Society & Change
Vol.1, No. 2, April-June 2007

Towards Indicators for Monitoring Biodiversity: Sharing the Sundarbans Experience[1]

Junaid Kabir Choudhury*
Niaz Ahmed Khan, PhD**

Abstract

Use of indicators for monitoring the biodiversity health status of mangroves is an innovative approach for Bangladesh mangroves as well as the global mangrove resources. Identification of effective indicators for such purposes needs long drawn studies over decades, but the use of experiences and observations is no less valuable in putting up a list of 'initially identified indicators' for the purpose. In the context of the Sundarbans, the experience in the use of this experimental approach coupled with the field verification by experts is presented in this paper.

Introduction

Bangladesh portion of the Sundarbans is the largest productive contiguous mangrove forest in the world, located in the southwestern part of the country between latitudes $89^0 00'$ and $89^0 55'$ East and longitudes $21^0 30'$ and $23^0 30'$ North. This was declared as 'Reserve Forest' during 1875-76, and was placed under the Forest Department (FD) for management. Since then its area in Bangladesh has remained unchanged. At the advent of the British rule in India, Sundarbans was twice its current size, most of which is lost to agriculture and habitation. At present it extends over 577,356 hectares of which 175,724 hectares is water.

There are three Protected Areas in Sundarbans Reserved Forests (SRF), which constitute the core area of the World Heritage Site, inscribed in 1997. The total area of the World Heritage Site is about 1,400 km^2, of which 490 km^2 is water.

---

1 This paper draws on the insights and experiences of the authors gained through their engagements in the Sundarbans in varied professional capacities over the years. The first author acted as a Team Leader in the IUCN-Sundarban Biodiversity Conservation Project. The use of information from the project and the support of the concerned staff are gratefully acknowledged.

* Forestry Specialist, IUCN-World Conservation Union, Dhaka, Bangladesh

** Professor of Development Studies, University of Dhaka, Bangladesh.

Management of the Sundarbans Reserved Forests

Management of Sundarbans mangroves under written prescriptions through selection felling was initiated during 1893-94 under a ten-year management plan written by R. L. Heinig. W. F. Lloyd increased the felling cycle to 40 years during 1903-08. Sir Henry Farrington's management plan, applied during 1906-12 enhanced girth limit for felling. F. Trafford prepared next management plan for the period 1912-32. S. J. Curtis formulated a detailed management plan for Sundarbans 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 capable to adopt such elaborate prescriptions. S. Choudhury revised the plan, which was in force till 1960.

The Forestal Forestry carried out a detailed scientific inventory of Sundarbans 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 Sundarbans for the period 1960-80.

The Overseas Development Administration of the United Kingdom conducted second detailed inventory of Sundarbans. 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 of 7.5 cm and above, for Sundri and Gewa respectively. The regeneration was reported satisfactory (Chowdhury *et al.* 1994).

Canonizado and Hussain prepared an integrated forest management plan for Sundarbans 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 is prescribed including improvement felling and extraction of Top Dying Sundri (TDS). For Gewa, the AAC prescribed is 53,000 M^3.

Since the government of Bangladesh extended the moratorium up to year 2005, this plan could not be implemented. The Khulna News Print Mills (KNM) has stopped Gewa extraction for the time being.

At present only Non Timber Forest Products (NTFPs) are being harvested, that too at a very small scale. Its harvest declined further in 2002, since the government enhanced the stumpage prices, reported to unreasonable.

The Current Concerns

The SRF is internationally recognized as an important mangrove ecosystem of high biodiversity value. It is the most important remaining habitat, in the world, of the critically endangered Bengal Tiger (*Panthera tigris tigris*). A number of other large mammalians once abundant in Sundarbans have already become extinct, including the swamp deer (*Cervus duvauceli*), one-horned rhinoceros (*Rhinoceros unicornis*) and wild water buffalo (*Bubalus arnee*). A recent study by IUCN found that currently 58 species of wildlife, indigenous to the Sundarbans, are threatened, of which 36 are either 'endangered' or 'critically endangered'. Though a comprehensive threat analysis is yet to be carried out, Karim (1994) listed the following:

- Changes in freshwater flow, affecting the vegetation pattern
- Sedimentation increase due to polder construction
- Pollution from agricultural and industrial activities
- Oil spills from boats and ships
- Over-exploitation of wood and NTFPs
- Sea level rise
- Damage due to cyclones and storm surges.

