

## **Environmental functions of the Teknaf Peninsula mangroves of Bangladesh to communicate the values of goods and services**

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**Abstract** - Mangroves are highly productive wetland ecosystems and extremely important coastal resources providing a variety of environmental goods and services, which are vital to our socio-economic development. To evaluate the role of mangroves, a total of 75 semi-structured interviews were conducted with coastal community, resource user, government official, NGO personnel, researchers, and private entrepreneur to gather primary and secondary information. Results indicated that in the past 30 years there has been planted about 1,460 ha of euryhaline mangroves under different management regimes. Teknaf peninsula mangrove influenced two key variables viz., productivity and physical structure which direct other ecological processes. The variable 'productivity' provide suitable habitat for nursery, growth, migration through recycling waste and nutrients. The respondents identified 13 mangrove resource user groups in Teknaf peninsula which shows high dependency to mangroves goods. The catch of finfishes, shrimps and prawns, crabs, molluscs, etc. from the mangroves area contributes value to the small-scale fisheries. The knowledge gained from the information content of the Teknaf peninsula mangroves ecosystem contributes value to scientific and educational community. In particular, it means that environmental goods and services provided by the Teknaf peninsula mangroves are rarely produced independently and the multiple interdependencies involved in providing such environmental supports.

**Keywords:** Environmental function, ecological processes, productivity, mangroves value, Teknaf peninsula, educational community.

### **Introduction**

Mangrove ecosystems are of great ecological and economic significance in the tropical and sub-tropical coast. Mangrove forests are among the world's most productive ecosystems and commonly known as 'tidal forests', 'coastal woodlands' or 'oceanic rainforests' (Qasim, 1998). A vast majority of human population lives in coastal area, and most communities depend on local resources for their livelihood.

Mangrove ecosystems play important ecological and socioeconomic roles by acting as a nutrient filter between land and sea (Robertson and Phillips, 1995), contributing to coastline protection (Vermatt and Thampanya, 2006), providing commercial fisheries resources (Constanza *et al.*, 1997; 1989) and nursery grounds for coastal fishes and crustaceans. The coastal zone (<200 m depth), covering ~7% of the ocean surface (Gattuso *et*

*al.*, 1998) has an important role in the oceanic carbon cycle, and various estimates indicate that the majority of mineralization and burial of organic carbon, as well as carbonate production and accumulation takes place in the coastal ocean (Gattuso *et al.*, 1998; Mackenzie *et al.*, 2004). The mangrove forests have been shown to sustain more than 70 direct human activities, ranging from fuel-wood collection to fisheries (Lucy, 2006; Kathiresan and Bingham, 2001). Mangroves are the salt tolerant evergreen forests found along sheltered coastlines, shallow-water lagoons, estuaries, rivers or deltas in 124 tropical and subtropical countries and areas, mainly growing on soft substrates. About 15.2 million ha of mangroves existed worldwide in 2005, down from 18.8 million ha in 1980 (FAO, 2007).

The world's largest contiguous and single block of mangrove forests are available in South Asia, the best known as "Sundarban" declared as "world Heritage Site" by UNESCO in 1999 because of supporting a large biodiversity rich unique ecosystem. It is one of the most and largest dynamic estuarine deltas of the world known as Ganges delta which is being controlled by the depositional activities of the Ganga, Brahmaputra and Meghna river at the point where it merges with the Bay of Bengal and shared between Bangladesh 6,017 km<sup>2</sup> (62%) and India 4,246 km<sup>2</sup> (38%) (Chaudhuri and Choudhury, 1994, Guha Bakshi *et al.*, 1999; Mitra and Banerjee, 2004; Hossain, 2009). Sundarban is the only mangrove forest in the world, which is the home of Royal Bengal tiger *panthera tigris* and having the highest population of tiger in the world. The ecological succession of West Bengal area of the Sundarbans in India is quite different from that of the Bangladesh's Sundarbans (Mitra, 2000). The Bangladesh coast supports about 587, 380 ha of natural mangroves and a further 100,000 ha of planted mangroves ( Hossain, 2001; Hossain, 2009).

Teknaf Peninsula is one of the longest sandy beach ecosystems (80 km) in the world. It represents a transitional ground for the fauna of the Indo-Himalayan and Indo-Malayan ecological sub-regions. Important habitats at the site include mangrove, mudflats, beaches and sand dunes, canals and lagoons and marine habitat ( Hossain *et al.*, 2008).

Mangrove ecosystems provide a variety of environmental good and services. Underestimations of their total value and of the impacts of human activities are major factors contributing to the widespread loss and degradation of mangrove ecosystems. Nonetheless, very little attention has been focused on this subject. A key problem is the high degree of interconnectedness within and between ecosystems. This makes it difficult to predict the role of environmental functions towards the goods and services of Teknaf peninsula mangroves. To address this problem, the concept of 'environmental function' is used in combination with systems diagrams. Based on primary and secondary information, system diagrams are used to identify and assess goods and services produced by the Teknaf peninsula mangroves system. These goods and services are then valued to enable assessment of the economic efficiency. This article aims to demonstrate that linking environmental functions through system diagrams with goods and services makes it possible to integrate physical performance of the Teknaf peninsula mangroves ecosystem.

## Materials and Methods

### *Study Area:*

The Teknaf Upazila (sub-district), the southeastern edge of Bangladesh, stands in the trans-boundary of Bangladesh and Myanmar occupying an area of about 388.68 sq km between latitude 21°10' N and 20°40' N and longitude 92°05' E and 92°25' E (Figure 1). It belongs to exposed coast bounded by hilly area and Ukhia Upazila on the north, the Bay of Bengal on the south and west, and on the east the Naaf River and Myanmar coast. The Naaf River is about 55 km long and flows towards the south and finally empty into the Bay of Bengal. It shows linkage with many canals, tributaries, creeks and stream corridors, forming criss-crossed coast. The area is blessed with a warm tropical climate and sufficient rainfall which enable to support a wide biological diversity. The western coast of Teknaf is sandy and the major soil type is non-calcareous alluvium (Islam, 2004).

