r
191	*Bubulcus ibis*	Cattle Egret	Go Bok	V, r
192	*Butorides striatus*	Little Heron	Choto Bok	C, r
193	*Casmerodius albus*	Great Egret	Jaitha Bok, Boro boga	C, r
194	*Dupetor flavicollis*	Black Bittern	Kala Boga	R?, r
195	*Egretta garzetta*	Little Egret	Sada Bok, Choto Bog	V, r
196	*Gorsachius melanolophus*	Malayan Night Heron	Malaya Nishibok	R, v/s
197	*Ixobrychus cinnamomeus*	Cinnamon Bittern	Khoira Bogla	C, r
198	*Ixobrychus sinensis*	Yellow Bittern	Holde Bogla	U, r
199	*Mesophoyx intermedia*	Intermediate Egret	Majhla Bogla	C, r

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Sl No	Taxon and Scientific Name	English Name	Local Name	Status
200	*Nycticorax nycticorax*	Black-crowned Night Heron	Nishi Bok	C, r
	Family: Threskiornithidae			
201	*Threskiornis melanocephalus*	Black-headed Ibis	Kalamatha Kastechora	C, w
	Family: Ciconiidae			
202	*Anastomus oscitans*	Asian Openbill	Shamuk Khol	C, r
203	*Ciconia episcopus*	Woolly-necked Stork	Dholagola Manikjor	R, v
204	*Leptoptilos javanicus*	Lesser Adjutant	Choto Modontak	U (VU), r
	Order: Passeriformes **Family: Pittidae**			
205	*Pitta brachyura*	Indian Pitta	Desi Sumcha	R, s
206	*Pitta megarhyncha*	Mangrove Pitta	Para Sumcha	C, r
	Family: Irenidae			
207	*Chloropsis aurifrons*	Golden-fronted Leafbird	Sona Kopali Horbola	V, r
	Family: Laniidae			
208	*Lanius cristatus*	Brown Shrike	Badami Kosai	V, w
209	*Lanius schach*	Long-tailed Shrike	Lomba lej Kosai	V, r
210	*Lanius tephronotus*	Grey-backed Shrike	Badami pit kosai	C, w
	Family: Corvidae			
211	*Aegithina tiphia*	Common Iora	Fotikjal	V, r
212	*Artamus fuscus*	Ashy Woodswallow	Mate Ababil	V, r
213	*Coracina macei*	Large Cuckooshrike	Boro Kabashi	C, r
214	*Coracina melanoptera*	Black-headed Cuckooshrike	Kalamatha Kabashi	C, s
215	*Corvus macrorhynchos*	Large-billed Crow	Lomba Thot Kak	V, r
216	*Corvus splendens*	House Crow	Pati Kak	V, r
217	*Dendrocitta vagabunda*	Rufous Treepie	Harichacha	V, r
218	*Dicrurus aeneus*	Bronzed Drongo	Bronze Finge	V, r
219	*Dicrurus hottentotus*	Spangled Drongo	Keshraj	C, r
220	*Dicrurus leucophaeus*	Ashy Drongo	Mete Finge	C, w
221	*Dicrurus macrocercus*	Black Drongo	Kalo Finge	V, r
222	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	Boro racket Finge	V, r
223	*Dicrurus remifer*	Lesser Racket-tailed Drongo	Choto Racket Finge	U, w
224	*Hemipus picatus*	Bar-winged Flycatcher-shrike	Dagipak Chutki latora	C, r
225	*Hypothymis azurea*	Black-naped Monarch	-	C, r

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226	*Oriolus chinensis*	Black-naped Oriole	Kalaghar banebou	C, w
227	*Oriolus oriolus*	Eurasian Golden Oriole	Eurasian sonabou	U?, w
228	*Oriolus xanthornus*	Black-hooded Oriole	Haldey Pakhi	V, r
229	*Pachycephala grisola*	Mangrove Whistler	Nonabon shismar	C, r
230	*Pericrocotus cinnamomeus*	Small Minivet	Choto latora	V, r
231	*Pericrocotus flammeus*	Scarlet Minivet	Shidure Shoheli	C, r
232	*Rhipidura albicollis*	White-throated Fantail	Dholagola Chatighurani	C, r
233	*Terpsiphone paradisi*	Asian Paradise-flycatcher	Asio shahbulbul	C, r
	Family: Muscicapidae			
234	*Copsychus malabaricus*	White-rumped Shama	Shama	V, r
235	*Copsychus saularis*	Oriental Magpie Robin	Doel	V, r
236	*Culicicapa ceylonensis*	Grey-headed Canary Flycatcher	Metematha kanarichutki	V, w
237	*Cyornis poliogenys*	Pale-chinned Flycatcher	Dholagola chutki	C, r
238	*Cyornis rubeculoides*	Blue-throated Flycatcher	Nilgola chutki	R, w
239	*Eumyias thalassina*	Verditer Flycatcher	Ambor Chutki	C, w
240	*Ficedula parva*	Red-throated Flycatcher	Lalbuk Chotok	V, w
241	*Luscinia calliope*	Siberian Rubythroat	Saberio Chunikonthi	U, w
242	*Monticola solitarius*	Blue Rock Thrush	Nil Shiladama	C, w
243	*Muscicapa dauurica*	Asian Brown Flycatcher	Asio badam chutki	R, v
244	*Muscicapa sibirica*	Dark-sided Flycatcher	Dhusor Chutki	U, w
245	*Phoenicurus ochruros*	Black Redstart	Lal Girdi	C, w
246	*Turdus unicolor*	Tickell's Thrush	Tickell's dama	R?, w
247	*Zoothera citrina*	Orange-headed Thrush	Komla matha dama	C, r
248	*Zoothera dauma*	Scaly Thrush	Tila dama	R?, w
	Family: Sturnidae			
249	*Acridotheres fuscus*	Jungle Myna	Jhuti Shalik	V, r
250	*Acridotheres ginginianus*	Bank Myna	Gang Shalik	R?, r
251	*Acridotheres tristis*	Common Myna	Bhat Shalik	V, r
252	*Sturnus contra*	Asian Pied Starling	Gobrey/Go/ Chonda Shalik,	V, r
253	*Sturnus malabaricus*	Chestnut-tailed Starling	Kath Shalik	V, r
254	*Sturnus roseus*	Rosy Starling	Golapi Shalik	R, v
255	*Sturnus sturninus*	Purple-backed Starling	Beguni shalik	R, v (Recorded in northern Sundarban)

