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AHM Mustain Billah
Istiaq Uddin Ahmad

ECONOMIC DEPLETION OF THE SUNDERBANS: A NEED FOR REGIONAL COOPERATION

Abstract

Sunderban Reserve Forest is the most diverse and richest natural resources area in Bangladesh. In every respect, the Sunderbans is considered to be the most important and the most valuable forest ecosystem in the country. It constitutes 51 percent of the total reserve forest estates of the country. It provides the largest share of forest produce accounting for 45 percent of all timber and fuel wood energy, and employment support for more than a million people. It has immense ecological importance such as protection from cyclones and tidal surges, production of wood for commercial and subsistence purposes, production of shrimp, habitat for wildlife, special habitat to Royal Bengal Tiger (*Panthera tigris*), conservation of biodiversity, unique facilities for ecotourism, major pathway in nutrient cycling and pollution abatement. Considering the above importance of the Sunderbans, in this study, an attempt has been made to give an account of its diverse physical resources. There are so many high value intangible resources that can not be accounted for physically. The present study attempted to highlight the economic and ecological importance of the largest mangrove of the world, and to explain

AHM Mustain Billah, Ph.D is a civil servant, presently working in Bangladesh Institute of Development Studies (BIDS) as Coordinator, Environment Policy Analysis, a component of Sustainable Environment Management Project (SEMP). His email contact is: mbillah@sdnbd.org

Istiaq Uddin Ahmad is an Assistant Chief Conservator of Forest and currently, a Ph.D fellow in the University of Minnesota,, USA. His e-mail address is: ahma0026@umn.edu

how salinity intrusion leads to degradation, which lies beyond the national jurisdiction. The economic valuation of some major tangible resources clearly demonstrated that the resource stocks in the Suderbans are declining over time. Valuation of other intangible resource will make us wonder how much of high potential resources are being wasted that can never be replaced and compensated. This signifies the most concern for the development and environment of the country. Only national efforts thus are not enough to resolve the issue. In order to preserve the world heritage and national capital stock of the country, two aspects are focused in this study: an economic appraisal to understand the gravity of loss and the salinity intrusion, which lie beyond the national jurisdiction and cause the depletion of the Sunderbans. Finally, the policy implications underscore the need for regional co-operation as an obligation of international agreements.

I. INTRODUCTION

Forest ecosystem is an important source of biological diversity and usually forms the dominant natural ecosystem in many countries, including those in Bangladesh. The biologically diverse forest ecosystem has been serving the human kind in a lot of ways for generations. In addition to providing timber resources, tropical forest ecosystem in particular, is a source of food and many agricultural crops and provides a wide variety of materials used in medicine, provides a source of eco-tourism and recreation opportunities, and helps maintain favourable environmental conditions. In the past, however, the forest has been viewed mainly as a source of timber to feed the wood-based industries. Sunderban Reserve Forest is the most diverse and richest natural resources area in Bangladesh. It makes an important corridor south of the Himalayan massif, between south and to the west and South East Asia to the east. The Sunderban Reserve Forest is located on the coastal belt and in the extreme southwestern part of the country. The western boundary follows the Hariyabhanga-Raimangal-Kalindi river. The Northern part of the

Sunderbans interfaces with intensively cultivated land intersected by tidal rivers, canals and streams (de Vere Moss, 1994).

In the Sunderban Reserve Forest (SRF), the main economic activities are production of timber resources such as pulpwood, firewood and non-timber such as thatching materials, honey, fish and shrimp fry. In the border zone, economic activities are agriculture and shrimp farming. In Khulna and surrounding districts, the main industries dependent on the Sunderban Reserve Forest for their raw materials are Khulna Newsprint Mills, the Khulna Hardboard Mill, the innumerable sawmills, the shrimp farming industries, fish processing industries and the likes.

SRF constitutes 51 percent of the total reserve forest estates of the country. About 41 percent of the total forest revenue are derived from the Sunderbans. It provides employment and subsistence of more than half a million people. It provides the largest share of forest produce accounted for 45 percent of all timber and fuel wood energy in the country. In the Sunderbans, the web and tides, the circadian changes in the water depth and its biochemical constituents and the seasonal influence of fresh water from the rivers that made the delta, provide the basis which all life and ecosystems depend on (IRD SRF1995 pg1).

The Sunderbans area lies within a zone of cyclone storm and devastating tidal bores, which occur during early summer and late rains. The Sunderbans serve as buffer against the violent forces to minimise the extent of damage done not only to the large number of people and their property but the environment and wildlife. But the Sunderbans ecosystem pays a high physical price in every catastrophic storm. Thus, the ecological importance of the Sunderbans can be summarised as follows:

Coastal protection from cyclones and tidal surges, production of wood for commercial and subsistence purposes, production of shrimp, habitat for wildlife, conservation of biodiversity and special habitat to Royal Bengal Tiger (Panthera tigris), unique facilities for ecotourism and major pathway in nutrient cycling and pollution abatement.

In order to meet the ever-growing demand for timber, fuel wood and other forest based amenities of the people, the resource stocks of the Sunderbans have been under pressure to deplete over time causing a serious concern for the economy of Bangladesh. The physical accounts of both timber and firewood indicated that production overtime decreased due to enforcement of moratorium from 232.9 thousand m^3 and 158 thousand metric ton in 1991-92 to 81 thousand m^3 and 124.9 thousand metric ton in 1995-96 respectively (IMP of SRF 1998).

Fuel wood also comes from branches of *sunderi, Gewa* and other bigger trees. For the period 1991-96, official reports stated that *Goran* harvest was averaging at 56 thousand metric tons per year. The last three years average stands higher at 62,400 metric ton indicating an increasing trend of resource extraction. The trend of *singra* and other fuel wood production decreased drastically from 28,434 metric ton in 1991-92 (with five years average at 12,328 metric tons) to 2,746 metric tons of the last 3 years average as revealed in ADB funded biodiversity project.