### *Data collection and Analysis:*

Participatory Rural Appraisal (PRA) technique following the approaches of Pido (1995), Pido *et al.* (1996), Townsley (1996), IIRR (1998) and Hossain *et al.* (2004) was used as an investigative and participatory method to explore possible trends in the use of mangroves at local scale. Based on mangrove distribution, the study area was divided into five unions and five villages were selected from each of the union to conduct the social survey. A total of 75 semi-structured interviews were conducted with coastal community, resource user, government official, NGO personnel, researchers, and private entrepreneur to gather primary information. Focusing on the role of mangrove, the semi-structured interview embodied four main themes:

1. Identification and perceived abundance of mangrove.
2. Identification of environmental goods from mangrove.
3. Understanding the ecological services provided by mangroves.
4. Understanding the environmental functions to communicate the mangrove values.

Participants were asked questions in group meeting regarding the availability of mangrove resources and their possible role in surrounding environments and local community as well. Using visual aid and following a common format, each informant was asked a series of questions were based on information gathered from a variety of sources that include informal interviews with local and regional government officials, unpublished and published reports and from several preliminary interviews conducted in the five villages of Teknaf peninsula. Different tools such as worksheets, maps, and figures were used to support the interview. In cross checking among different groups, a high degree of uniformity was maintained. Group meetings with local communities are an important way of learning about local conditions and resources (Pelto and Pelto, 1978).

In addition, direct observation prevents rapid appraisal from being misled by myth (Chambers, 1980) and it often provides more valid and less costly information than other research methods (KKU, 1987). Local analyses of secondary information were done by using topographic maps and land use maps at 1:10,000 and 1:50,000 scale, a series of photographs and videos which also minimized the information gap.

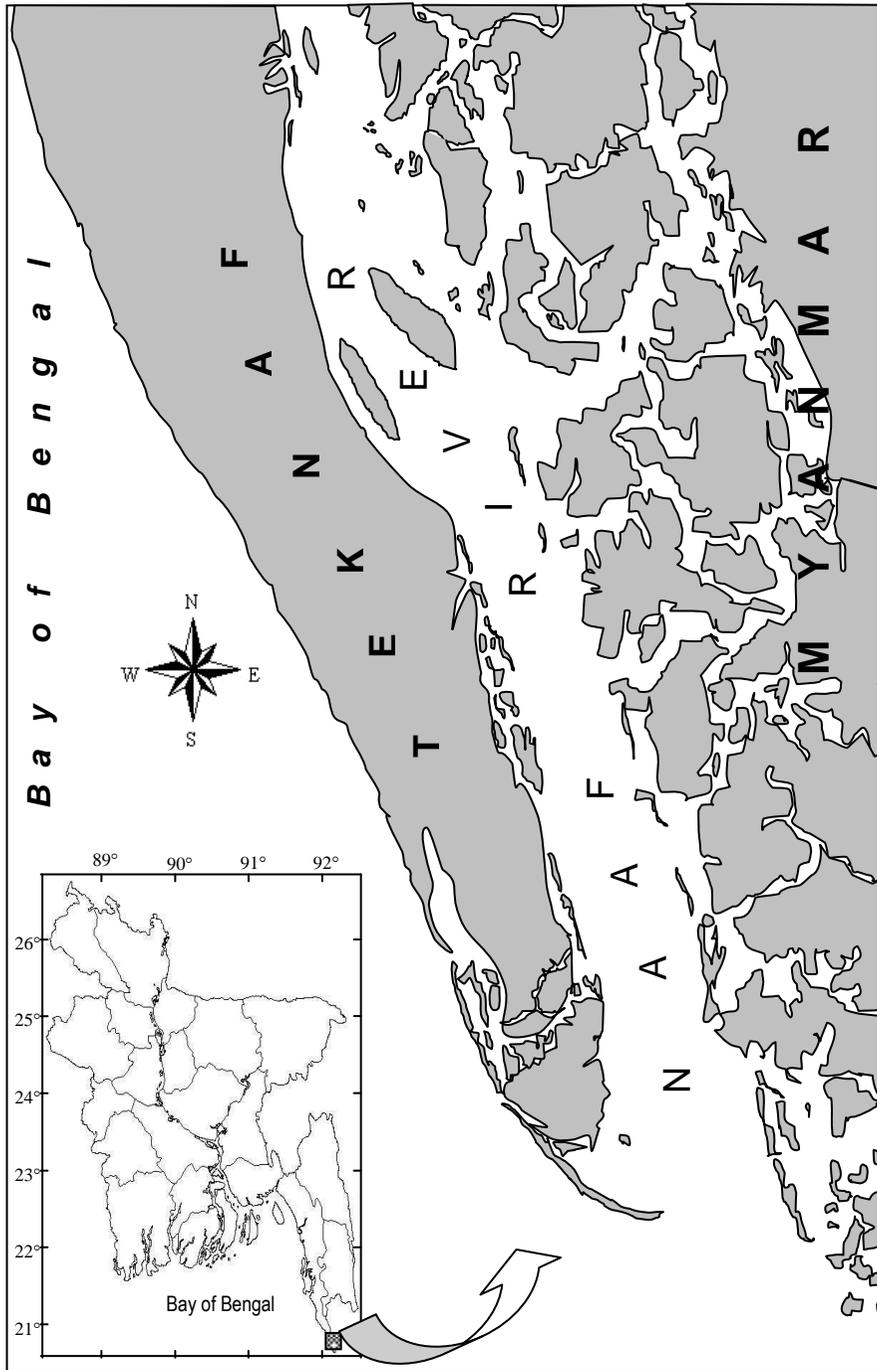


Figure 1. Geographical location of the Teknaf coast and Naaf River.