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Sl No	Taxon and Scientific Name	English Name	Local Name	Status
256	*Sturnus vulgaris*	Common Starling	Pati shalik	R?, v
	Family: Sittidae			
257	*Sitta castanea*	Chestnut-bellied Nuthatch	Chora Bonomali	R, r
258	*Sitta frontalis*	Velvet-fronted Nuthatch	Bonomali	C, r
	Family: Certhiidae			
259	*Parus major*	Great Tit	Boro Tit	V, r
	Family: Hirundinidae			
260	*Hirundo daurica*	Red-rumped Swallow	Lalpacha ababil	C, w
261	*Hirundo fluvicola*	Streak-throated Swallow	Dagigola ababil	R?, w
262	*Hirundo rustica*	Barn Swallow	Ababil	V, w
263	*Hirundo smithii*	Wire-tailed Swallow	Taralej ababil	R?, v
264	*Riparia paludicola*	Plain Martin	Pati ghornakuti	R?, r
265	*Riparia ripari*	Sand Martin	Bali ghornakuti	R?, w
	Family: Pycnonotidae			
266	*Pycnonotus cafer*	Red-vented Bulbul	Bangla Bulbuli	V, r
266	*Pycnonotus jocosus*	Red-whiskered Bulbul	Sipahi Bulbuli	V, r
	Family: Cisticolidae			
267	*Cisticola juncidis*	Zitting Cisticola	Vomra choton	V, r
268	*Prinia flaviventris*	Yellow-bellied Prinia	Holde pet prinia	U, r
269	*Prinia inornata*	Plain Prinia	Nirol prinia	C, r
	Family: Zosteropidae			
270	*Zosterops palpebrosus*	Oriental White-eye	Udoye Dhola chok	V, r
	Family: Sylviidae			
271	*Acrocephalus stentoreus*	Clamorous Reed Warbler	Bachal Nol futki	C, w
272	*Locustella certhiola*	Pallas's Warbler	Palasi futki	U, w
	Iduna aedon	Thick-billed warbler	Motathot futki	U,w
273	*Locustella naevia*	Grasshopper Warbler	Grasshopper futki	U, w
274	*Macronous gularis*	Striped Tit Babbler	Dagi tit chatare	V, r
275	*Malacocincla abbotti*	Abbott's Babbler	Abbot ar chatare	V, r
276	*Orthotomus sutorius*	Common Tailorbird	Tuntuni	V, r
277	*Phylloscopus affinis*	Tickell's Leaf Warbler	Tikeler futki	U, w
278	*Phylloscopus collybita*	Common Chiffchaff	Pati chifchaf	R?, w
279	*Phylloscopus fuscatus*	Dusky Warbler	Dhusor futki	C, w
280	*Phylloscopus inornatus*	Yellow-browed Warbler	Holde futki	V, w
281	*Phylloscopus magnirostris*	Large-billed Leaf Warbler	Lomba thot pata futki	R?, w
282	*Phylloscopus reguloides*	Blyth's Leaf Warbler	Blyther futki	C, w
283	*Phylloscopus trochiloides*	Greenish Warbler	Sobuje futki	V, w
284	*Pomatorhinus schisticeps*	White-browed Scimitar Babbler	Dholavru kaste chatare	C, r
285	*Seicercus tephrocephalus*	Gray-crowned Warbler	Metemtha futki	R, w

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286	*Turdoides earlei*	Striated Babbler	Dagi Satare	C, r
287	*Turdoides striatus*	Jungle Babbler	Satbhaila, Bon Satare	V, r
	Family: Alaudidae			
288	*Alauda gulgula*	Oriental Skylark	Udoye Vorot	V, r
289	*Calandrella raytal*	Sand Lark	Bali vorot	V, r
290	*Eremopterix grisea*	Ashy-crowned Sparrow Lark	Mete jhuti vorot	U, r
291	*Mirafra assamica*	Rufous-winged Bushlark	Bharat	V, r
292	*Mirafra erythroptera*	Indian Bushlark	Bharat	R?, r
	Family: Nectariniidae			
293	*Aethopyga siparaja*	Crimson Sunbird	Shidure moutushi	C, r
294	*Anthreptes singalensis*	Ruby-cheeked Sunbird	Chunimukhi moutushi	C, r
295	*Arachnothera longirostra*	Little Spiderhunter	Choto makormar	R?, r
296	*Dicaeum cruentatum*	Scarlet-backed Flowerpecker	Lalpit fuljhuri	V, r
297	*Dicaeum erythrorynchos*	Pale-billed Flowerpecker	Fuljhuri	V, r
298	*Dicaeum trigonostigma*	Orange-bellied Flowerpecker	Komla pet fuljhuri	U, r)
299	*Nectarinia asiatica*	Purple Sunbird	Beguni Moutushi	V, r
300	*Nectarinia zeylonica*	Purple-rumped Sunbird	Moutushi	C, r
	Family: Passeridae			
301	*Anthus hodgsoni*	Olive-backed Pipit	Jalpai pet tulika	C, w
302	*Anthus richardi*	Richard's Pipit	Richard Tulika	C, w
303	*Anthus roseatus*	Rosy Pipit	Golapi Tulika	R?, w
304	*Anthus rufulus*	Paddyfield Pipit	Dhani Tulika	V, r
305	*Dendronanthus indicus*	Forest Wagtail	Bon Khajoni	C, w
306	*Lonchura malabarica*	Indian Silverbill	Deshi chadithot	U, r
307	*Lonchura malacca*	Black-headed Munia	Kalomatha Munia	C, r
308	*Lonchura punctulata*	Scaly-breasted Munia	Tila Munia	V, r
309	*Motacilla alba*	White Wagtail	Dhola Khonjan	V, w
310	*Motacilla cinerea*	Gray Wagtail	Mete khonjon	C, w
311	*Motacilla citreola*	Citrine Wagtail	Citrine khonjon	C, w
312	*Motacilla flava*	Yellow Wagtail	Holde Khonjon	C, w
313	*Motacilla maderaspatensis*	White-browed Wagtail	Baro Khonjan	V, r
314	*Passer domesticus*	House Sparrow	Charui	V, r
315	*Ploceus philippinus*	Baya Weaver	Babui	V, r
	Family: Fringillidae			
316	*Carpodacus erythrinus*	Common Rosefinch	Pati tuti	U, w
317	*Emberiza melanocephala*	Black-headed Bunting	Kalamukh Chotok	R, w

