An analysis of the damages of Chakoria Sundarban mangrove wetlands and consequences on community livelihoods in south east coast of Bangladesh

Shafi Noor Islam

Euro-Aquae Hydro-Informatics and Water Management,
Brandenburg University of Technology Cottbus,
Konrad-Wachsmann-Allee 1,
D – 03046 Cottbus, Germany
Fax: +49-0355-69-2743
E-mail: shafinoor@yahoo.com

Abstract: Mangrove wetlands constitute a part of human natural and cultural heritage. They have importance for the country's economic, industrial, ecological, socio-economic and cultural aspects. The Chakoria Sundarban is the second largest mangrove wetland ecosystem in south eastern coastal region in Bangladesh. It covers 3.5% of the main Sundarban. The poor of the Chakoria mangrove wetland areas were dependent on mangrove resources for their livelihoods. The wetland habitat is threatened due to unplanned decision and destruction of mangrove forest. The Chakoria mangrove forest and wetland has been completely disappeared within 107 years (1903 to 2010). It was recognised as a driving force for coastal socio-economic improvement and biodiversity conservation. An analytical analysis of the various issues leading to mangrove forest ecosystem degradation is made in this study. The result shows that the coastal communities have lost their livelihoods option. The objective of this study is to understand the present sensitive mangrove wetland ecosystems and shrimp culture scenario analysis for future development.

Keywords: Chakoria Sundarbans; mangrove wetland; ecosystem; policy; resource protection; management.

Reference to this paper should be made as follows: Islam, S.N. (2014) 'An analysis of the damages of Chakoria Sundarban mangrove wetlands and consequences on community livelihoods in south east coast of Bangladesh', *Int. J. Environment and Sustainable Development*, Vol. 13, No. 2, pp.153-171.

Biographical notes: Shafi Noor Islam is a Lecturer in Euro-Aquae Hydro-Informatics and Water Management, at the Brandenburg University of Technology Cottbus, Germany. He holds PhD in Environmental Sciences. He was working as Guest Lecturer at the Technical University of Berlin. He has Post-Doctoral experiences and a candidate for Dr.rer.nat.habil. degree at the BTU Cottbus, Germany. His main activities are in the interdisciplinary water resource research, water salinity modelling and mangrove ecosystem analysis. Wetlands, food security and ecosystem services are the focus research fields. He has published 50 articles in international journals and books. He has research experiences in China, Malaysia, Indonesia, Germany, Sweden, Poland, Denmark, Italy, Spain, France, Netherlands, Belgium and Mexico.

1 Introduction

The coastal mangrove ecosystems of Bangladesh contains a highly functional and structurally diverse ecology which is gradually being degraded (Iftekhar, 2006; Miah et al., 2010).Throughout history, human settlements have concentrated along coastlines, rivers and in alluvial plains they provide for agriculture, fisheries and trade. Mangrove wetlands have great importance for the regional economy, industrial, ecological, socio-economic and cultural importance in the coastal regions (Islam, 2007). It contains very rich components of biodiversity of local, national and regional significance (Islam, 2007; Islam and Gnauck, 2009a). It is also providing critical habitat for biodiversity, including wild shrimp larvae which used to stock farms and recruitment areas for brood stock and spawners used in hatcheries (Primavera, 1993; Ronnback, 1999).During the last three decades, mangroves have experienced widespread deforestation, ecological degradation, and as a consequence more than 50% of the world's mangroves have been removed (FAO, 2007). In Bangladesh the rate of mangrove destruction is almost 45%. The conversion into shrimp aquaculture ponds constitutes the main threat to mangroves in many countries (Primavera, 1997; Naylor et al., 1998). It is estimated that 1–1.5 million ha of coastal lowlands have been converted into shrimp farms, mainly in China, Thailand, Vietnam, India, Indonesia, Philippines, Malaysia, Bangladesh, Ecuador, Mexico, Honduras, Panama, and Nicaragua (Rosenberry, 1998; Rosamond, 2002). In Bangladesh, mangroves support rich biological diversity of flora and fauna and their biodiversity have been contributing substantially to the socio-economic life of the coastal community by providing opportunities of employment, food, nutritions, fuel, fodder and transportation (Rahman, 1995). In addition mangroves of Bangladesh have suffered drastically from the impacts of burgeoning anthropogenic activities (Khan et al., 1994; Nair, 2004; Islam, 2010). A number of shrimp ponds have been developed along the periphery of the Sundarbans mangrove reserve forest area in Khulna region and in the Chakoria Sundarban region in the south east coast of Cox's Bazar in Bangladesh (Deb, 1997). The degradation of mangrove of south eastern coast in Bangladesh has started three decades ago, with the rapid expansion of shrimp farming the mangrove ecosystem has been greatly affected (Deb, 1997).