## Results and Discussion

### *Mangrove forest in Teknaf Peninsula:*

Mangrove forest occurs in Teknaf peninsula both as natural forest with planted stands and mostly distributed in the intertidal zone. The supra-littoral and littoral zone is more suitable for mangrove afforestation than the sub-littoral zone in Teknaf peninsula, where the tidal range varies from 2.5 to 4.42 m. The Department of Forest initiated mangrove afforestation in Teknaf region on the outside of the protective coastal embankments in 1974 with the primary objective of saving life and properties of the coastal communities from cyclone and tidal bore. In the past 30 years there has been planted about 1,460 ha of euryhaline mangroves (Table 1), *Sonneratia* spp. (local name *Keora*) in 70% area and *Avicennia* spp. (local name *Baen*) in 20% area under the Coastal Afforestation Project, Forest Resource Management Project and Coastal Green Belt Project at Teknaf coast. There are also found Hantal (*Phoenix paludosa*) and Nunia Jhao (*Casurina littorea*).

### *Environmental Functions of the Teknaf Peninsula Mangroves:*

The Teknaf Peninsula mangroves perform numerous functions that include a set of ecological processes responsible for providing an environmental good or service. The quality of mangrove cover derives the ecological processes (Figure 2) which control the performance of environmental functions and so the supply of environmental goods and services (Figures 3 and 4). Use of these goods and services contributes value to the users (Figures 5 and 6). An environmental problem develops with overuse where demand for any good or service exceeds its supply. A problem may trigger feedbacks within the ecosystem, or generate costs via linkages between the ecological and the economic systems (Gilbert and Janssen, 1998).

### *Ecological processes:*

Two mangrove quality categories viz., good and degraded – are identified in Teknaf peninsula (Figure 2), with degradation and regrowth generating dynamics between them. Mangroves are removed with irrational and unplanned horizontal expansion of coastal shrimp culture and salt pen development along the bank of the Naaf River. Historically, this has concentrated on degraded sites. Among the five (5) unions of Teknaf peninsula, mangroves of Teknaf Sadar and Sabrang unions severely degraded, where the other areas also vulnerable due to the recent shrimp farm development, residential, commercial and agricultural real estate by land filling activities. The quality of Teknaf peninsula mangrove cover has a direct influence on two key variables viz., productivity and physical structure which direct other ecological processes. The variable 'productivity' provide suitable habitat for nursery, growth, migration through recycling waste and nutrients. The physical structure of mangroves is largely determined by their above-ground root systems and this also contributes to productivity. The retardation of water flow, as well as the roots themselves, facilitates sediment control. There are few environmental problems occurs due to the degradation of the mangroves in Teknaf peninsula which are defined in Figures (3 and 4).

Table 1. Historical trends of year-wise mangrove afforestation in Teknaf for 30 years time scale.

Year	Plantation site	Name of project and planted area (ha)					
		CAP	MAP	FP	FRMP	EFRMP	CGBP
1974-75	Teknaf Sadar	10					
1975-76	Teknaf & Shah-Porir Dip	142					
1976-77	Teknaf, Shah-Porir Dip, Nhila	209					
1977-78	Shah-Porir Dip, Nhila	107					
1978-79	Do	182					
1979-80	Do	121					
1980-81	Teknaf & Shah-Porir Dip		81				
1981-82	Shah-Porir Dip		101				
1982-83	Shah-Porir Dip and Katabonia		263				
1983-84	Shah-Porir Dip		121				
1984-85	Teknaf Sadar		41				
1991-92	Teknaf and Shah-Porir Dip			20			
1992-93	Teknaf, Shah-Porir Dip, Nhila				26		
1993-94	Do				20		
1994-95	Shah Porir Dip				3		
1995-96	CGP Embankment, Nhila						Strip – 3 km
1998-99	Nhila				2		
1999-00	FRMP-Nhila						
	CGP-Embankment						Strip – 29 km
	R&H-Nhila				3		Forest 1.8
2000-01	Foreshore-Shahporir Dip						
	R&H-Shah Porir Dip						Strip – 8 km
	Link- Shah Porir Dip						Forest 1.8
2003-04	Foreshore-Teknaf Sadar						
	Nhila					4	
Total		771	607	20	54	4	Strip – 40 km Forest 3.3

Source: Coastal Forest Department, 2004

CAP = Coastal Afforestation Project, MAP = Mangrove Afforestation Project, FP = 2<sup>nd</sup> Forest Project, FRMP = Forest Resource Management Project, EFRMP = Extended Forest Resource Management Project, CGBP = Coastal green Belt Project