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318	*Emberiza pusilla*	Little Bunting	Choto Chotok	R,w

Source: Hussain and Acharya (1994), Khan (1986, 2010), Khan (2005) and Sahgal *et al.* (2007)

Table 3: Status and distribution of Reptiles (Phylum: Chordata, Class: Reptilia) in the Sundarban

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
	Order: Testudinea **Family: Bataguridae**			
1	*Batagur baska*	Common River Terrapin	Baro Kasim/ Kaitta	R (CR)
2	*Geoclemys hamiltonii*	Spotted Pond Turtle	Mogom Kasim	U (VU), only in freshwater belt
3	*Hardella thurjii*	Crowned River Turtle	Kali Kasim/ Kaitta	U (VU)
4	*Batagur dhongoka*	Three-striped Roof Turtle	Dhoor Kasim	U (EN)
5	*Batagur kachuga*	Red-crowned Roof Turtle	Kori Kasim/ Kaitta	U (CR)
6	*Morenia petersi*	Yellow Turtle	-	U (VU)
7	*Pangshura tecta*	Indian Roofed Turtle	Kori/Hail Kasim/ Kaitta	C
8	*Pangshura tentoria*	Median Roofed Turtle	-	U
	Family: Cheloniidae			
9	*Caretta caretta*	Loggerhead Sea Turtle	-	R? (EN)
10	*Chelonia mydas*	Green Turtle	Sabuj Samudrik Kasim	R (EN)
11	*Eretmochelys imbricata*	Hawksbill Sea Turtle	-	R?
12	*Lepidochelys olivacea*	Olive Ridley Turtle	Jalpaironga Samudrik Kasim	C (EN)
	Family: Dermochelyidae			
13	*Dermochelys coriacea*	Leatherback Sea Turtle	Baro Samudrik Kasim	R?
	Family: Trionychidae			
14	*Aspideretes gangeticus*	Ganges Softshell Turtle	Kuchrong/ Khalua Kasim	U (VU)
15	*Aspideretes hurum*	Peacock-marked Softshell Turtle	Dhum Kasim	C (VU)
16	*Chitra indica*	Narrow-headed Softshell Turtle	Sim Kasim	U (EN)
17	*Lissemys punctata*	Spotted Flapshell Turtle	Patapori/Shundi Kasim	C
18	*Pelochelys cantorii*	Cantor's Softshell Turtle	Hedoilla/Jata Kasim	U (EN)
	Order: Lacertilia **Family: Agamidae**			

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19	*Calotes versicolor*	Common Garden Lizard	Raktachosa Girgiti, Rangchia (K), Sikalthui (T)	V
	Family: Gekkonidae			
20	*Gekko gecko*	Tokay Gecko	Tokkhak, Kokkey, Tattong, Houkka, Kokke (K), Tokke (T)	V
21	*Hemidactylus brookii*	Brook's House Gecko/ Spotted Indian House Gecko	Khoshkhoshey Tiktiki	C basically silent
22	*Hemidactylus frenatus*	Common House Gecko	Haroil Tiktiki, Prasni (K), Nobraisha (T)	V most vocal
	Family: Scincidae			
23	*Mabuya carinata*	Keeled Grass Skink	Anzoni, Lenzana	V
	Family: Varanidae			
24	*Varanus bengalensis*	Bengal Monitor	Hung Gui, Gui Shap, Makru (G)	V
25	*Varanus flavescens*	Yellow Monitor	Sona Gui	R? only in freshwater
26	*Varanus salvator*	Water Monitor	Ramgadi Gui	C
	Order: Serpentes **Family: Typhlopidae**			
1	*Ramphotyphlops braminus*	Common Blind Snake	-	U
2	*Typhlops diardii*	Diard's Blind Snake	Baro Dumukha	R
3	*Typhlops jerdoni*	Jerdon's Blind Snake	Choto Dumukha	C
4	*Typhlops porrectus*	Slender Blind Snake	-	R
	Family: Acrochordidae			
5	*Acrochordus granulatus*	Western Wart Snake	Reti/Ukha Shap	R
	Family: Boidae			
6	*Eryx conicus*	Common Sand Boa	Balu-bora Shap	R
7	*Python molurus*	Rock Python	Azagar/ Meghdumbur/ Moyal/ Chaklapora Shap	R
	Family: Colubridae			
8	*Ahaetulla nasuta*	Common Vine Snake	Laodoga Shap	U
9	*Ahaetulla prasina*	Short-nosed Vine Snake	Laodoga Shap	U
10	*Amphiesma stolatum*	Striped Keelback	Dora Shap/Chilu Shap	C
11	*Atretium schistosum*	Olive Keelback	Maita Shap	V
12	*Boiga cyanea*	Green Cat Snake	Sabuj Phonimonosa Shap	U
13	*Boiga gokool*	Eastern Cat Snake	-	R