Besides these, the TDS, invasiveness of alien species, loss of biodiversity etc. deserve to receive due attention as concerns towards sustainability of SRF.

There are similar threats to the aquatic ecosystem of the Sundarbans. The resultant impact of enhanced shrimp farming along Bangladesh coast has induced a very high demand on natural shrimp fries that exhibit better performance over the hatchery fries. This in turn generated the tremendous pressure on shrimp fry collection from the SRF waters, which has become a major concern now.

A brief preliminary field study undertaken by the author during June 2002 indicates alarmingly low proportion of sapling-size plants in SRF, though the regeneration is adequate. One of the major causes of such situation seems to be the excess and indiscriminate harvest of this size saplings by the shrimp fry collectors, mostly under FD permits, that they use for netting shrimp fries. A rough estimate indicated that these shrimp fry collectors alone chop off over one million such saplings, mostly good and straight looking ones, annually from SRF.

The Concept of Biodiversity

Biodiversity of natural resources is a new concept. The recent global emphasis on the conservation of germ plasm, coupled with the awareness

on sustainability has generated this momentum on biodiversity and biodiversity conservation. The IUCN's Red List and the contributions of Species Survival Commission (SSC) assisted in developing a tool to monitor biodiversity. Using the assumption that species status is broadly reflective of the status of biodiversity as a whole, the SSC, while still working on the issue, has so far suggested the following indices (Mainka and McNeely 2001).

- Biodiversity Status Index (BSI)
- Biodiversity Knowledge Index (BKI)
- Biodiversity Trend Index (BTI)
- Cause of Threat Index (CTI)
- Conservation Action Index (CAI)
- Spatial Indices

The intention is to draw attention towards biodiversity trends.

The existing concerns of deforestation and biodiversity loss in the SRF led to the launching of Sundarbans Biodiversity Conservation Project (SBCP) since year 2000, by Asian Development Bank (ADB) with financial assistance from the Royal Netherlands Government and the World Bank/the Global Environment Facility (GEF), with the ultimate goal of placing in position a complete sustainable and environment friendly forest management system for SRF to ensure biodiversity conservation as well.

Under such situation, the IUCN The World Conservation Union, Bangladesh office has been entrusted with the task of developing a system for monitoring the biodiversity health status of SRF. The IUCN's approach in this regard is to build upon a logical step-by-step process of obtaining the information necessary to answer a series of questions in turn, which are

- What ecological zones and characteristic habitats can be identified in the SRF?
- What species are known presently to occur in each zone and/or habitat?
- What species will be used as indicators?
- How will these be measured?
- How the biodiversity health assessment technologies be transferred?
- How will the biodiversity health assessment system be sustainable at the end of the project?

The Rationale for Biodiversity Monitoring and the Concept of Indicators

Since the biodiversity loss is a major concern in the SRF and the management plan (to be adopted) is expected to conserve and enhance biodiversity, it is necessary to evaluate its performance. Besides, such monitoring is expected to work as an early warning system for the managers to take measures to combat any probable future disaster.

The conventional tool of assessing biodiversity involves large-scale inventory of the resources, both flora and fauna, which is exorbitantly expensive and almost an impossibility for a poor country like Bangladesh, especially when such activity is required once or twice a year. A reasonably good understanding of the Ecosystem Dynamics of the resource and the ecological linkages between the various tires of its biological entities, shall help identify and establish, either some species by itself, or some parameters of a given species, to indicate the biodiversity health status of the given ecosystem or habitat or the SRF at large.

It is in this context that we are looking for the "Indicators" that can be used for monitoring the biodiversity health status of Sundarbans.

Biodiversity Indicators from the Red List

The Red List program is expected to deliver the vision, goals and objectives as outlined above. Extensive consultations are being held to develop biodiversity indicators or indices from the IUCN Red List. The Red List Program is based on continuous monitoring of a selection of higher taxonomic groups that broadly cover and represent the full range of ecosystems. The Species Survival Commission (SSC) has started the process, which is expected to develop the indices for use by 2003.

Biodiversity Assessment

The biodiversity health assessment model that will be used to assess the biodiversity of SRF is an adaptation of the Pressure-State-Response model promoted by UNDP (Dumanski and Pieri 1994), including "Impact" as a fourth factor. The model identifies the following four main aspects.