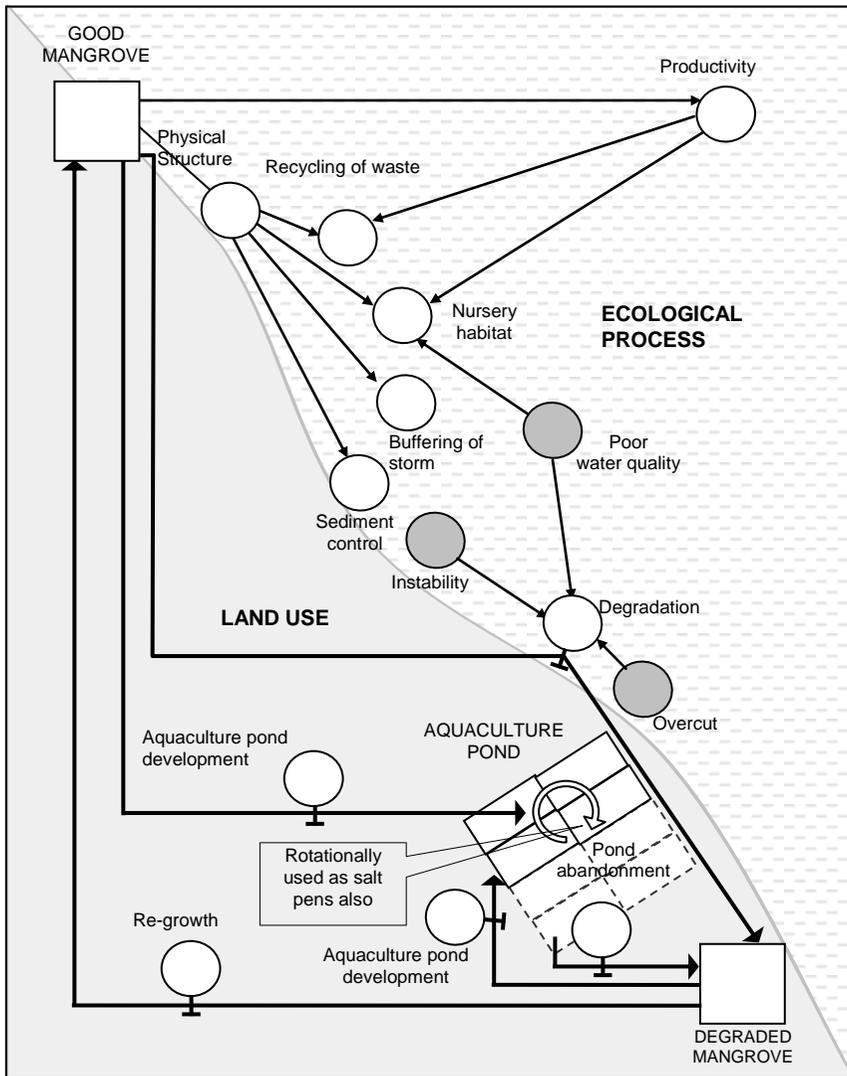


Figure 2. Land use and ecological processes in the Teknaf peninsula mangroves

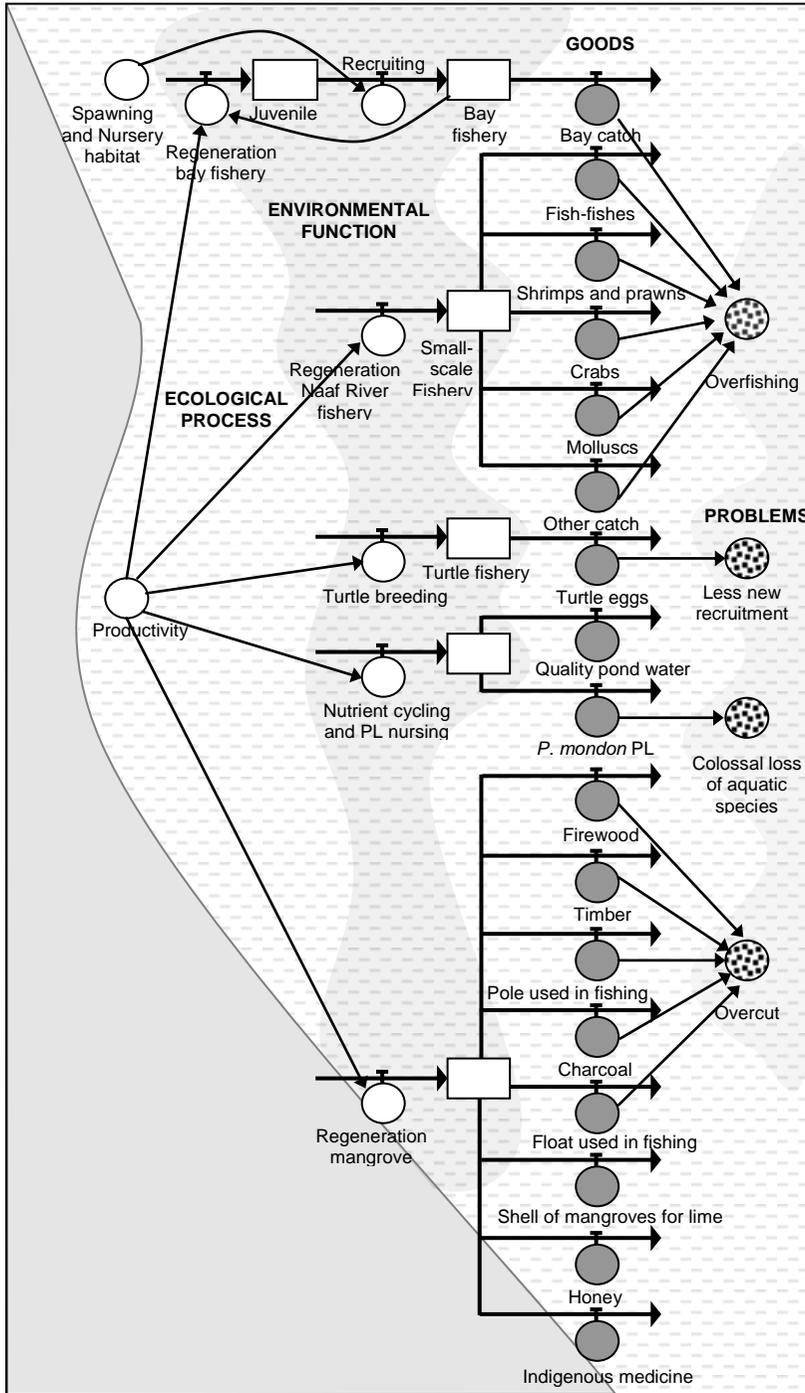


Figure 3. Production of environmental goods by the Teknaf peninsula mangroves