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Sl No	Taxon and Scientific Name	English Name	Local Name	Status
14	*Boiga trigonata*	Common Cat Snake	Phonimonosha Shap	U
15	*Cerberus rynchops*	Dog-faced Water Snake	Maichha Shap	V
16	*Chrysopelea ornate*	Ornate Flying Snake	Kalnigini/ Urukku/Uranta Shap	U
17	*Coelognathus Helena*	Common Trinket Snake	-	R
18	*Coelognathus radiates*	Copper-headed Trinket Snake	Dudhraj/Arbali Shap	R
19	*Dendrelaphis pictus*	Painted Bronzeback Tree Snake	Rangila Gecho Shap	U
20	*Dendrelaphis tristis*	Common Bronzeback Tree Snake	Badami Gecho Shap, Patalot Shap	C
21	*Enhydris enhydris*	Common Smooth Water Snake	Paina/Huria Shap	V
22	*Enhydris seiboldii*	Seibold's Smooth Water Snake	-	R
23	*Fordonia leucobalia*	White-bellied Mangrove Snake	Sadabook Jolar Shap	R
24	*Gerardia prevostiana*	Glossy Marsh Snake	Maita Shap	C
25	*Lycodon aulicus*	Common Wolf Snake	Gharginni Shap	V
26	*Lycodon fasciatus*	Banded Wolf Snake	-	R
27	*Lycodon jara*	Yellow-speckled Wolf Snake	-	R
28	*Oligodon arnensis*	Common Kukri Snake	-	U
29	*Oligodon cinereus*	Black-barred Kukri Snake	-	R
30	*Oligodon cyclurus*	Cantor's Kukri Snake	-	R
31	*Oligodon dorsalis*	Spot-tailed Kukri Snake	-	R
32	*Oligodon taeniolatus*	Russell's Kukri Snake	-	R
33	*Psammophis condanarus*	Condanarus Sand Snake	-	R
34	*Ptyas korros*	Indo-Chinese Rat Snake	-	U
35	*Ptyas mucosus*	Indian Rat Snake	Daraj/Dhaman Shap	C
36	*Sibynophys subpunctatus*	Duméril's Black-headed Snake	-	R
37	*Xenochrophis cerasogaster*	Dark-bellied Marsh Snake	Kalu-pet Jolar Shap	U
38	*Xenochrophis piscator*	Checkered Keelback	Dhora Shap	V
	Family: Elapidae (all deadly venomous species)			
39	*Bungarus caeruleus*	Common Krait	Kal-keutey Shap	C
40	*Bungarus fasciatus*	Banded Krait	Shakini/ Shonkhini/ Akhainna Shap	U
41	*Bungarus niger*	Greater black krait	Kalo Keotey	R
42	*Naja kaouthia*	Monocled Cobra	Gokhra Shap	U
43	*Naja naja*	Spectacled Cobra	Khoia Gokhra Shap	C

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
44	*Ophiophagus hannah* (Probably several species grouped under this complex)	King Cobra	Raj Gokhra Shap/ Shankhachur	U
	Family: Hydrophiidae (all deadly venomous species)			
45	*Astrotia stokesii*	Large-headed Sea Snake	Boromatha Samudrik Shap	R
46	*Enhydrina schistose*	Hook-nosed Sea Snake	Borshi-nak Samudrik Shap	V
47	*Hydrophis caerulescens*	Many-toothed Sea Snake	-	C
48	*Hydrophis cantoris*	Cantor's Narrow-headed Sea Snake	Kantorer Sharu-matha Samudrik Shap	C
49	*Hydrophis cyanocinctus*	Annulated Sea Snake	Boloi-jukta Samudrik Shap	U
50	*Hydrophis fasciatus*	Banded Sea Snake	Lati Samudrik Shap	C
51	*Hydrophis gracilis*	Common Narrow-headed Sea Snake	Sharu-matha Samudrik Shap	U
52	*Hydrophis nigrocinctus*	Black-headed Sea Snake	Kalo-matha Samudrik Shap	C
53	*Hydrophis obscures*	Estuarine Sea Snake	Mohonabashi Samudrik Shap	C
54	*Hydrophis ornatus*	Cochin Banded Sea Snake	Kochiner Boloi-jukta Samudrik Shap	R
55	*Lapemis curtus*	Malabar Sea Snake	Malabar Samudrik Shap	R
56	*Pelamis platurus*	Black and Yellow Sea Snake	Rangila Samudrik Shap	U
	Family: Viperidae (all deadly venomous species)			
57	*Daboia russelii*	Russell's Viper	Chandra-bora/ Ulu-bora Shap	R
58	*Trimeresurus albolabris*	White-lipped Pit Viper	Sabuj-bora/Teya-bora/ Hawa Shap	U
59	*Trimeresurus erythrurus*	Spot-tailed Pit Viper	Futa-lej Samudrik Shap	U
	Order: Crocodylia Family: Crocodylidae			
60	*Crocodylus porosus*	Estuarine Crocodile	Lonapanir Kumir	U

Source: Hussain and Acharya (1994), Khan (1986, 2010), Khan (2005) and Sahgal *et al.* (2007)

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Table 4: Amhibia: Status and distribution of amphibians (Phylum: Chordata, Class: Amphibia) in the Sundarban