- *Pressure:* Refers to assessing the triggering factors through a threats analysis. In the production zone, it is mainly the use and harvest of resources. In the protection zone, these are hydrodynamic changes and changes in habitat functions.
- *State:* Refers to assessing the current situation of the resources by means of baseline surveys, mostly through desk study of existing information.

- *Response:* Refers to the various management actions.
- *Impact:* Refers to the tangible and quantifiable effects of the response.

The health status of biodiversity of the SRF may be assessed at different levels, such as species, ecosystem and habitat. Biodiversity health assessment should focus on the overall habitat-mix, the macro-ecological setting, the man-made and natural pressures exerted and also the effects of global processes such as climate change and remote processes such as water pollution, sediment load etc.

Conventionally, species have been used in many biodiversity inventories as indicators to measure the health of an ecosystem. For the SRF focus may be on:

- Species, which are rare, endangered or are of particular interest.
- Species, which are vulnerable.
- Species, which have records of being particularly vulnerable to environmental changes.
- Species, which are important in ecosystem structure and function.
- Biodiversity-rich sites, which are vulnerable or rare or important for species conservation.

The methodological phases for studying biodiversity through this experimental approach are as follows:

- Define what is going to be monitored and assessed and identify, jointly with key stakeholders, the pertinent biodiversity assessment indicators.
- Collect and review secondary data and establish the baseline.
- Collect new data, identify and verify indicator species, hotpots and trends.
- Continue to collect data on selected indicators and verify their credibility for SRF.

The major aspects and areas, deserving special focus during such a study, include the following:

- Orchids, Lichens.
- Dragonfly, Butterfly.
- Mangrove Regeneration.
- Undergrowth.
- Alien, Invasive Species.
- Crustaceans.
- Cetaceans.
- Herpeto-fauna.

- Birds.
- NTFPs.
- FD Capacity Building

Since the conservation of the invaluable biodiversity of the Sundarbans mangroves, has been identified as one of the major goals of management of the resource, it is obligatory to assess the biodiversity health status at given intervals, not only for evaluating the impact of implementation of the given management prescriptions in this regard, but also to alert the managers as an 'early warning system'.

Initially Identified Indicators

Based on all the above methodology, a list of Initially Identified Indicators has been developed through various workshops, meetings, and brain storming sessions in conjunction with the stakeholders. Along with professors of various universities, many experienced foresters who have worked in the Sundarbans, relevant stakeholders actively participated during the process of identifying indicators. The list of the Initially Identified Indicators, emerged through this process of stakeholder consultation, is as follows (IUCN 2002):

Initially Identified Indicators for Monitoring the Biodiversity of the SRF

FLORA

Subgroups	*Initially Identified as Indicators*	*Remarks*
Orchids	*Luisia brachystachys* *Oberonia gammiei* *Dendrobium anceps* *Bulbophyllum roxbhurghii*	Indicate closed canopy, old mature stands, favorable water regime of air, etc.
Ferns	*Microsorium punctatum* (Bird nest fern) *Acrostichum aureum(Tiger fern)*	Indicate older stands of Sundri Indicate degraded openings, hardpan underneath, close cover, high sedimentation, etc.
Lichens	Fruticosa	Indicate wetter habitat and closed canopy
Mosses		Indicate wetter habitat and closed canopy
Tree Species	*Heritiera fomes* (Sundri) *Sonneratia apetala* (Keora) *Rhizophora mucronata* (Jhana) *Ceriops roxburrghii* (Goran) *Avicennia officinalis* (Bain)	Indicate fresh water zone Indicate newly formed land Indicate saline muddy river bank Indicate saline raised sites Indicate sand deposition

Subgroups	*Initially Identified as Indicators*	*Remarks*
Climber and Creepers	*Derris trifoliata* (Kalia lata) *Sarcolobus globosus* (Bawali lata)	Indicate fresh water flow
Palms	*Nypa fruticans* (Golpatta) *Phoenix paludosa* (Hental)	Indicate fresh water muddy sites Indicate edges of saucer formation & maturing aspects of soil formation, heavy sedimentation, raised sites, etc.
Grasses and Sedges	*Porteresia coarctata* (Dhanshi) *Cyperus exaltatus* (Malia ghash)	Indicate new formation Indicate depressed sites holding rainwater
Undergrowth-Shrubs & Herbs	*Hibiscus tilliaceous* (Bala) *Aegialitis rotundifolia* (Noona Jhau) *Aegiceras majus* (Khalshi) *Acanthus ilicifolius* (Hargoza)	Indicate open canopy Indicate depressed saline sites Indicate higher salinity, muddy bank, moderate shade, bee association, etc. Indicate moderately open & less sandy site
Invasive Species	*Eichhornia crassipes* (Kochuri pana) *Micania scandens* (Asam Lata) *Entada rheedii* (Gila Lata) *Eupoterium odoratum* *Derris trifoliate* (Kalia Lata) *Sepium indicum*	Indicate fresh water flow Indicate open site Indicate older tree growth