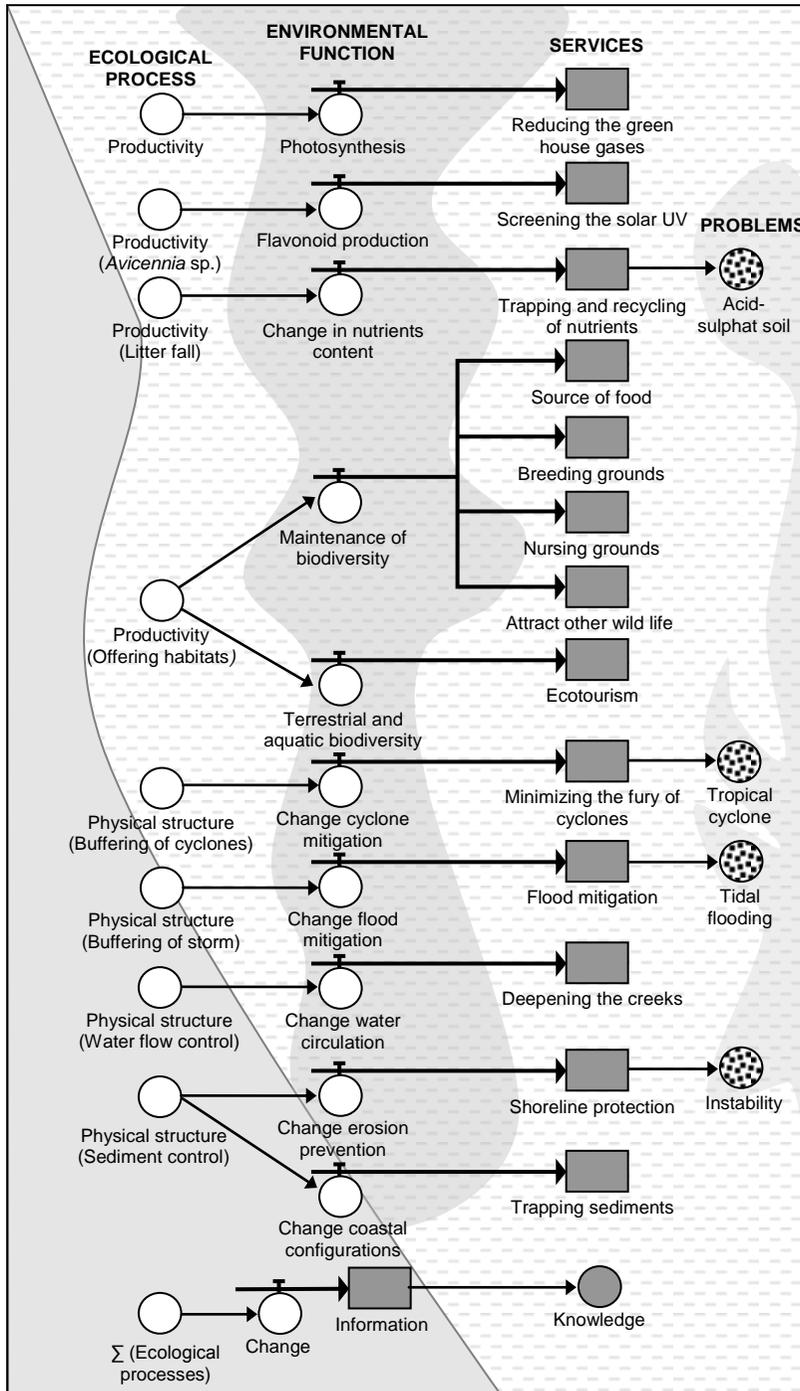


Figure 4. Production of environmental services by the Teknaf peninsula mangroves.

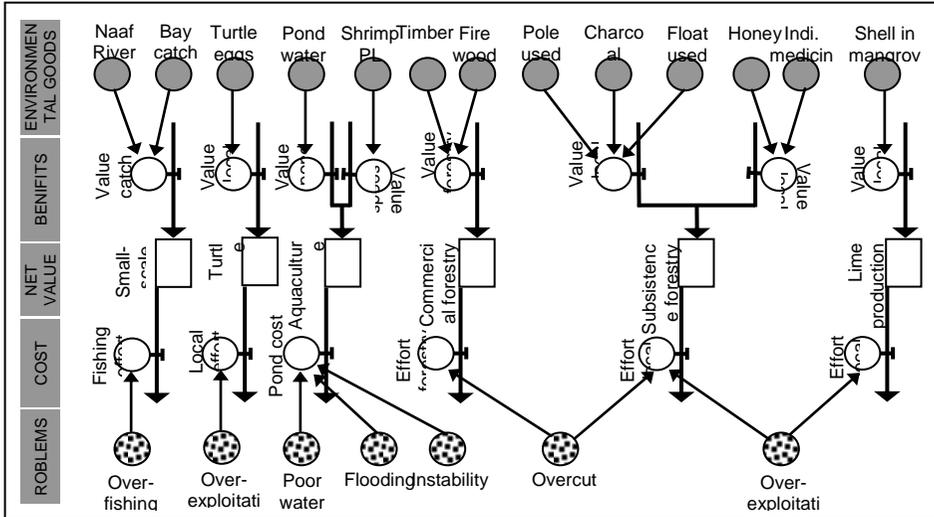


Figure 5. Value of environmental goods provided by the Teknaf peninsula mangroves.