The depletion of the Sunderbans causing a threat of salinity intrusion and damaging the ever largest fish breading zone of the country. The employment potentiality of a large number of people of the coastal area is also under threat. The Sunderbans, declared as "World heritage", is a concern of the global community. The management of the Sunderbans has different implications for the economy of Bangladesh with respect to resource depletion and environmental degradation. An economic appraisal and valuation of resource and environment are urgently needed to make the complex coastal ecosystem comprehensible to the policy makers. In order to manage the Sunderbans sustainably, the most important task is to identify the factors responsible for depleting it. In addition to national policy and necessary management action plan, there are certain factors that are beyond national jurisdictions, like, upstream intervention in the flow of Ganges and deforestation in the Himalayas requiring urgent attention at regional level.

The main and broad objective of the study is to give an account of resource changes in the Sunderbans in value terms. The valuation of the Sunderbans will provide an understanding as to how the socio-economic, environmental and ecological benefits are changing over time. The specific objectives are:

(i) to give an account of the economic and environmental importance of the resources in the Sunderbans;

(ii) to review and determine the major factors responsible for resource depletion and environmental degradation in SRF;

(iii) to develop a conceptual framework for valuation of mangrove resources in SRF;

(iv) to examine the issue of salinity intrusion that has transboundary and regional policy implications.

The study is organised as follows: The section II deals with inventory of resources of the Sunderbans and its causes; section III focuses on resource valuation techniques and its approaches. Section IV discusses about methods of economic valuation of the resources in the Sunderbans. Section V describes the results of the study. The section VI highlights the policy implications in the regional context. Finally, the recommendations for policy changes at national and regional levels are made in the section VII.

II. CHANGES IN PHYSICAL STOCKS IN THE SUNDERBANS

Resources in the Sunderbans

The tree resources in the Sunderbans are decreasing alarmingly over the last four decades. An analysis of information from three inventories manifested a clear picture of rate of depletion as shown in Table 1.

Table 1: Tree Resource Depletion in the Sunderbans

Species (Tree /ha)	1959 (FORESTAL inventory) [a]	1983 (ODA) [b]	1996 (FRMP) [c]	% change over 4 decades
Sunderi (15 cm dbh)	211	125	106	50
Gewa (15 cm dbh)	61	35	20	67
All other species	296	180	144	51
Sunderi (10 cm dbh)	511	296	290	43
Gewa (10cm dbh)	345	224	228	34
All other species	952	557	561	41

Source: Forest Inventory of Sunderban (1998)

a. Forest Inventory carried out by FAO

b. Overseas Development Assistance

c. Forest Resource Management Project (FRMP) carried out by Forest Department.

The damage inflicted by top dying of *Sunderi* presently is very significant. FRMP inventory shows that less than 3% of the Sunderi volume is infected. This may be estimated at roughly 34,600 m^3 per year or 22% of increment (IMP-SRF 1998). The FRMP (1998) base map estimated a net decrease in land area of the Sunderbans of 3,026 ha, compared to the 1983 ODA mapping estimate. If this trend of forestland change is allowed to continue, it represents a periodic loss of 60,000 m^3 above 15+cm dbh growing stock.

Non-wood (Non-aquatic) Resources

There are many other non-wood resources such as G*olpata* (*Nypafruticans*), honey and bee's wax grasses, *hantal* (small palm), canes bamboo and other minor products. In extracting *Golpata* there are prescribed practices: to remove all but two leaves, one emerging young leaf and other supporting leaf. Fruiting G*olpata* are supposed to be undisturbed. Hardly this prescription is abided by. The official record revealed that the harvest of G*olpata* for the period 1991-96 had been averaging at 67,000 metric ton per year. However, over the last 3 years, it has been decreased to 65,500 metric ton indicating a slight declining trend. Considerable quantity is lost due to poor harvesting practices (MPSRF 1998). Currently as a part of moratorium programme *golpata* harvest is discontinued.

The production of *hantal* is also ever declining. Over the last 5 years it stood at 5,500 metric tons per year. However, over the last 3 years it stood at 1,250 metric tons per year. The Grass production is also decreasing. While the last five years' average production stands at 4,900 metric tons per year, the last three years' average production stands at 4,700 metric tons. Honey extraction during the year 1991-96 stands at 139 metric tons per annum, but the same over the last three years stands at 117 metric tons. Bee's wax average of the last 5 years was 35 metric tons, presently this comes down to 29 metric tons (MP-SRF 1998). Thus, there is an unmistakable declining trend in the production of all the items discussed above. Therefore, an urgent attention is needed to conduct a study on resource depletion and environmental degradation of the Sunderbans.

Non-aquatic Resources in SRF

There is more than 12,000 km of rivers in the Sunderbans. Roughly one third of its area is under water. Limited studies have been carried out by Chantarasri (1994), Pena (1994) Ahsanullah (1994) and Khulna University (1994). During their survey, 27 families and 53 species of pelagic fishes, 49 families and 124 species of demersal fishes, 5 families and 24 species of shrimp, 3 families and 7 species of crabs, 1 species of locust lobster, 3 species of turtle, 4 species of pelecypod and 2 species of gastropods were found in the Sunderbans. The annual records of harvest for various fishery resources by the Department of Forest indicated that the collection of shrimp fry increased almost two and half times during the last five years. The study of Chantarsri (1994) and Khulna University demonstrated that the maximum sustainable yield of shrimp fry increased 672 million per year compared to the previous estimated actual production of 334 million. The findings of the studies observed that Mud, Crab, Hilsa and Catfish have been over exploited. An account of physical stock of resources in the Sunderbans revealed that fuel wood production decreased from 86 million tons in 1991-92 to 61 million tons in 1995-96. The declining trends prevailed for all other resources as well. Only exception is a slight increase in fish production, where it increased from 3.9 million in 1991-92 to 4.4 million in 1992-93. For the rest of the period since 1992-93, the production level remained almost constant with small deviations. Timber and pulpwood production decreased from 48 and 141 million m^3 in 1991-92 to 18 and 63 million m^3 in 1995-96 respectively (IMP of SRF 1998).

The production of fish species demonstrated that the production of Oyster shell increased from 1050 in 1991-92 to 1138 metric tons in 1995-96. Similarly the production of Giant prawn, hilsa fish and crab also increased over the time, indicating over exploitation of resources due to higher population pressure. The production of few major species that is considered in this study does not reflect the real picture of the resource depletion. In addition to this, the production statistics maintained by the Forest Department and Smith's (1998) calculation cast considerable doubt on the validity of data and sampling method used (IMP of SRF 1998).