Sl No	Taxon and Scientific Name	English Name	Local Name	Status
	Order: Anura **Family: Bufonidae**			
1	*Bufo stomaticus*	Marbled Toad	-	U
2	*Duttaphrynus melanostictus*	Common Toad	Kuno Bang	V
	Family: Dicroglossidae			
3	*Euphlyctis cyanophlyctis* (Probably several species grouped under this complex)	Skipper Frog	Mali Bang	V
4	*Euphlyctis hexadactylus*	Green Frog	Sabuj Bang	U
5	*Fejervarya cancrivora* (Gravenhorst, 1829	Crab-eating Frog	Kankra-bhook Bang	U
6	*Fejervarya limnocharis* (Probably several species grouped under this complex)	Cricket Frog	Jhijhi Bang	V
7	*Fejervarya syhadrensis*	Southern Cricket Frog	-	U
8	*Hoplobatrachus crassus*	Jerdon's Bull Frog	-	U
9	*Hoplobatrachus tigerinus*	Indian Bull Frog	Sona/Kola/ Bhawa Bang	V
10	*Kaloula taprobanica*	Sri lanka Bull Frog	Sril lanka frog	R
	Family: Microhylidae			
11	*Microhyla ornata*	Ornate Microhylid Frog	-	v
	Family: Ranidae			
12	*Hylarana tytleri*	Leaping Frog	-	R?
13	*Sylvirana taipehensis*	Two-striped Grass Frog	Kad Bang	U
	Family: Rhacophoridae			
14	*Polypedates leucomystax*	Asian Brown Tree Frog	Gecho Bang	C
15	*Polypedates maculatus*	Indian Tree Frog	Gecho Bang	V

Source: Hussain and Acharya (1994), Khan (1986), Khan (2005) and Sahgal et al. (2007)

Annex 2: Checklist of Flora in the Sundarban

Table 5: List of Cyanobacteria

Family	Scientific name	Local name	Life form
Hyellaceae	*Hydrocoleum cantharidosum*	-	Cyanobacteria
	Schizothrix lamyi	-	Cyanobacteria
	Xenococcus cladophorae	-	Cyanobacteria
	Xenococcus chaetomorphae	-	Cyanobacteria
Oscillatoriaceae	*Oscillatoria amoena*	-	Cyanobacteria

Table 6: List of wood decay fungi and mushroom

Sl. No.	Name of the Fungus	Host and nature of damage
1	*Acremonium strictum* W. Gam	Sundri, seedling root rot
2	*Botryosphaeria ribis* (Fr.) Gross & Dug.	Sundri, twig gall canker
3	*Calocybe indica*	A mushroom

Sl. No.	Name of the Fungus	Host and nature of damage
4	*Chaetomella raphigera* Swift.	Keora, collar rot
5	*Cytospora* sp.	Keora, die back associate
6	*Daedalea flavida* Lev.	Genwa, wood decay
7	*Daedalea quercina* L. ex. Fr.	Genwa, wood decay
8	*Daedalea cf. hobsoni*	Genwa, wood decay
9	*Daedalea zonata* Schw.	Sundri, wood decay
10	*Fomes badius*	Sundri, wood decay
11	*Fomes conchatus* (Pers. ex.Fr.) Gill.	Sundri, wood decay
12	*Fomes dochmius* (Berk. ex. Br.) Cooke	Sundri, wood decay
13	*Fomes rimosus* (Berk.) Cke.	Passur, Sundri, wood decay
14	*Fomes* sp.	Goran, Keora, wood decay
15	*Ganoderma lucidium* (Leyss.) Karst	Sundri, root rot & die back associate
16	*Hexagonia apiaria* (Berk.) Cooke	Sundri, wood decay
17	*Hexagonia tenuis* Hook. ex. Fr.	Genwa, wood decay
18	*Hymenochaete tabacina*	Sundri, wood decay
19	*Hymenochaete* sp.	Goran, Sundri, wood decay
20	*Hypoxylon hypomiltum* Mont.	Genwa, wood decay
21	*Hypoxylon* sp.	Sundri, wood decay
22	*Lenzites palisoti* Fr.	Genwa, wood decay
23	*Marasmius equicrinus* Muller. Ex. Kalchbr.	Sundri, Hores hair blight
24	*Marasmiellus scandens* (Massee) Dennis & Reid	Sundri, leaf blight
25	*Petstalotia* sp.	Sundri, leaf blight
26	*Phialophora bubakii* (Laxa.) Schol.-Schwarz.	Sundri – Dieback associate
27	*Polyporus xanthopus* Fr.	Genwa, wood decay
28	*Polyporus grammocephalus* Berk.	Genwa, wood decay
29	*Polyporus luteo-umbrinus* Romell	Sundri, wood decay
30	*Polyporus ochroleucus* Berk.	Goran, wood decay
31	*Polyporus rhodophaeus* LV.	Sundri, wood decay
32	*Polyporus sanguineus* Fr.	Genwa, wood decay
33	*Polyporus xanthopus* Fr.	Genwa, wood decay
34	*Polyporus zonalis* Berk.	Genwa, wood decay
35	*Polystictus hirsutus* var. *calvens* Clements	Genwa, wood decay
36	*Polystictus leoninus* Klotzsch	Genwa, wood decay
37	*Poria corticola* (Fr.) Cooke	Sundri, wood decay
38	*Poria* sp.	Keora, Sundri, wood decay
39	*Schizophyllum commune* Fr.	Genwa, Keora, Passur, Sundri
40	*Stereum hirsutum* (Willd.) Pers.	Sundri, wood decay
41	*Tremetes lactinea* Berk.	Genwa, Keora
42	*Tremetes persoonii* Fr.	Keora, wood decay
43	*Tremetes* sp.	Sundri, wood decay

Source: Shayesta *et al*. (1999), Rahman (2001), Encyclopedia of the Flora and Fauna of Bangladesh, Vol. 2.