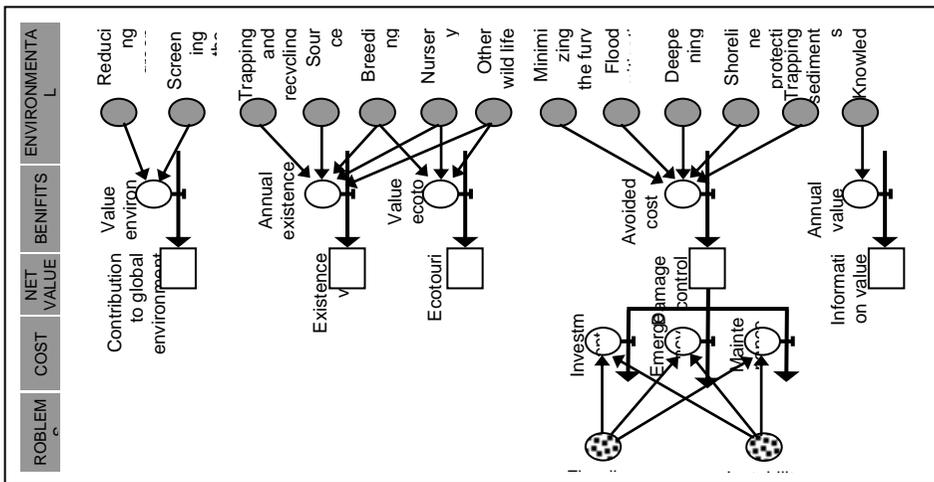


Figure 6. Value of environmental services provided by the Teknaf peninsula mangroves.

*Environmental goods:*

Figures (3 and 4) describe the production of environmental goods and services by the Teknaf Peninsula mangroves. The figures use a common

format moving from left to right: ecological process, environmental function, environmental goods and services and environmental problem. The respondents identified 13 mangrove resource user groups in Teknaf peninsula (Figure 7) which shows high dependency to mangroves goods.

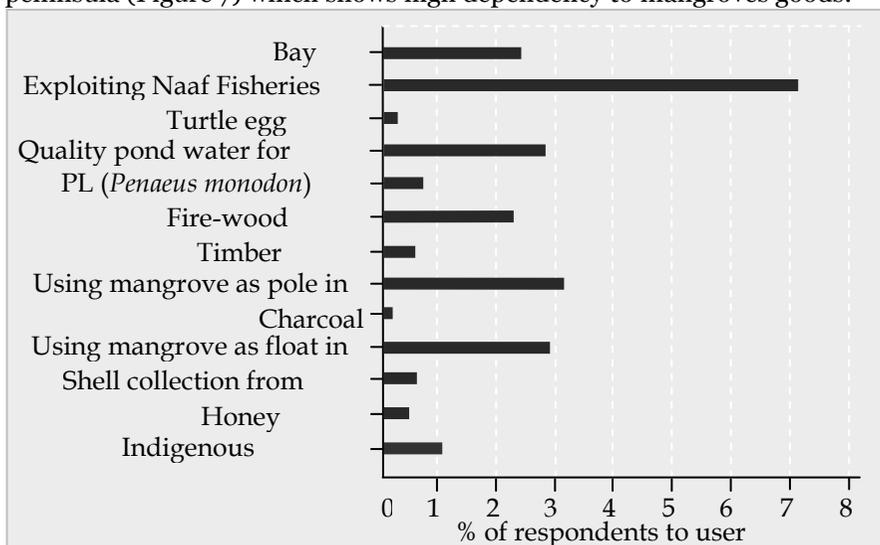


Figure 7. Mangroves resource users group in the Teknaf peninsula.

#### *Naaf River Fishery:*

Mangrove ecosystems are important for fish production. They serve as nursery, feeding and breeding grounds for many fishes and shellfishes. Nearly 80% of the fish catches are directly or indirectly dependent on mangrove and other coastal ecosystems worldwide (Kjerfve and Macintosh, 1997). The Teknaf peninsula mangroves supports the habitat of 161 different fisheries species, comprising of 98 species of fin fishes, 23 shrimps and prawns, 13 crabs, 11 molluscs, 3 echinoderms, 4 species of other crustaceans and 9 unidentified (Chowdhury *et al.*, 2009 and Chowdhury *et al.*, 2008). Local communities of the villages are extremely dependant on fisheries resources of the Naaf River. 1932 fishermen were engaged in fishing in the Naaf River estuary which exploited about 6000 MT of fisheries resource annually. The total catch comprised of 38.85% shrimps and prawns, 15.27% fin-fishes, 5.33% crabs, 4.29% echinoderms, 0.58% molluscs and 35.67% other crustaceans. It is widely believed that the mangroves are like the roots of the sea and, if there are no mangroves forest along the coast, there will be either no fish or fewer fish in the sea and the sea will act like a tree without roots. One hectare of mangroves can yield 767 kg of wild fish and crustaceans, which is more than the yield in extensive system that can yield <500 kg /ha/yr (Primavera, 1991).

#### *Aquaculture Industry:*

The mangroves provide suitable water and seeds for aquaculture industries. The collection of shrimp post larvae (*Penaeus monodon*) from

the Naaf River is the principle source of post larvae for stocking extensive and improved extensive coastal shrimp culture ponds in Teknaf. There are 354 shrimp farms occupying 2675 ha area in Teknaf coast. 400 fishers get an annual yield of about 15 million seeds of *Penaeus monodon* for aquaculture, in the mangroves of Teknaf peninsula.

#### *Turtle Fishery:*

Five species of marine turtle are reported to occur in the coastal waters of Bangladesh: the olive ridley (*Lepidochelys olivacea*), the green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) (Rashed and Islam, 1999). The beach of Shahporir Dip in Teknaf peninsula is a suitable breeding ground for turtle. Olive ridley and green turtles are dominant in mangrove vegetated areas of Shahporir Dip, Hawksbill and leatherback turtle nests are rarely found.

#### *Ecological Services:*

Much of the ecological service of mangroves lies in protecting the coast from solar UV-B radiation, 'green house' effects, and fury of cyclones, floods, sea level rise, wave action and coastal erosion. Mangrove swamps act as traps for the sediments, and sink for the nutrients. The root systems of the plants keep the substrate firm, and thus contribute to a lasting stability of the coast. The ecosystem provides a source of food, breeding grounds and nurseries for many food fishes and shellfishes, and they do very often encourage and attract other kinds of wildlife. They further help in offering protection to other associated flora and fauna of the ecosystems including the islands. The mangrove ecosystems are highly productive and comparable to good agricultural land. Benefits of mangroves are 25 fold higher than that of paddy cultivation.