There are 43 designated wetlands and sensitive sites are recognised in Bangladesh and Chakoria mangrove forest is one of the sites which is severely damaged due to anthropogenic influences. In the past Chakoria Sundarban mangrove wetland was playing an important role in the south east coastal region (Islam and Gnauck, 2008, 2009b). About 400,000 people of the Chakoria upazila of Cox's Bazar district are directly or indirectly depended on coastal mangrove resources for their livelihoods (Hussain and Samsuddoha, 2008; Islam and Gnauck, 2008, 2009b). Mangrove wetlands conservation is increasingly becoming significant in Bangladesh as more people particularly the coastal dwellers derive their livelihoods support from mangrove wetlands goods and services (PDO-ICZMP, 2005). A comprehensive analysis of the various issues leading to mangrove wetlands degradation is made in this study. The paper discusses about the livelihoods activities of coastal community in the Chakoria Sundarban mangrove ecosystem located in Cox's Bazar district.

2 Objective of the study

The objective of this study is to understand the present sensitive coastal mangrove ecosystem status of Chakoria Sundarban in different aspects. The specific objectives are as follows:

- to analyse the mangrove destruction, imbalance ecosystem and negative impacts on community livelihoods in the Chakoria Sundarban area of Cox's Bazar district
- to analyse the scenario of the degraded mangrove ecosystem and its goods and services which are the root causes for squeezing of livelihood opportunities of the coastal communities in Chakoria Sundarban region
- by introducing the potentiality of GIS, remote sensing (RS) application and making some practical recommendations for conservation, better management plan we can lay the path for future development of ecosystem goods and its services in the Chakoria coastal region for livelihood sustainability of the east coast of Bangladesh.

3 Data and methodology

The study was conducted based on primary and secondary data sources. A short field visit was arranged for primary data collection on the Chakoria Sundarban area in Cox's Bazar district in 2008. 12 focus group discussion (FGD) and participatory rural appraisal (PRA) practices were arranged in Chakoria upazila in the Cox's Bazar district, which includes the interior coastal region. The ecological and socio-economic data on Chakoria Sundarban mangrove wetlands area were collected from secondary sources, expert people interviews and personal life story talking. Some information which has been collected from the main Sundarbans region also been used for this study. Besides the geomorphological, anthropological, the present land use and community livelihood related data were collected from various environmental research reports published in 2008 and 2010. A number of standard approaches were used for data analysis including review literature of studies to get basic understanding of mangrove wetlands degradation and rural livelihood changing pattern. The secondary data inputs came from different publications of the Government agencies, NGOs reports and research organisations in Bangladesh. Collected data and information were rearranged, analysed, graphic designed and visualised through using EXCEL, VISIO 32 and ArcGIS 10 software.

4 Geographical location, physical setting and climatic condition

The Chakoria Sundarban area is located along the Chittagong coast in Chakoria upazila of Cox's Bazar district. The area is most extended plain land mass located between 21° 35´ N to 21° 48´ N latitude and 91° 57´ E to 92° 15´ E longitude (Hossain, 2001; Musa, 2008). The land is flat and intersected by innumerable creeks and channels. The forest occupies the central part of the Matamuhuri River delta (Siddiqi, 2001; Musa, 2008). The mangrove forest is composed of 11 islands in the delta of the Matamuhuri River. The width of the delta in the north is 14 km. Mean annual maximum and minimum temperature of the area varies between 20° and 32°C. The annual rainfall in the Chakoria Sundarban is about 3,500 mm (Siddiqi, 2001). The rainfalls are heavy and frequent during the monsoon season. The rains are comparatively heaviest in term of depth during the month of May to October. The location of the landward boundary of the coastal zone is a function of three basic geophysical processes: tidal fluctuations, salinity, risk for cyclone and storm surges. The mangrove forest occupies the central part of the Matamuhuri delta. The whole forest is a mud flat, formed by siltation in the mouth of Matamuhuri River. Quality and composition of soil are more or less like those of the western part of the main Sundarbans mangrove. The Chakoria Sundarban mangrove forest covered an area of about 21,000 ha and only 8,540 ha was declared as reserved forest in 1903 (Cowan, 1926). Subsequently this mangrove wetland forest used to cover an area of 7,490 ha reserved and 1,020 ha protected forests up to 1988, when the process of releasing land from the Forest Department to the Fisheries purposes was started.