Table 7: List of Algae

Family	Scientific name	Local name	Life form
Cladophoraceae	*Boodleopsis sundarbanensis*	Shamudrik Shabuj Shoibal	Algae
	Chaetomorpha aerea		Algae

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Family	Scientific name	Local name	Life form
	Chaetomorpha gracilis		Algae
	Cladophorella sundarbanensis		Algae
	Enteromorpha intestinalis	Shabuj Shamudrik Shoibal	Algae
	Enteromorpha prolifera	Shamudrik Shabuj Shoibal	Algae
	Lola capillaris		Algae
	Lola implexa		Algae
	Rhizoclonium grande		Algae
	Rhizoclonium hookeri		Algae
	Rhizoclonium kerneri		Algae
	Rhizoclonium riparium	Kladoforal Shoibal	Algae
Delesseriaceae	*Caloglossa adnata*	Lohit Shoibal	Algae
	Caloglossa leprieurii	Lohit Shoibal	Algae
	Cottoniella filamentosa	Lohit Shoibal	Algae
Nostocaceae	*Anabaena variabilis*		Algae
Punctariaceae	*Colpomenia sinuosa*	Badami Shoibal	Algae
Rhabdoniaceae	*Catenella nipae*		Algae
	Catenella repens		Algae
Rhodomelaceae	*Bostrychia tenella*	Lohit Shoibal	Algae
	Caloglosia leprieurii		Algae
	Pterosiphonia pennata	Lohit Shoibal	Algae
Vaucheriaceae	*Vaucheria erythrospora*	Vaucheria Shoibal	Algae
	Vaucheria mayyanadensis	Vaucheria Shoibal	Algae
	Vaucheria prescottii	Vaucheria Shoibal	Algae
	Vaucheria pronosperma	Vaucheria Shoibal	Algae

Source: Encyclopedia of the Flora and Fauna of Bangladesh, Vol.3 & 4.

Table 8: List of Lichens

SL. No.	Scientific name	Morphoform Type
1	*Anaptycia podocarpan* Trev.	Foliose
2	*Anaptycia* sp.	Foliose
3	*Bacidia humana* A. Zahlbr var. *rugosa* A. L. Smith	Crustose
4	*Bacidia* sp.	Crustose
5	*Coccocarpi* sp.	Foliose
6	*Dimelaena areana*	Crustose
7	*Haematomma puniceum* Waino.	Crustose
8	*Lecanora* sp.	Crustose
9	*Leptogium caesium* Waino.	Foliose
10	*Leptogium moluccamum* Waino.	Foliose
11	*Parmelia latissima* Fee.var. *sorediata* Hue	Foliose
12	*Petusaria multipuncta* Nyl.	Crustose
13	*Pertusaria* sp.	Crustose
14	*Phaeographina exerta* Muell. Arg.	Crustose
15	*Rhizocarpon geographicum* DC	Crustose
16	*Usnea florida* Wigg.	Fruticose

Sources: Pasha, M.K. (2004) and Basak *et al*. (2005)

Table 9: List of Moss

Family	Scientific name	Local name	Life form
Leucobryaceae	*Leucophanes glaucescens*	Not known	Moss

Source: Encyclopedia of the Flora and Fauna of Bangladesh, Vol.5.

Table 10: List of Pteridophytia (ferns and fern-allies)

Family	Scientific name	Local name	Life form
Acrostichaceae	*Acrostichum aureum*	Tiger fern/ Hodo	Fern
Adiantaceae	*Adiantum lunulatum*		Fern
Aspleniaceae	*Asplenium polyodon*		Fern
Huperziaceae	*Phlegmariurus phlegmaria*		Fern
Isoetaceae	*Helminthostachys zeylanica*	Shada Dhekia	Fern
Plypodiaceae	*Drynaria quercifolia*		Epiphytic
	Microsorium punctatum		Fern
	Pyrrosia lanceolata		Fern
Perkeriaceae	*Ceratopteris thalictroides*		Fern
Ophioglossaceae	*Ophioglossum reticulatum*		Fern
Psilotaceae	*Psilotum nudum*		Epiphytic
Pteridaceae	*Acrostichum speciosum*		Fern
	Pteris longifolia	Dhekia	Fern
	Pteris vittata		Fern
Schizaeaceae	*Lygodium flexuosum*		Fern
	Lygodium japonicum		Fern
Thelypteridaceae	*Ampelopteris prolifera*		Fern
	Christella arida	Bish Dhekia	Fern
	Stenochlaena palustris	Lata Dhekia	Fern
Vittariaceae	*Vittaria elongata*	Grassy fern	Fern
Woodsiaceae	*Diplazium esculantum*		Fern

Table 11: List of Angiosperms

Family	Scientific name	Local name	Life form
Acanthaceae	*Acanthus ilicifolius*	Hergoza	Shrub
Apocynaceae	*Calotropis gigantea*		Shrub
	Cerbera manghas	Dakur	Tree
Araeceae	*Cryptocoryne ciliata*		Shrub
Asclepiadaceae	*Finlaysonia obovata*	Baonia, Dudhi Lata, Baid, Kananchi, Lamnichi	Woody Twining
	Hoya parasitica		Epiphyte
	Sarcolobus carinatus	Baoli Lata, Baoni Lata, Bandali Lata	Twining Shrub
	Sarcolobus globosus	Baoli Lata, Baoli Phal, Baoni Lata, Haroya.	Twining Shrub
	Wattakaka volubilis	Titakunga, Madhumalati, Nakchickna.	Twining Shrub
Asteraceae	*Eupatorium odoratum*		Climber
	Mikania scandens		Climber
Avicenniaceae	*Avicennia alba*	Baen	Tree
	Avicennia marina	Sada baen	Tree
	Avicennia officinalis	Kala baen	Tree
Caesalpiniaceae	*Cynometra ramiflora*	Singra	Tree
	Senna multiglandulosa		Shrub
Celastraceae	*Salacia prinoides*		Vine or Shrub