Depletion of Non-aquatic Resources

A good variety of non-timber forest products is extracted from the Sunderbans, like, honey, wax, grass and hontal. The annual production report states that the extraction of these resources has declined from 14 thousand metric tons in 1991-92 to 9 thousand metric tons in 1995-96. Despite the low extraction, the economic loss due to resource depletion did not change much. This indicates the increase in the value of these resources. These traditional goods do not have formal market. The demand from local market around the Sunderbans does not reflect the real price and value of these resources. Had there been a good market of honey in the Middle East, the commercial production of honey would have been promoted. The higher demand would stimulate expansion of modern technology for more production of honey and other non-timber forest products. The production of wax was observed to decrease slightly from 43 metric tons in 1991-92 to 39 metric tons in 1995-96. The production of *hantal* has declined almost by half. The trend in grass production does not change much over the study period indicating a higher demand for food of livestock and intensive exploitation of the existing resource base of the country. The total production of non-aquatic resources and non-timber resource has also been declining over time.

Salinity Intrusion: a cause of degradation

In addition to poor management practices, salinity intrusion is considered to be the most crucial factor for the depletion of the Sunderbans, which needs an urgent attention. Fresh water flow either from rainwater or from upstream is critical to the conservation and management of mangrove forests in the Sunderbans. Mangroves under different coastal settings and climatic conditions have definite relations with the salinity distribution pattern. Salinity here is an index of various integrating factors (relative maritime and freshwater influence). In the Sundarbans, a dynamic equilibrium condition is maintained between freshwater flow and sea water interactions. Historically, the Sundarbans have evolved under the reduced salinity, which needs to be maintained by a large amount of freshwater flow from the upstream. Mangrove biota is changing in interrelated ways mostly due to diversion of water through human intervention. Species composition is mostly directed by freshwater influx from distributaries like rivers *Gorai* and Passure. In the current changing circumstances, most of the distributaries have lost their connections with the main flow of Ganges due to geological process and upstream interventions.

The mangrove ecosystem is delicate, dynamic and complex. Every one of the components of the environment namely, climate, salinity *vis-a-vis* sweet water supply, siltation, erosion, substrate and nutrients has a first order impact on the flora and fauna of the ecosystem. Unlike many other mangroves of the tropical coast, the Sundarbans have got a unique assemblage of plant and animal species adapted to the low salinity regime. Any increasing salinity, thus, affects plants in many ways: osmotic inhibition of water absorption, specific effects on nutrition or toxicity or both. Salinity intrusion beyond its desired limit restricts and controls the spatial distribution of species. It has also negative impact on productivity. Increase salinity intrusion considerably retards the growth of trees. The study showed that the growth of primary productivity of mangroves increases with the sufficient availability of freshwater interaction with salinity. In slightly saline areas, trees attain a good height whereas in strongly saline areas trees are stunted. Thus, the degree of salinity influence the production of mangrove forest significantly. *Sundari* (*Heritiera fomes*) is the dominant species of tree in the Sundarbans that constitutes 73% of the growing stock. Large-scale death of *Sundari* has become a serious concern to the sustainability of the forest. A decrease in fresh water flow to the sundarbans during the dry season causes a serious physiological stress to the trees and other species. The susceptible trees then get secondary infection by insect and fungi, and thus, have resulted in extensive mortality of *Sundari.*

Salinity of the river water is a source of salts (either nutrients or toxicant) to the plant's physiological process. Salinity is also a critical factor for the viability of river borne mangrove seeds and propagules, which are disposed through rivers. Moreover, morphological conditions of the mangroves are so adapted that events like shedding leaves by some mangroves occur during the extreme dry periods when soil salinity is high while most mangroves shed their fruits during the rainy season when the chances of survival of the propagules are higher due to low salinity of the river water.

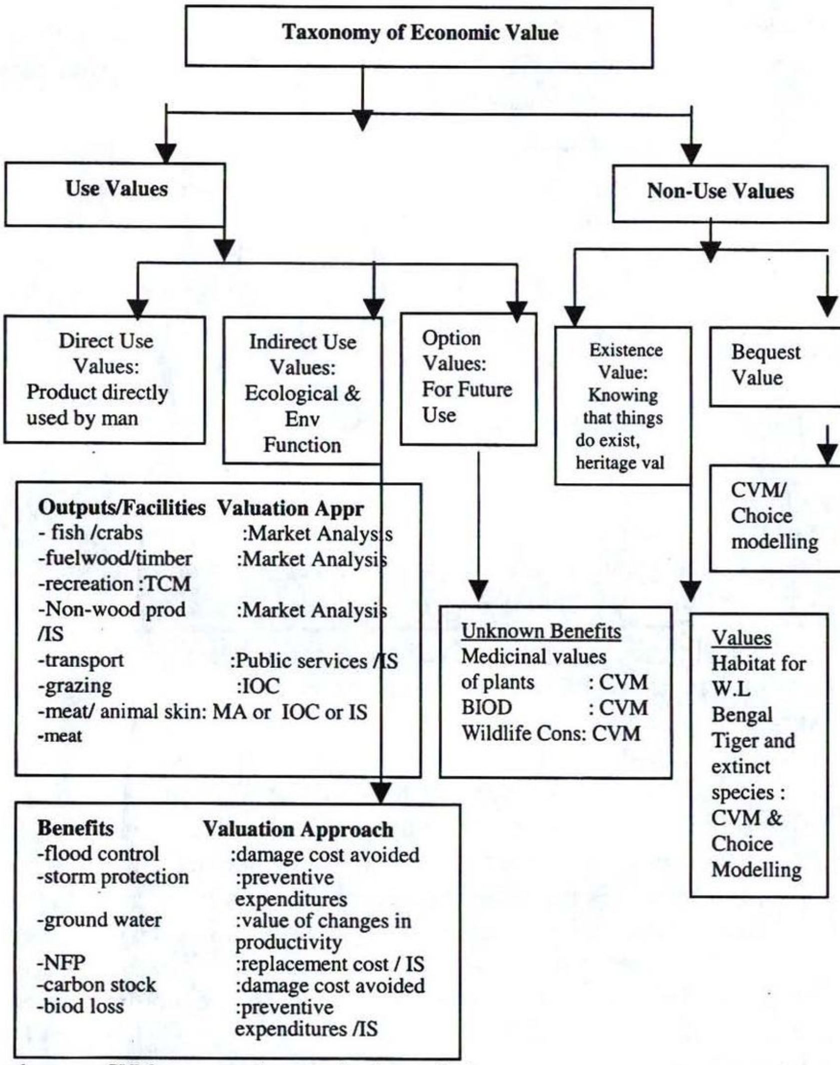
A change in the abundance of plant has profound effects upon associated animals in floristically simple mangrove communities. Densely high canopy trees shelter a large number of birds from predators and provide nesting sites. The stress due to increase in salinity that reduces the plant height and canopy coverage also destroy habitat for the birds and other animals. Population density may also vary with the variation of salinity. The degree of salinity also influences the mobility of many animals in and around the Sunderbans. Some marine birds and mammals intrude various distances upstream depending upon their tolerance for reduced salinity. Freshwater species occur at various distances downstream depending upon their tolerance for increased salinity. Thus, salinity is a strong determinant of the distribution and conservation of biodiversity in SRF that requires regional co-operation. .