Figure 1 displays the location of the case area and the process of massive destruction of mangrove forest in the Chakoria Sundarban in Cox's Bazar. The climatic condition Cox's Bazar area is average dry-hot, humid-hot and cold temperature (Musa, 2008). The temperature is another climatic factor affecting the growth and development of the biological resources in these areas. The climate and rainfall distribution of the area is of tropical nature dominated by the south west monsoon of the Indian Ocean (Musa, 2008). The humidity is generally high throughout the period; the range is from a minimum of 27.6% to a maximum of 98%. The cyclone storms originating in the high seas during April–May and October–November associated with tidal wave severely affect the tidal area, when crops, livestock, properly and human lives are lost (Musa, 2008). The landscape of Chakoria Sundarban mangrove forest has been changed in five different stages within last 107 years. The Table 1 showing the forest landscape changing pattern in the Chakoria coastal region.

Figure 1 The geographical location of Chakoria Sundarbans mangrove wetlands (see online version for colours)

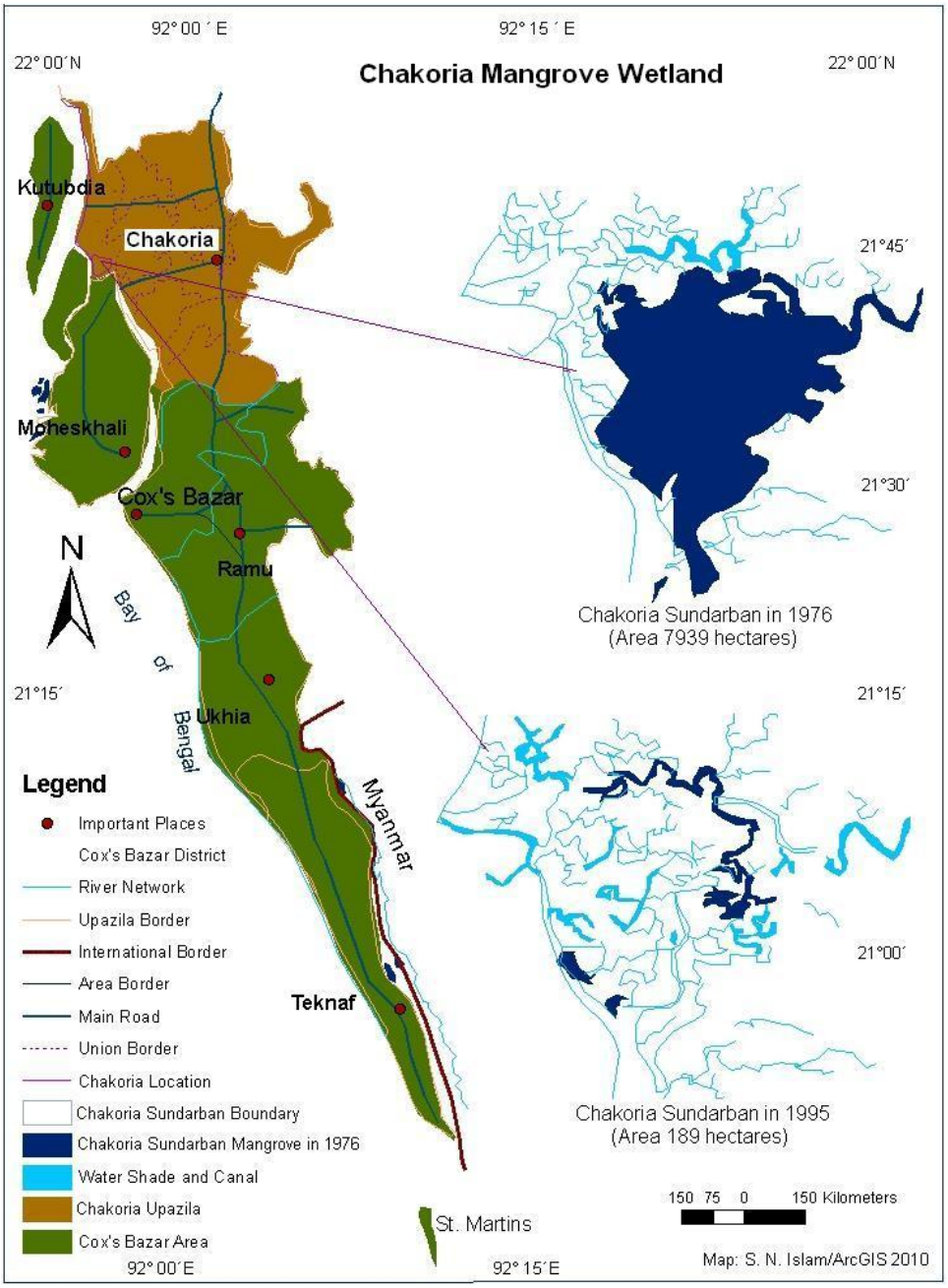


Table 1 Historical changes of Chakoria mangrove forest for 107 years' time scale

Time	*1903*	*1929*	*1952–1975*	*1977–1988*	*2001–2010*