Initially Identified Indicators for Monitoring the Biodiversity of the SRF

FAUNA

Subgroups	*Initially Identified as Indicators*	*Remarks*
Mollusks	*Telescopium telescopium* *Crassostrea* sp (Giant oysters) *Sepia* sp.	Indicate lower salinity
Crustaceans	*Scylla olivacea* (Mud crab) *Penaeus monodon* (Bagda chingri) *Macrobrachium rosenbergii* (Golda chingri) *Carcinoscorpius rotundicanda* (Horse shoe crab) Barnacles*	Sundarban water is the natural spawning ground of both the species of 'Chingri'. Indicate existence of high detritus loaded brackish water bodies. Relates to salinity features

Subgroups	*Initially Identified as Indicators*	*Remarks*
Insects	*Danaus melanippus* (Monarch butterfly) *Pantala flavescene* (Dragon fly) Fireflies* Lady bird beetle* Lycaenid Butterfly*	Association with some specific mangroves Indicate old and climax mangrove site Indicate existence of *Sonneratia* stand Abundance indicate control of aphids on newly flashing twigs of Sundri
Amphibians	*Euphlyctis hexadactyla* (Green frog)	Indicate brackish water merge with fresh water zone
Reptilians	*Crocodylus porosus* (Estuarine Crocodile) *Ophiophagus hanna* (King Cobra) *Varanus salvator* (Gooi Shap)	Indicate existence of old tree growth with hollows
Birds	*Haliaeetus leucogaster* (White-bellied Sea Eagle) *Laptoptilis javanicus* (Lesser Adjutant) *Numenius arquata* (Eurasian Curlew) *Heliopais personata* (Masked Finfoot)	
Mammals	*Panthera tigris* (Bengal tiger) *Orcaella brevirostris* (Irrawaddy Dolphin) *Cervus axis* (Spotted deer) *Lutra perspicillata* (Smooth-coated Otter)	Indicate existence of mangrove habitat with its complete structure Indicate fish abundance, salinity gradient Indicate availability of fodder especially *Sonneratia*, grasses, etc. Indicate abundance of small fishes
Fishes	*Seatophagus argus* (Bishkata) Vetkey Kawin magoor Taposhi	Indicate less saline but rich detritus loaded water Indicate fresh water abundance

** Scientific names to be obtained later*

Epilogue

The rationale and significance of developing indicators for studying biodiversity of the world mangrove systems in general and the Sundarbans in particular can hardly be over-emphasized. In this brief paper, we have shared the experience of adopting an innovative approach towards developing a set of effective and user-friendly indicators. The work however is in the initial stage, and far from exhaustive. It needs further consolidation, refinement and expansion through continuous feedback from the field, and systematic stakeholder consultation. Although we have still a long way to go, given the utility and importance of this exercise, it certainly remains a worthwhile endeavor.

References

Chowdhury, R. A. and Ahmed, I. 1994 History of Forest Management. *Mangroves of the Sunderbans Volume two : Bangladesh*. Zakir Hussain and Gayatri Acharya (eds.). IUCN Publication. P 155-180

Dumanski, J. and Pieri, C. 1994 Application of the Pressure-State-Response Framework for the Land Quality Indicators Program.

Forestal Forestry and Engineering International Ltd. 1960 *Inventory of Sundarbans Forests*. Vancouver, Canada.

IUCN. Bangladesh 2002 Workshop Reports on Initial Identification of Indicators. Conservation Monitoring of Sundarbans Biodiversity.

Karim, A. 1994 Environmental Impacts. *Mangroves of the Sunderbans Volume two : Bangladesh*. Zakir Hussain and Gayatri Acharya (eds.). IUCN Publication. P 203-217

Mainka, S and McNeely, J. 2001. The IUCN Red List of Threatened Species__ A Tool for Monitoring Biological Diversity.