III. RESOURCE VALUATION TECHNIQUES: APPROACHES

Economists generally depend on market prices to demonstrate the value of goods and services. For the goods and services exchanged in a well-defined market, information on prices and quantities are readily available. This information can be used to estimate the value of particular goods and services through constructing a demand curve. In this situation, a consumer reveals his preference through his willingness-to-pay (WTP) to obtain that particular good which is subject to his available income.

However, for mangrove ecosystem, all forest goods and services do not have market prices, thus, their values would have to be estimated through other different methods. This is particularly true for most of the non-timber forest products (NTEPs) or services such as water, recreation, wildlife, wild fruits, genetic resources, carbon sequestration, nutrient cycling and honey extraction to name a few. One characteristic of such goods or services is the occurrence of 'free riders', in which case consumers refuse to express their true willingness to pay (WTP), but could obtain utility from the good or service. As such, prices might be distorted leading to inappropriate estimation of the true economic value of the resources. The major role of valuation is, therefore, to assign the value to goods and services with distorted or non-existent market prices or to value them in terms of their opportunity cost.

Typically, the benefits derived from forest resources are to be measured in terms of WTP of users or consumers for using and experiencing the goods and services. An approximation of users WTP for particular recreational opportunities, for instance, can be developed from a demand curve, which indicates the quantity of use that users in a market would be willing and able to purchase at each price. Other estimates could be in terms of the expenditures on preventive measures taken by consumers or users to avoid a future loss. Thus, conservation of mangrove resources could be seen as a form of WTP for current, as well as, future benefits. Resource economists have yet to agree on taxonomy of economic values. There are many classifications of values and benefits given in the literature (see Barbier 1992, Munasinghe 1993, Pearce 1993). In the present study, the following category of economic values are used (Figure 1). Following the above, taxonomy of economic valuation of mangrove resources can be described as follows:



where CVM = contingent valuation method
TCM = travel cost method
IOC =indirect opportunity cost
IS = indirect substitute approach

Source: Adapted from Barbier *et al.* 1991, Hanely, 1993 and IIED, 1994.

Figure 1: Taxonomy of Economic Value

Figure 1 manifests different appropriate techniques regarding the measurement of the wetland benefits such as timber production, fish, fuel wood and transport have the direct use value. The value of the production is obtained from directly exploiting these resources.

The limitation of the availability of data prevents comprehensive total economic valuation (TEV) of wetland benefits. TEV can provide approximate magnitude of benefits loss due to degradation of wetland resources. The National Conservation Strategy (NCS) implementation project-1 so far has carried out some scientific studies on Tanguar Haor, which may provide useful information regarding the natural resource base of the haor. Based on those information an estimate was made to capture the benefits (direct use value) of some resources for Tanguar Haor (Billah *et al.,*2000). A similar effort is made for economic valuation of mangrove resource in the Sunderbans.

Direct use values refer to the productive or consumptive values of ecosystem components or functions. Direct uses may be marketed or non-marketed, with some of the latter activities often being important for the subsistence needs of local communities. Examples of a marketed direct use are timber and other non-timber forest products, which can be harvested and sold to consumers. The use of medicinal herbs collected from the forest resources by local communities is an example of non-marketed direct use. Direct uses of forest often have involvement with both commercial and non-commercial activities; non-commercial activities are very important for the subsistence of the rural people. The commercial uses may be important for both domestic and international markets. In general, the value of marketed goods and services is easier to measure than the value of non-marketed and subsistence direct uses.

Indirect use values refer to the value of regulatory environmental functions that support or protect an economic activity.

For instance, mangrove forest protects life and ecosystems from tidal bore, cyclone, and conserve biodiversity and store carbon dioxide. Although few studies of key environmental functions in tropical region have been conducted, it is evident from the empirical studies that economic value of regulatory environmental functions is highly significant. The values of environmental functions can be derived from the supporting or protecting economic activities that have directly measurable values.

Option values refer to the amount that an individual or society would be willing to pay to conserve an ecosystem for future uses. For example, preservation of biological diversity can preserve wild genetic verities for future uses such as the development of a new pharmaceutical drug. The other example, forest resource may be underutilised today, but may have future value in terms of scientific, educational, commercial and other economic uses. A special category of option values are *bequest values,* that arises from individuals placing a high value on conservation of tropical wetlands such as the Sunderbans in Bangladesh for future generation to use.

Existence values relate to society's willingness-to-pay to conserve biological resources for their own sake, regardless of their current or optional uses. For instance, many people reveal their WTP for the existence of biological resources such as wildlife and landscape for scenic view without participating in the direct use of the wildlife.

The methods used to determine each value mentioned above depends on the nature of forest goods and service in questions (Figure 1). For the direct use value, the methods available include market-based technique, changes in productivity approach, hedonic prices and public prices. For indirect use values the method used are relocation cost, preventive expenditures value of changes in the productivity and damage cost avoided. The contingent valuation approach can be used to value the indirect use, option and existence values (Figure 1). This method requires good understanding of forest goods and services production system. The following section discusses briefly some of the methods that can be used in valuing forest goods and services. A good literature on the methods used can be found in IIED (1994) and Mitchell and Carson (1989), (Hanley, 1993).