Mangrove evolution in Chakoria Sundarban	Reserved mangrove forest and 8,540 ha was declared as reserve forest out of 21,000 ha	Allowed human settlement and the area was 18,200 ha	Human settlement expanded the area was 7,939 ha	Shrimp and salt encroachment and the area was 1,020 ha	The entire mangrove forest altered in shrimp farms with minor salt bed and human settlement and only 0.5 ha can be seen as a sign of mangrove forest

Table 1 shows the Chakoria Sundarban mangrove forest and its historical destruction due to different anthropogenic influences such as deforestation, shrimp farming, salt bed and human settlement development in the coastal region (Hossain et al., 2001; Musa, 2008).

5 Chakoria Sundarban mangrove forest ecosystem and its functions

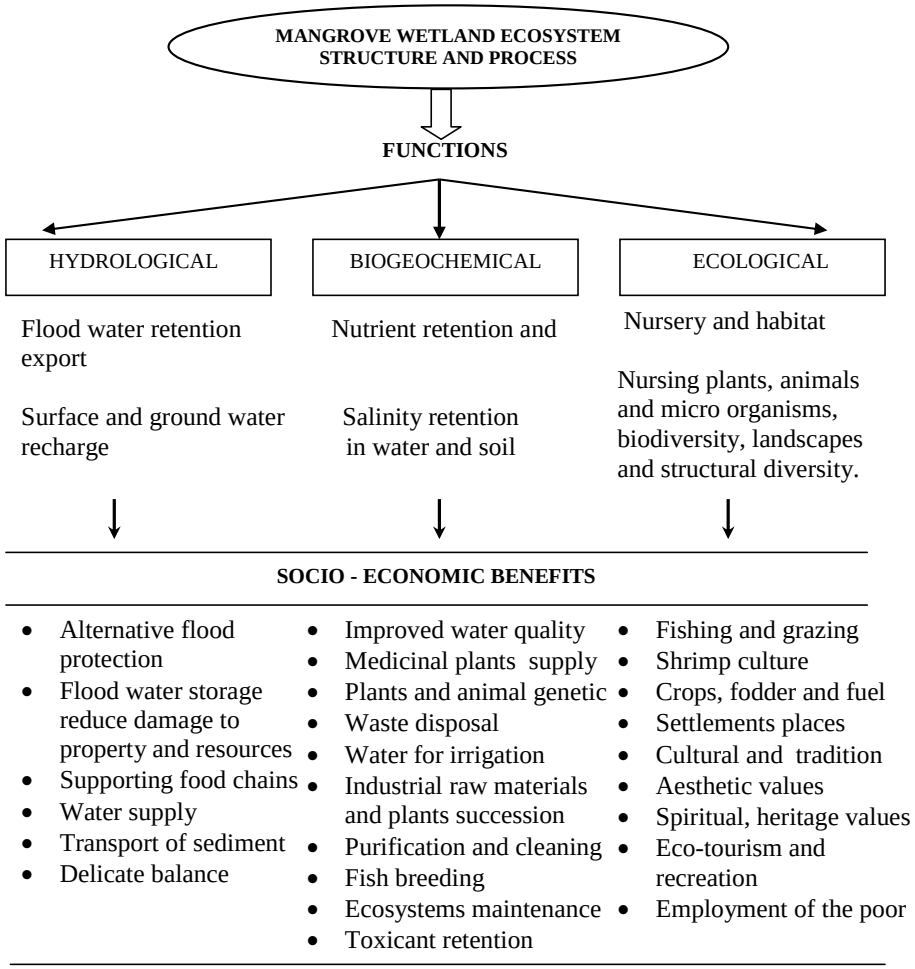
Chakoria Sundarban and its biodiversity was spectacular sensitive site in Bangladesh. It had 28 species of plants with average 10 to 15 metres height. Sundri, Gewa, Keora, Baen, etc., were the main trees. One fish species and naturally growing shrimps were abundant in the Chakoria Sundarban region. Marine fish and shrimp lay their eggs in the open sea. The larvae of these aquatic resources were spread a few weeks in the Matamuhuri River and canals within the mangroves and feeds on plankton, and then they return to the sea. The sweet water shrimp moves in the opposite direction to complete their life cycle in the brackish water. The intricate spread of the mangrove species is a safe shelter to the fish, shrimp and aquatic reptiles. The mangrove species help to save the sensitive coastal ecosystem and make balance of its functions (Figure 2).