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Family	Scientific name	Local name	Life form
Chenopodiaceae	*Arthrocnemum indicum*	Jadu Palang	Herb
	Salicornia brachiata		Herb
	Suaeda maritima		Herb
Clusiaceae	*Calophyllum inophyllum*	Kath Champa, Sultan Champa	Tree
Combretaceae	*Lumnitzera racemosa*	Kirpa	Tree
Convolvulaceae	*Cuscuta reflexa*		Parasitic plant
	Ipomoea carnea		Shrub
	Ipomoea pes-caprae	Chhagol kuri	Herb
	Ipomoea violacea		Herb
Cornaceae	*Stictocardia campanulata*		Herb
Cyperaceae	*Cyperus corymbosus*	Gola Methi	Herb
	Cyperus exaltatus		Herb
	Cyperus imbricatus	Burethi	Herb
	Cyperus javanicus		Herb
	Cyperus malaccensis	Chumati Pati	Herb
	Cyperus procerus		Herb
	Cyperus scariosus	Nagarmutha	Herb
	Cyperus tagetiformis		Herb
	Eleocharis spiralis		Herb
	Fimbristylis ferruginea		Herb
	Fimbristylis polytrichoides		Herb
	Fimbristylis tristachya		Herb
	Machaerina rubiginosa		Herb
	Schoenoplectus littoralis		Herb
	Scirpodendron ghaeri		Herb
	Scirpusarticulatus	Putputi-chechra	Herb
	Scirpus lacustris		Herb
Euphorbiaceae	*Excoecaria agallocha*	Genwa	Tree
	Excoecaria indica	Urmoi, Batla, Batul	Tree
	Flueggea virosa	Khaukra, Shikori	Shrub
Fabaceae	*Aganope heptaphylla*		Robust Climber
	Canavalia maritima		Perennial twining shrub
	Caesalpinia crista	Letkanta	Tree
	Caesalpinia bonduc		Shrub
	Crotalaria retusa	Atasi, Bilijhunjhuni	Under-shrub
	Crotalaria saltiana		Herb
	Dalbergia candenatensis	Chandl-lata	Shrub
	Dalbergia spinosa	Chanda Katta	Shurb
	Dendrolobium umbellatum		Shrub
	Derris trifoliata	Guala-lata, Kali-lata, pan-lata	Shrub or Climber
	Derris scandens	Amkurchi, Kali-lata, Noa-lata	Woody Climber
	Entada pursaetha		Climber
	Mucuna gigantea	Soash Guri	Woody Twining
	Vigna luteola		Perennial Herb

Family	Scientific name	Local name	Life form
Flagellariaceae	*Flagellaria indica*	Ban chanda	Climbing Shrub
Hippocrateaceae	*Salacia chinensis*	Madhu-phal, Chotboroi	Woody Climber
Leeaceae	*Leea aequta*		Shrub
	Leea crispa		Shrub
Liliaceae	*Crinum asiaticum*	Bara kanur, Nagdal	Herb
Lecythidaceae	*Barringtonia racemosa*	Kumbi, Kumia	Tree
Loranthaceae	*Dendrophthoe falcata*		Epiphyte
	Viscum monoicum	Shamu lata	Woody parasite in tree
Malvaceae	*Hibiscus tiliaceus*	Bolla	Small tree
Meliaceae	*Amoora cuculata*	Amur	Tree
	Xylocarpus granatum	Dhundul	Tree
	Xylocarpus mekongensis	Passur	Tree
Mimosaceae	*Acacia tomentosa*	Maranthi, Anjar, Salsaibabla	Small Tree
Myrsinaceae	*Aegiceras corniculatum*	Khulshi	Shrub
Orchidaceae	*Bulbophyllum roxburghii*		Epiphyte
	Dendrobium anceps		Epiphytic Herb
	Luisia brachystachys		Epiphyte
	Luisia zeylanica		Epiphytic Herb
	Oberonia gammiei		Epiphyte
	Trias oblonga		Epiphyte
	Vandopsis gigantea		Epiphyte
Palmae	*Nypa fruticans*	Golpata	Stemless palm
	Phoenix paludosa	Hantal	Clustered palm
Pandanaceae	*Pandanus foetidus*	Keya-kanta	Bushy shrub
Plumbaginaceae	*Aegialitis rotundifolia*	Nuniya	Shrub
Poaceae	*Arundo donax*		Giant reed
	Eriochloa procera	Nolgash	Herb
	Hemarthria compressa	Pan Seru	Herb
	Imperata cylindrica		Herb
	Myriostachya wightiana	Dhanshi/Nalai	Perennial grass
	Panicum repens	Dhani ghas	Herb
	Paspalum vajinatum	Water couch grass	Grass
	Phragmites karka	Nalkhagra	Reed
	Porteresia coarctata	Dhani ghas, Harakata	Grass
	Saccharum spontaneum		Grass
	Zoysia matrella	Manila grass	Grass
Pontedteriaceae	*Eichhornia crassipes*	Kachuripana	Herb
Rhizophoraceae	*Bruguiera gymnorrhiza*	Kankra	Tree
	Bruguiera parviflora		Tree
	Bruguiera sexangula	Kankra, Rohinia	Tree
	Ceriops decandra	Goran	Shrub
	Ceriops tagel	Motgoran	Shrub
	Rhizophora apiculata	Bhora	Tree
	Rhizophora mucronata	Bhora, Garjan	Tree
Rubiaceae	*Canthium angustifolium*	Bishnein, Kantanali, kota-malli	Shrub
Ruppiaceae	*Ruppia maritina*	Not known	Herb