#### *Minimizing the fury of cyclones:*

Mangrove forests protect all types of coastal communities from the fury of cyclones and storms. Mangroves seem to act as a protective force towards this natural calamity (Mackey and Smail, 1996). The best example on finds is the cyclone which occurred on the 29<sup>th</sup> April, 1991 with a wind speed of 220-230 km hr<sup>-1</sup> along the Teknaf coast and played havoc largely in the areas devoid of mangroves. On the contrary, practically no damage occurred in regions with luxuriant mangrove growth. Similarly, in the Shahporir Dip where large scale deforestation and reclamation of mangrove land for other purposes have been undertaken, maximum losses of life and property have been reported from time to time during stormy weather. These events beyond doubt prove that mangroves can form the best shelterbelt against cyclones and storms and have generated awareness among the local communities of the importance of mangrove forests as protectors of life and property.

*Prevention of the coastal erosion:*

The mangrove systems minimize the action of waves and thus prevent the coast from erosion. The reduction of waves increases with the density of vegetation and the depth of water. This has been demonstrated in Teknaf peninsula. In the tall mangrove forests, the rate of wave reduction per 100 m is as large as 20% (Mazda *et al.*, 1997).

*Trapping the sediments:*

One of the important functions of mangroves is trapping of sediment, and thus acting as sinks to the suspended sediments (Wolanski, 1995; Furukawa *et al.*, 1997). The mangrove trees catch sediments by their complex aerial root systems and thus function as land expanders. In situ observation, few newly accreted lands were observed in Subrang Union of Teknaf peninsula where mangrove plantations were done in 1991-92. In numerous cases, there has been proof of annual sedimentation rate, ranging between 1 and 8 mm, in mangrove areas with expansion of land (Bird and Barson, 1977).

*Deepening the creeks:*

Water circulation through mangrove forests is important especially for the riverine forest like Teknaf peninsula mangroves, which often consists of tidal creeks and surrounding forest swamps. The water movement in the creeks is different from the swamps, as the former is deep, while the latter is shallow, colonized with vegetation. The cause of water movement is the tide. The flow of water during the low tide is much greater than that of the high tide. For example, the riverine mangroves produce asymmetrical tidal currents which are 50% stronger at the low tide than at the high tide (Medeiros and Kjerfve, 1993). The fast low tide tends to flush out the material from the mangrove area and maintains the depth of creeks. If the area of forest swamp is reduced, then the speed of the low tide is reduced and there is a possibility for the creeks to get clogged up. This has been commonly observed in the Teknaf Sadar union where deforestation of mangroves has reduced the navigability of the canals and river mouths.

*Trapping and recycling of nutrients:*

The mangrove sediments have the ability to retain nutrients. This depends on the sediment characteristics and flow patterns of the sites. Mangroves such as *Avicennia* spp. in general are tolerant to high organic load. In Teknaf Sadar union, *Avicennia* spp. is newly planted in aquaculture ponds for controlling salinity and pH in rainy season. Mangrove sediments have a high capacity for absorbing and holding heavy metals thereby preventing the spread of metal pollution in coastal areas. The sediments contain 90% of Mn and Cu released and almost 100% of the Fe, Zn, Cr, Pb and Cd in the total ecosystem.

The detached parts of the mangrove plants when fall on the floor are called 'litter-fall'. These include leaves, stems, roots, flowers and fruits. The decomposed organic matter along with microbial biomass is known as detritus. This is an important product produced in the mangrove ecosystems. Calorific value of detritus in the Naaf estuary ranged from 157

to 4659 cal g<sup>-1</sup> dry weight (average 1186). This is because the detritus from Naaf contains substantial quantities of decaying mangrove leaves. The Naaf River estuarine complex is a mangrove ecosystem (1460 hectares of mangrove forest are spread all along the estuarine areas in left bank at Bangladesh part, where it is assumed that right bank at Myanmar occupied 10 times more mangroves) with litter yield, ranging from 4.3 to 6.9 tones ha<sup>1</sup> yr<sup>-1</sup> with a maximum fall in pre and post-monsoon months and minimum during the monsoon season.

#### *Biomass and Litter Production:*

Mangroves contribute significantly to the global carbon cycle. Mangrove forest biomass may reach 700 t ha<sup>-1</sup> (Twilley *et al.*, 1992) estimate the total global mangrove biomass to be approximately 8.7 gigatons dry weight (*i.e.* 4.0 gigatons of carbon). Estimates of the annual global litter fall from mangroves range from 130 to 1870 g m<sup>-2</sup>. In Teknaf peninsula, *Avicennia* spp. litter production is high in the post-monsoon period and low in the pre-monsoon season. Litter from the mangroves is composed of leaves, twigs, branches and seeds. Seeds alone accounted for about 25% of the total litter fall for *Avicennia* spp. in mangrove habitat at Teknaf peninsula. Accumulated mangrove litter may wash into rivers and streams when rain or tides inundate the forest (Conacher *et al.*, 1996).

#### *Litter Decomposition and Nutrient Enrichment:*

Mangrove ecosystems produce large amounts of litter in the form of falling leaves, branches and other debris. Decomposition of the litter contributes to the production of dissolved organic matter (DOM) and the recycling of nutrients both in the mangrove area and in adjacent habitats. The weight loss of different classes of leaf and non-leaf litter varied from 43 to 78% as partial decomposition rate was found to be slower for non-leaf litter in Bangladesh Sundarbans (Hoq *et al.*, 2002). The average concentration of NO<sub>2</sub>-N, PO<sub>4</sub>-P, and SiO<sub>3</sub>-Si in the Naaf River was 0.69±0.21µ-g at/l, 0.72±0.25µ-g at/l, and 70.67±38.80 µ-g at/l respectively (Hossain *et al.*, 2007). The organic detritus and nutrients could potentially enrich the coastal sea and, ultimately, support fishery resources. The soil of mangrove vegetated areas in Teknaf peninsula contains 1.539±0.369% organic carbon. Decomposition is influenced by tidal height, rainfall and temperature. In Teknaf peninsula mangrove forests, mangrove debris decomposes substantially faster in the rainy season. The animals may process large volumes of the litter, contributing significantly to nutrient dynamics. Mangrove forest in Teknaf peninsula, crabs process about 65% of the litter deposited in the high intertidal. In field experiments, Twilley *et al.* (1997) found that mangrove crabs process the mangrove leaf litter in only one hour. Because the mangrove material is quite refractory, it may need to decompose for some time before it is useful to other invertebrates.