IV. METHODS FOR ECONOMIC VALUATION

Valuation of Timber Resources

A detailed methodology for determining the economic value of timber resources is given in equation 2. The most popular technique to value timber resources is using the residual value technique. This is because of data availability and ease of computation using spreadsheet programme. Using residual technique, data needed to calculate stumpage value include timber volume, log prices, extraction costs, and profit margin.

Stumpage is standing timber in unprocessed form as found in the forest i.e. timber on the stump normally means:

(a) the physical content of standing tree, within a contiguous area whether live or dead, (b) timber that is cut in connection with right-of - way clearing as long as it remains in the forest and is not cut into logs.

Stumpage value is the economic rent from timber extraction which is equivalent to its sale value less social and private cost of producing and transporting the timber (DENR, Philippines 1990; Davis and Johnson 1987; Awang and Vincent 1993). Therefore stumpage value can be calculated for each species using formula developed by Davis and Johnson in (1987) and later on slightly modified by Vincent (1990) and Billah 2000).

The formula is as follows:

$$Si = Vi\ (Pi - C - Pmi) \text{ ------------(1)}$$

where

Si = resource value according to species group i.e. resource value per / ha.
V i = volume of timber according to species group
P i = log price according to species group
C = average logging cost per cubic meter
Pm i = profit margin
i = an index according to species group
i = (1,2,3, ---- n)

Other researchers have also estimated stumpage value for different forest ecosystems. Their studies differ in terms of the level of analysis and forest ecosystems. Studies by Repetto and Gillis (1988) and Vincent (1990) based on aggregate data with average log price for all species. A study by Kumari (1994) was based on peatswamp forest in Selangor. The data used in her study was aggregate data and there was no price variation on log price. Despite data constraints, the present study estimated stumpage of major species of the Sunderbans mangroves using logs prices for respective species.

One of the most difficult tasks in resource valuation is to obtain resource extraction cost data particularly in developing countries, in Bangladesh information for logging cost yet to be estimated with. The components of logging costs and stumpage value are shown below diagrammatically in figure 2.

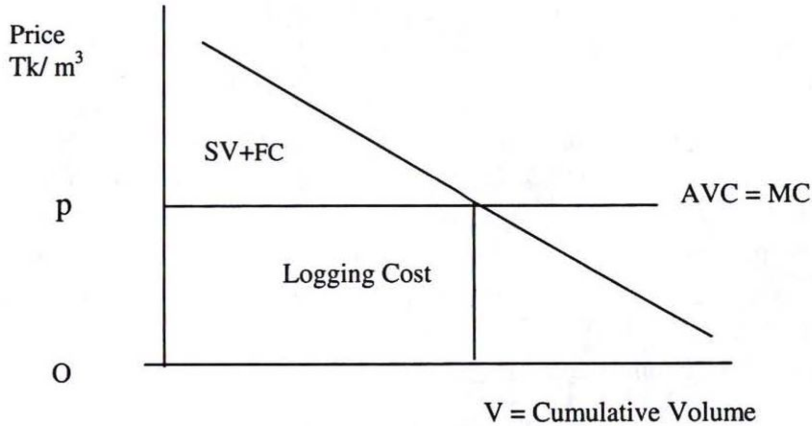


Figure 2: The components of logging costs and stumpage value

Species wise price data used in the study for valuation of timber and firewood obtained from integrated management plan of SRF (Annex 6, p.7). Since no study has yet been carried out for logging cost, an arbitrary assumption is made based on certain percentage of log price of different species. The profit margin is assumed 20% in this study.

Estimating the Fishery Resource Rent

In order to estimate the resource rent for fishery resource the following model is applied. Rent is defined here as the excess of revenue over the opportunity cost of effort and cost of operating that capital. The economic benefit or resource rent from the fishery at a given time can be expressed as:

$$\Pi_t (X, h) = p\, h(X) - c(X)\, E \qquad (2)$$

Where, p and h are the price of landed fish and harvest rate respectively and c (X) is the average cost of per unit of effort E.

Fishing costs are classified as fixed costs, variable costs and opportunity costs of effort i.e. Capital and labour. The method of estimation of these costs helps to separate components of rent to the fishermen and the state. Variable costs or operating costs are specified as those that are incurred only when operating a fishing unit such as food cost, gear and their maintenance costs.

The study attempted to make the valuation of resource depletion of the sunderans and its impact on the economy based on the secondary sources of information available from previous studies. The valuation of physical resources is made using current prices and cost in crude way. The information from primary sources and the use of real prices would reflect the more accurate picture of resource depletion of mangrove of the country.

For the economic valuation of fishery resources data used from the integrated management plan of SRF, where all fish products caught in the inshore fisheries and estuarine/offshore fisheries that attribute to the sunderbans. The integrated srf study demonstrated a serious under recording of fish catches. For example, recorded fish catch for 1994-95 was about 7.5% of the actual total catch (IMP SRF, 1998). In the valuation, the market price at first point of sale like on the beach of the sunderbans is used.

V. RESULTS: ECONOMIC DEPLETION OF SUNDERBAN MANGROVE

Value of Timber Resources

The Sunderbans mangrove is very rich with extensive diversity of natural resources in the coastal area of country. Different resources have different utility in the economy, as the resources are heterogeneous in nature; they have different techniques of estimating the values as well. The economic depletion of resources is estimated separately in a possible manner. Species-wise stumpage value indicated that economic loss of *Sunderi* timber decreased but not much substantially, as compared to *Gewa* and other species. There are two implications of declining the value of *Sunderi*. Firstly, a bar on felling *Sunderi* by regulation. Secondly, top dyeing of *Sunderi* trees has been increasing which are allowed to fell causing economic loss to decline at a lower pace. The economic loss for Rural Electrification Board (REB) poles is very erratic. The expansion of REB programme in the country created a high demand for poles that led to increase the economic loss for extraction of poles in the Sunderbans. In the case of timber stock removal from the Sunderbans, *Gewa* has the highest share while in the case of value loss Sunderi represents the highest share because of its higher value as demonstrated in the Table 2.