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Family	Scientific name	Local name	Life form
Sapindaceae	*Allophylus cobbe*	Chita	Shrub
Solanaceae	*Solanum trilobatum*	Trikum-pata	Thorny scrambler, Slightly woody
	Solanum xanthocarpum	Kantakari	Herb
Sonneratiaceae	*Sonneratia apetala*	Keora	Tree
	Sonneratia caseolaris	Ora	Tree
Sterculiaceae	*Heritiera fomes*	Sundri	Tree
Tamaricaceae	*Tamarix indica*	Nona jhao	Tree
Thunbergiaceae	*Thunbergia species*	Jermani lota	Climber
Tiliaceae	*Brownlowia tersa*		Shrub
Typhaceae	*Typha domingensis*	Hogla/ Kan	Herb
	Typha elephantine	Hogla	Herb
Verbenaceae	*Clerodendrum inerme*		Shrub
Vitaceae	*Cissus quadrangularis*	Harenga	Herbaceous Climber
	Vitis trifolia	Amallata	Climber
	Tetrastigma bracteolatum	Golgoti lata	Climber

REFERENCES

Cultivation of Hindoostan, published anonymously is February 1830 in the Kaleidoscope (Vol. II, Nov. VII) published by H.L.V. Derozio

Hussain, Z., and Acharya, G. (eds.). 1994. Mangroves of the Sundarbans, Volume Two: Bangladesh. IUCN – The World Conservation Union.Dyna Print, Bangkok, Thailand.

IUCN Bangladesh, 2012.Environmental Management and Biodiversity Conservation Plan for Bangladesh Sundarbans' Biodiversity.

IUCN Bangladesh, 2000. Red list of threatened animals of Bangladesh. Dhaka.

Khan, M.A.R. 2010. Wildlife of Bangladesh- from Amphibia to Mammalia. A checklist. Shahitya Prakash, 87 Purana Palton Line, Dhaka 1000, 128 pp.

Md Abul Faiz,1 Aniruddha Ghose,2 Md Farid Ahsan,3 Md Ridwanur Rahman,4 Md Robed Amin,5

Md Mahtab Uddin Hassan,3 Md A. Wahed Chowdhury,3 Ulrich Kuch,6 Thalita Rocha,7 John B. Harris,7 R. David G. Theakston8 and David A. Warrell9. 2010

Rahman, M. A. 2001. Diseases and disorders of the tree species in the Sundarbans and their management. In Siddiqi, N.A. and Baksha, M.W. (eds) Mangrove Research and Development. Bangladesh Forest Research Institute, Chittagong. Pp 86 -97.

Shayesta, B., Rahman, M. A. and Khisa, S. 1999. Checklist and host index of parasitic algae, bacteria, fungi and mistletoes on forest trees and timber in Bangladesh. Bulletin 6, Forest Pathology Series. Bangladesh Forest Research Institute, Chittagong.60 pp.

The greater black krait (Bungarus niger), a newly recognized cause of neuro-myotoxic snake bite envenoming in Bangladesh. Brain, 133: 3181-3193[doi:10.1093/brain/awq265 Brain 2010: 133; 3181–3193 | 3181

The Sundarban Inheritance (2007). Bittu Sahgal, Sumit Sen, Bikram Grewal (Sanctuary Asia)

W.W. Hunter (1875), A Statistical Account of Bengal, Vol. 1, Districts of the Parganas and Sundarban (London: Truebner and Co.,)

The Authors

Dr. Reza Khan	Specialist Wildlife and Zoo Management Public Parks and Horticulture Department Dubai Municipality, United Arab Emirates
Ishtiaq Uddin Ahmad	Country Representative IUCN Bangladesh Country Office
Dwijen Sharma	Botanist
Aban Marker Kabraji	Regional Director IUCN Asia
Michael Dougherty	Head of Asia Communications IUCN
Bipradas Barua	Litterateur
Dr. M. Monirul H. Khan	Associate Professor Department of Zoology Jahangirnagar University
Khasru Chowdhury	Journalist
Inam Ahmed	Deputy Editor The Daily Star
Md. Monwar Hossain	Professor Department of Zoology Jahangirnagr University
Dr. Bidhan Chandra Das	Professor Conservation Biology & Climate Change Research Unit Department of Zoology University of Rajshahi, Bangladesh
Dr. S M A Rashid	Chief Executive Centre for Advanced Research in Natural Resources & Management (CARINAM)

Mushfiq Ahmed	Program Coordinator Prokriti O Jibon Foundation
Enam Ul Haque	Founder Bangladesh Bird Club
Sayam U. Chowdhury	Principal Investigator Bangladesh Spoon-billed Sandpiper Project Vice president Bangladesh Bird Club
Zahangir Alom	Project Manager and Senior Researcher Wildlife Conservation Society (WCS)
Dr. Abul Hossain	Dean Faculty of Science Noakhali Science and Technology University
Rubaiyat Mansur Mowgli	Country Representative Wildlife Conservation Society (WCS)
Dr. Istiak Sobhan	Program Coordinator IUCN Bangladesh
Dr. M Mahfuzur Rahman	Professor Department of Botany Jahangirnagar University
Iftekher Mahmud	Journalist The Daily Prothom Alo
Dr. Ainun Nishat	Vice Chancellor BRAC University
Md. Kamruzzaman	Climate Change Researcher
Samiul Mohsanin	Monitoring Officer Nature Conservation Management (NACOM)
Remeen Firoz	National Consultant Project Assessment Specialist UNDP Bangladesh

M Abdullah Abu Diyan	GIS/Remote Sensing Analyst Visiting Lecturer North South University
Junaid Kabir Choudhury	Deputy Chief Conservator of Forest (Rtd.) Bangladesh Forest Department
Md. Abdul Aziz	Associate Professor Department of Zoology Jahangirnagar University
Gazi Munsur Aziz	Journalist
Shimanto Dipu	Principal Investigator White-rumped Vulture Conservation in Bangladesh Project IUCN Bangladesh Country Office



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