#### *Eco-tourism:*

Stretches of muddy beaches are seen along the Naaf River. The beaches differ in shape, appearance, slope and their exposure to intertidal zone.

Such a beautiful gently sloping beach with mangrove forest in the background has been enriched the coastal line of Teknaf peninsula in the east. Visits to the fascinating Naaf estuary with mangrove forest and cruising journey to Saint Martin's Island is really spectacular to tourist. The coastal zone and the near shore areas of Teknaf peninsula consist of diverse environment including muddy and sandy beaches, sand dunes, and mangrove vegetated Naaf estuary which act as a corridor between the terrestrial and marine biodiversity and attract huge number of national and international tourist per annum.

*Value of Goods and Services:*

Figures (5 and 6) attempt to capture environmental-economic aspects of using the Teknaf Peninsula mangroves. The approach taken is to imply a net value per sector but considering only 'environmental' benefits and costs. The figures show an annual value derived from using environmental goods and services (flows) accumulating in a net value per sector (stocks). The catch of finfishes, shrimps and prawns, crabs, molluscs, etc. contributes value to the small-scale fisheries. Various goods, mainly for firewood, shell on the mangroves, honey, and medicine, were taken by locals from the mangrove ecosystem and so contribute to the value of the subsistence forestry sector. Excessive increases of effort to harvest these environmental goods triggered the over-fishing, over-cut and over exploitation problems. The shoreline protection and flood mitigation services of mangrove ecosystems help governments and private individuals to avoid the costs of constructing dykes to limit storm and erosion damage. Biodiversity provides an annual value to two sectors, ecotourism and existence value. Migratory bird species which use the Teknaf peninsula mangroves contributes to ecotourism. The knowledge gained from the information content of the Teknaf peninsula mangroves ecosystem contributes value to scientific and educational community.

*Problems in Teknaf peninsula mangroves:*

The mangrove forest has been subjected to heavy human interference in Teknaf coast. The factors responsible for the destruction of mangrove forest are shrimp farming, salt production, removal of forest produces for fuel wood, and human settlement. Irrational and unplanned horizontal expansion of coastal shrimp culture has completely destroyed the mangrove forest at the eastern boarder of Teknaf Sadar and Subrang. Degraded mangroves have negative effects on environmental goods and services (Tables 2 and 3), which completely coincide with the findings of expert judgment. The respondents of the Teknaf peninsula indicated that the clearance of mangrove forest is not only causing a colossal loss of coastal habitat, aquatic resources and biodiversity, but also increase the soil erosion, changing sedimentation patterns and shoreline configurations, increasing vulnerability to cyclonic storms, tidal bores and the denudation of feeding, breeding and nursery ground for various marine, estuarine and freshwater fishery resources. Therefore, a well-established management practice of shrimp farming, salt production, human settlement and other

Table 2. Local perception regarding the role of mangrove to environmental goods in comparison with expert judgment.

Environmental Goods	Good mangrove		Degraded mangrove	
	Local perception	Expert judgment	Local perception	Expert judgment
Bay catch	+	++	0	0
Naaf River fisheries resources	++	+++	0	+
Turtle eggs	0	++	0	0
Quality pond water for aquaculture	+	+++	0	+
PL ( <i>Penaeus monodon</i> )	+	++	0	0
Fire wood	+	+	++	+++
Timber	0	0	++	++
Pole used in fishing	0	0	++	++
Charcoal	0	0	+	+
Float used in fishing	0	0	++	++
Shell collection from mangrove	++	++	0	0
Honey	+	++	0	0
Indigenous medicine	++	++	+	+

+++ : large contribution; ++ : moderate contribution; + : small contribution; 0 : no contribution

Table 3. Local perception regarding the role of mangrove to ecological services in comparison with expert judgment.

Environmental Services	Good mangrove		Degraded mangrove	
	Local perception	Expert judgment	Local perception	Expert judgment
Reducing the Green house gases	+	+++	0	+
Screening the solar UV	0	+++	0	+
Recycling and trapping nutrients	+	+++	0	+
Source of food for aquatic organism	++	+++	0	+
Breeding grounds	++	+++	0	+
Nursery grounds	++	+++	0	+
Attract other wild life	+	+++	0	0
Ecotourism	+	+++	0	0
Minimizing the fury of cyclone	+++	+++	0	+
Flood mitigation	++	+++	0	0
Deepening creek	+	++	0	0
Shoreline protection	+++	+++	0	0
Trapping sediments	++	+++	0	0
Knowledge	+	+++	+	+++

+++ : large contribution; ++ : moderate contribution; + : small contribution; 0 : no contribution

activities in the mangrove ecosystem need to incorporate into the government policy to maintain environmental and economic sustainability. Equally, mangrove afforestation program needs to undertake in the newly accreted coastal lands for the socio-economic and environmental benefits of the Teknaf peninsula. The results from the present study indicate that Teknaf peninsula mangroves are complex systems which provide a variety of goods and services to local community. By comparing the local perception and expert judgments, it was found that the interconnectedness with in such ecosystems is relatively high which leads to uncertainty and unpredictability. In particular, it means that environmental goods and services provided by the Teknaf peninsula mangroves are rarely produced independently and the multiple interdependencies involved in providing such environmental supports.

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