Table 2: Stumpage Value for Timber Resources by Species (thousand Tk)

	Sunderi	Gewa	REB Poles	Other Species	TSV
1991-92	171023	90867	18819	5142	285851
1992-93	511504	82689	0	1090	595283
1993-94	124077	57246	13366	321	195009
1994-95	171749	54384	2076	35	228244
1995-96	121478	31702	4285	334	157800

Source: Author's estimate

In the case of timber and firewood valuation, only major species are taken into consideration. The important limitation is the fact that the different species of timber has different value. Detailed consideration of species group and diameter size and economic cutting cycle will determine the proper value of the resource depletion.

The total value of timber and firewood collected from the Sunderbans for the last five years demonstrated that the economic loss in the initial period was very high, Tk. 595 million, which was double of the previous year. But in the subsequent years due to enforcement of moratorium the economic loss started to decline. As depicted in figure 3, resource depletion declined from Tk. 195 million in 1993-94 to Tk. 158 million in 1995-96.

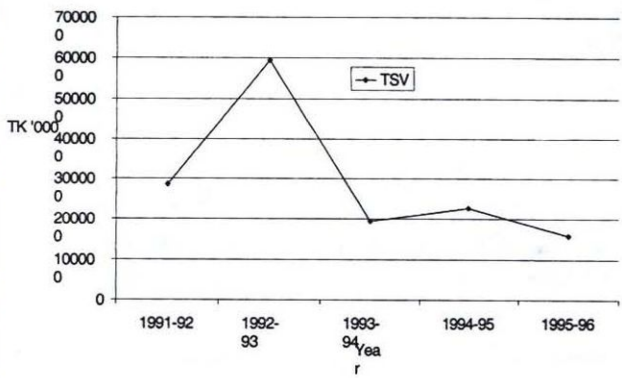


Figure 3 : Total Stumpage Value Depletion

Economic Depletion of Firewood

Similar to stumpage value, the valuation of firewood is made taking into account the major species. The economic loss of firewood for major species showed that value of *Goran* increased from Tk 36 million in 1991-92 to Tk 68 million in 1994-95. The economic loss for *Sunderi* as firewood was higher during the early part of 1990s; around Tk 20 million, but in 1995-96 it declined to about Tk 7 million. A similar trend of declining economic loss for singra and other wood species of firewood may have been caused by the imposition of moratorium as indicated in table 3. The use of *Golpata* and *Bola* and *Hangla* used as fuel wood showed the higher trend of economic loss during the study period.

Table 3: Value of Firewood by Species (thousand Tk)

Species	Goran Firewood	Sunderi Firewood	Singra Firewood	Other fire wood	Bola	Golpata	Hangla	Total Value of Firewood
1991-92	36399	24708	14507	10023	0	107180	0	192816
1992-93	48495	10687	9621	13506	0	103627	0	185936
1993-94	62017	22208	601	6011	0	111689	0	202525
1994-95	67847	14359	328	4	1378	110989	106	195011
1995-96	50523	7496	779	175	73	116685	10	175741

Source: Author's estimate

In the case of firewood, the economic loss in the early years was higher: around Tk 192 million in 1991-92 that shot up to Tk 203 million in 1993-94. But later on, the loss started to decline as the resource extraction was arrested because of the imposition of moratorium. As shown in figure 4, the economic loss declined from Tk 203 million in 1993-94 to Tk 176 million in 1995-96.

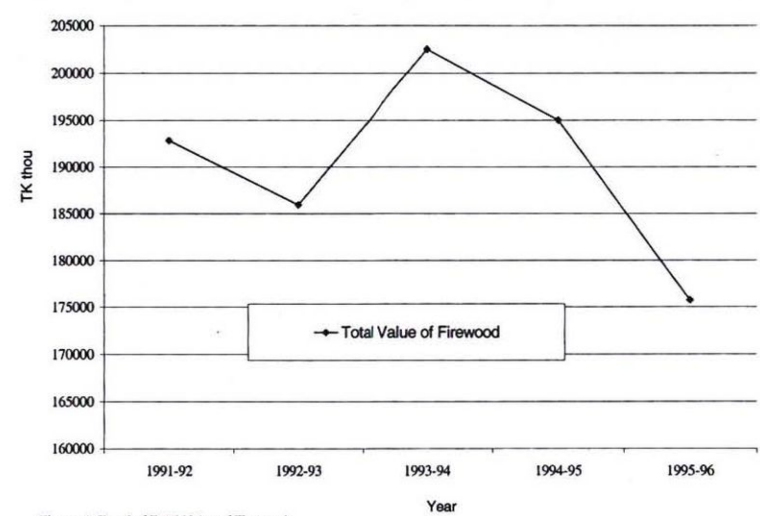


Figure 4: Trend of Total Value of Firewood

Value of Aquatic Resources

Table 3 clearly indicated that species wise economic loss of the aquatic resources of the Sunderbans where almost all major species were found to increase during the study period except white fish where economic loss declined from Tk 93 million in 1991-92 to Tk 90 million in 1995-96. The economic loss of tiger shrimp fry increased three times higher over the study period. This is because of higher demand for shrimp in the world market. The value for shrimp head also increased remarkably from Tk .018 million in 1991-92 to Tk .269 million in 1995-96 as indicated in Table 4.

Table 4: Value of Fishey Resources (thou Tk)

Year	OysterShell	white fish	Giant prawn/tiger shrimp	Small shrimp	Hilsa fish	Crab	Tiger shrimp fry	Srimp head	Total Value
1991-92	2157	93538	1463	2478	16111	6511	50	18	122325
1992-93	2326	104247	1534	2600	15417	12072	60	75	138332
1993-94	3098	86343	11590	2712	14021	13333	113	134	131344
1994-95	3191	90924	12129	2990	15511	18580	134	252	143711
1995-96	3293	90982	12156	1989	19420	17242	135	269	145484

Source: Author's estimate

The total value of aquatic resources also increased from Tk 122.3 million in 1991-92 to Tk 145.5 million in 1995-96 except for the period of 1993-94 as exhibited in figure 5. Earlier studies revealed that socio-economic conditions of the people of the Sunderbans area were bad and they had been the victims of acute economic stress. Moreover, there was a high demand for fish in the country as cheap protein that lead to increase the extraction of fish resources over time causing a great threat to resource destruction. Generation of production cost and species-wise time series data of fish will give a better trend of resource value.

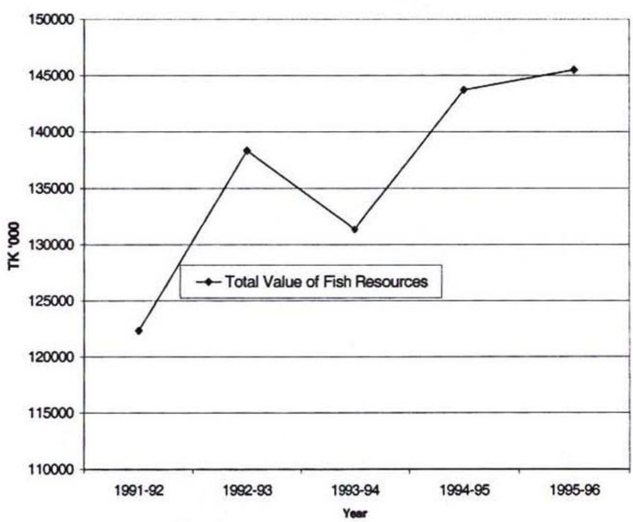


Figure 5: Total Value of Fish Resources

Economic Depletion of Non-aquatic and Non-wood Resources

The value of non-traditional resources is found to be increasing like honey value increased from Tk 10 million in 1991-92 to Tk 12 million in 1995-96. A similar trend prevailed for other non-aquatic and non-wood resources of the Sunderbans. This implies that due to economic expansion and rapid population growth in the country the extraction of natural resources intensified as shown in table 5.

Table 5: Values of Non-Aquatic, Non-timber Resources (thousand Tk)

Year	Honey	Wax	Grass	Hantal	Total Value
1991-92	10252	886	2063	1734	14935
1992-93	12352	976	2723	1223	17274
1993-94	7573	593	2562	1431	12159
1994-95	6467	528	2659	316	9971
1995-96	12666	986	2212	1023	16886

Source: Author's estimate

A time analysis of economic value of non-traditional resources showed that, since the early 1990s, there was a demand for non-traditional resources of the Sunderbans. Possibly, due to political instability, the non-traditional resources did not have much demand causing lower depletion of economic value of resource depletion as shown in figure 6.

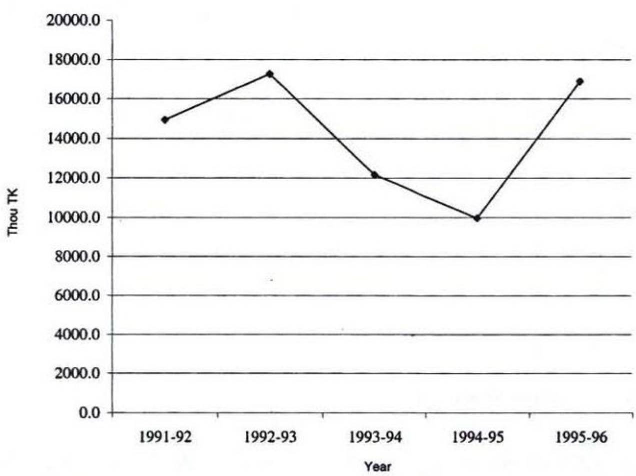


Figure 6 : Total Value of Non-aquatic Resources (Thou TK)

The sundarbans cover a significant land area in terms of total forest area coverage of Bangladesh. Population explosion combined with inadequate management and weak institutional capability has considerably deteriorated the forest resources of Bangladesh. Though Sundarban is far better managed than any other forest in Bangladesh, stock inventory of last couple of years shows a downward trend of its resources. Sundarban has a unique ecosystem and this forest is gaining increasing importance for its environmental role, in improving the biological productivity of the land and in conserving bio-diversity. Sundarban is also an important resource for economic development, for providing employment, income generation and added welfare.

VI. POLICY IMPLICATIONS FOR REGIONAL INTEGRATION

Both biophysical and economic depletion provides a guide for policy makers to understand the impact of the depletion of Sunnderbans. This sort of appraisal would help them in undertaking appropriate policy measures at national level. The most crucial factor that affects the Sundrbans is the salinity intrusion due to upstream intervention such as unilateral withdrawal of Ganges water and deforestation in the Himalayan is the issue beyond national jurisdiction needs to be addressed at regionally, where international framework could be the best guide for all.

The Sunderbans is a unique and the largest chunk of mangrove eco-system in the world, which form a physical continuum with many small and medium rivers like Gorai, Passure and Baleshwar. The River Gorai meets the sea ramifying a number of estuaries. The main source of freshwater flow in Gorai is the Ganges water, which originates from Gongatri of Himalayas. The continuous natural and anthropogenic changes caused to reduce the volume and flow of Ganges water over time. Some of these causes are: deforestation in the Himalayas that resulted in the increase in sedimentation in the upstream and silted the riverbed. This eventually caused water to over-flow and run out of the natural streams. The other factor that caused the freshwater flow to decline is the diversion of water and indiscriminate withdrawal at the upstream.

Two sources of freshwater flow are very crucial for ecological condition of SRF. These are either rainwater or freshwater flow from Ganges at the upstream. In the Sunderbans, major share of freshwater originates from the discharge of the rivers like Gorai and Passure. A dynamic equilibrium condition requires to be maintained between freshwater flow and sea water interaction. It is reported that a minimum of 5000 cusecs of steady freshwater at Gorai is required to hold salinity of Khulna Zone below 1000 micro mhos (Karim *et. al* 1982). A minimum flow of freshwater below this is critical for the ecological balance of SRF.

The earlier studies showed that salinity of water has both seasonal and spatial variations. During pre-monsoon (March-April) conductivity of river water is higher that ranges before 7 micro mhos/cm to 52 micro mhos/cm because of less precipitation and less land discharge and minimum flow of fresh water from upstream rivers. In post monsoon season (August-September) the conductivity of water river decreases (0-21.5) micro mhos/cm due to higher precipitation and higher freshwater from the upstream than that of pre-monsoon season (EIA Report of Goari, 2001).

The simulated salinity level for the Sunderbans based on the absolute minimum flow level suggested that salinity intrusion and its duration into the SRF is dependent on the continuity of upstream water flow of Ganges. Thus, maintaining the regular upstream freshwater flow needs regional co-operation in sharing the resources and maintaining the ecological balance of the SRF . (EIA Report of Goari, 2001).

It is important to note that the srf is recognised internationally as an important ramsar site and a repository for globally significant bio-diversely. Together with the indian part of the Sunderbans, the SRF provides the last refuge to a host of mammals, including the last viable population of the Royal Bengal Tiger (*panthera tigris*) in the world. It has inestimable value as a reservoir for extremely diverse fisheries: diversity consisting about 400 species of fishes and shrimps. It is also a buffer from the ocean and essential breading place for both marine and inland fish and other aquatic life. It represents an ecologically significant area and its conservation and management relates to implementation and compliance with obligation of a number of international treaties and conventions. The major international agreements are:

I) International Plant Protection Convention (Rome, 1951);
II) Plant Protection Agreement for South East Asia and Pacific Region (as amended) (Rome, 1956.);
III) Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 1971) ("Ramsar Convention");
IV) Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington, 1973.) ("CITIES Convention");
V) Convention on Biological Diversity 1992 (CBD);
vi) Conversion on Marine pollution (MARPOL) 1973; and
vii) Conversion on the conservation of migratory species of wildlife (CMS).

Bangladesh and its neighbouring countries are the signatories to many of these international instruments. The identification of the role and obligations of international treaties, protocols and convention and compliance to those in global and regional context may provide an acceptable framework for sharing the resources. The common objectives of all the international instruments are:

(i) to conserve nature for the interest of the local and global community (CBD Article 1, MAPOL 1973 preamble, CMS preamble and Ramsar convention Article 2 and 3.

(ii) to ensure equitable sharing of the benefits of resources including appropriate access to the resources (CBD Article 1).

(iii) to consider the rights over the use of resources (CBD Article 1).

The principles of adopting the international instruments are as follows. Any activity within the jurisdiction of a state cannot cause damage to environment of other states or areas beyond the limits of national jurisdiction (CBD Article 3, CMS Article II). Another principle is to extend co-operation in respect of areas beyond national jurisdiction and other matters of mutual interests for conservation and sustainable use of resources (CBD Article 5, CITES (preamble), MARPOL Article 17, CMS Article II and VII and CMS article VIII) and Ramsar Convention article 5 stressed the need for the settlement of disputes through mutual consultation.

For the evaluation and monitoring of the impact assessment and minimising the adverse effects, the international instruments emphasised on a host of procedures to be followed. The major procedures to:

(i) carry out environmental impact assessment in undertaking any project that is likely to have significant adverse effects on biodiversity so that these negative impacts can be avoided (Ramsar 71 Article 6, CBD Article 14).

(ii) exchange information and consultation on activities that may have significant negative impact on biodiversity of areas under national jurisdiction or areas beyond the limits of national jurisdiction through bilateral, regional or multilateral arrangement as appropriate (CBD Article 14 and Ramsar convention article 5).

(iii) conserve resources and remove obstacles that may have adverse effects (CMS, article III)

Keeping in view the obligations from international instruments including the biodiversity conservation on the earth, the Sunderbans deserve to get priority for attention, as it has been declared as World Heritage (Ramsar Site) in 1997. The conservation of the Sunderbans of both Indian and Bangladeshi part is no longer the responsibility of any particular country, like, Bangladesh alone. There is urgent need for compliance to the international agreements to protect the World Heritage and develop some regional mechanism for resource sharing. It is likely to have some impact on the conservation of biodiversity in the SRF, arrest the process of deforestation in the Himalayas and the maintaining of regular flow of freshwater to neutralise salinity. According to the conventions mentioned above, states at the upstream have the higher responsibility to extend the co-operation in innovating and integrating a regional approach. Similarly, downstream nations highlighting the international obligation may put forward some acceptable framework for co-operation that would be beneficial to all.

VII. RECOMMENDATIONS

Forest is a resource base and a habitat. It is capable of making economic and ecological contribution towards a nation's progress. In view of the ecological/environmental challenges facing the Sundarbans and the increasing needs for the exploitation of its potentials to contribute to the economic development of the country, it is necessary to devise a balanced and coherent forest policy. The policy should be aimed at ensuring ecologically sound and sustainable development of forest resources through balanced and appropriate measures of forest resource expansion, conservation, management and utilisation with all its backward and forward linkages. In this regard, it is of crucial importance that a rational balance between the ecological and economic roles of forest should be established. The long-term goals are to be more explicitly defined by specific categories of objectives and related policy measures. Taking into account the challenges facing the Sundarbans and the tasks ahead it could be visualise that a forest policy needs to achieve at least the following objectives:

a) to effectively conserve, rehabilitate, replenish, expand, develop and manage the forest resources of the Sundarbans as a renewable national asset, to meet the vital needs of the forest goods and services, for the benefits in perpetuity.

b) to protect wild flora and fauna, conserve ecosystems, preserve bio-diversity by maintaining essential ecological processes and improving the environmental services of forest through maintenance and, where necessary, the restoration of ecological balance and the establishment of protected areas.

c) to protect, develop and manage wood and non-wood resources of the Sundarbans in order to maintain a natural environmental balance.

d) to promote efficient and economic harvesting, processing and utilisation of forest products in order to promote sustainable growth of forest based economic activities.

e) to support a large number of inhabitants of the Sundarbans for their livelihood without jeopardising the existing resources of the forest.

f) to establish an adequate and effective mechanism of co-ordination/co-operation with other sectors associated with Sundarban resource utilisation.

g) to facilitate human resource development and promote goal-oriented forestry/forest product research

The achievement of these and related policy objectives depends on how effectively the policy measures are adopted and implemented.

In addition to the above national efforts, an integrated regional co-operation is unavoidable for sustainable management of the Sunderbans. The Sunderban ecosystem represents a linked landscape along the river continuum of the Ganges and its distributaries on the one hand, and coastal bores along the Bay of Bengal on the other. The system is not independent of the neighbouring land areas and the coastal zones. The issue of conservation and management of the ecological balance of the Sunderbans lies within the SAARC region, which is also the most suitable forum to develop an acceptable framework for enhancing co-operation for mutual benefits.

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