Earlier the Chakoria Sundarban was so dense and full of tigers, deer, wild cats, wild boars, foxes, monkeys and reptiles, the life of the brave people living close to it was full of joy and challenges. In the present Chakoria Sundarban animals and birds are rarely seen and silence dominates day and night. Mangrove ecosystems contribute to human welfare in two basic ways, such as; the structural building blocks of ecosystems – plants, animals, soils, land, water and provide the raw materials for all economic production. Secondly ecosystems provide life support functions as well as other valuable services and many of them are potential for human life support and welfare (Farley et al., 2010). Figure 2 shows the mangrove wetland ecosystem, its structure, process and the social benefits to the coastal communities. In the figure, three types of mangrove ecosystem functions are triggering such as hydrological function, biological function and ecological functions.

These three functions (Figure 2) were promoting socio-economic benefits to the coastal communities in the Chakoria Sundarban coastal region. On the other hand in general mangrove ecosystem offers four different types of services such as supporting services, provisioning services, regulating services and cultural services. The whole services which were received by the coastal communities in the Chakoria Sundarban region. But, at present the mangrove wetland ecosystem is totally disappeared in the Chakoria Sundarban region because of unplanned decision and destruction of mangrove

forest. This mangrove ecosystem services were the main option of coastal communities' livelihoods, it is now vanished owing to shrimp farms, salt beds and settlement development (Iftekhar, 2006; Miah et al., 2010).

Figure 2 Mangrove function process and socio-economic benefits



Source: Islam (2010)

6 Unplanned policy and destruction of Chakoria Sundarban mangrove

The mangrove forest of Chakoria Sundarban had well demarcated boundary as it was surrounded by waterways on all sides. In the north sub-division, the forest had a common boundary with the unclassed state forest of Chittagong Hill tracts. In the south-east the forest adjoins the settled land and faces the Maiskhal channel connected to the Bay of Bengal in the south. In this area there are many low lying islands which are mostly submerged at high tide (Pustry et al., 2010). The main Sundarbans (6,017 km^2) which is

located in the south western region of Bangladesh has been declared as 560th Ramsar wetland site of the world on the basis of wetland types: F, G, I, M and Ramsar site selection criteria. Beside the main Sundarban wetland part there is another Sundarban mangrove forest region which is known as Chakoria Sundarban mangrove forest situated in the Cox's Bazar district in the south eastern part of the country. It is quite small in comparison with the Sundarban in greater Khulna region (Katebi, 2001). The Chakoria Sundarban mangrove area (21,000 ha) was representing 3.5 % of the main Sundarbans is located in the greater Khulna region. Moreover it is one of the oldest mangrove forests in the Indian subcontinent and has been subjected to heavy human interference. The wetland is divided into two blocks, namely

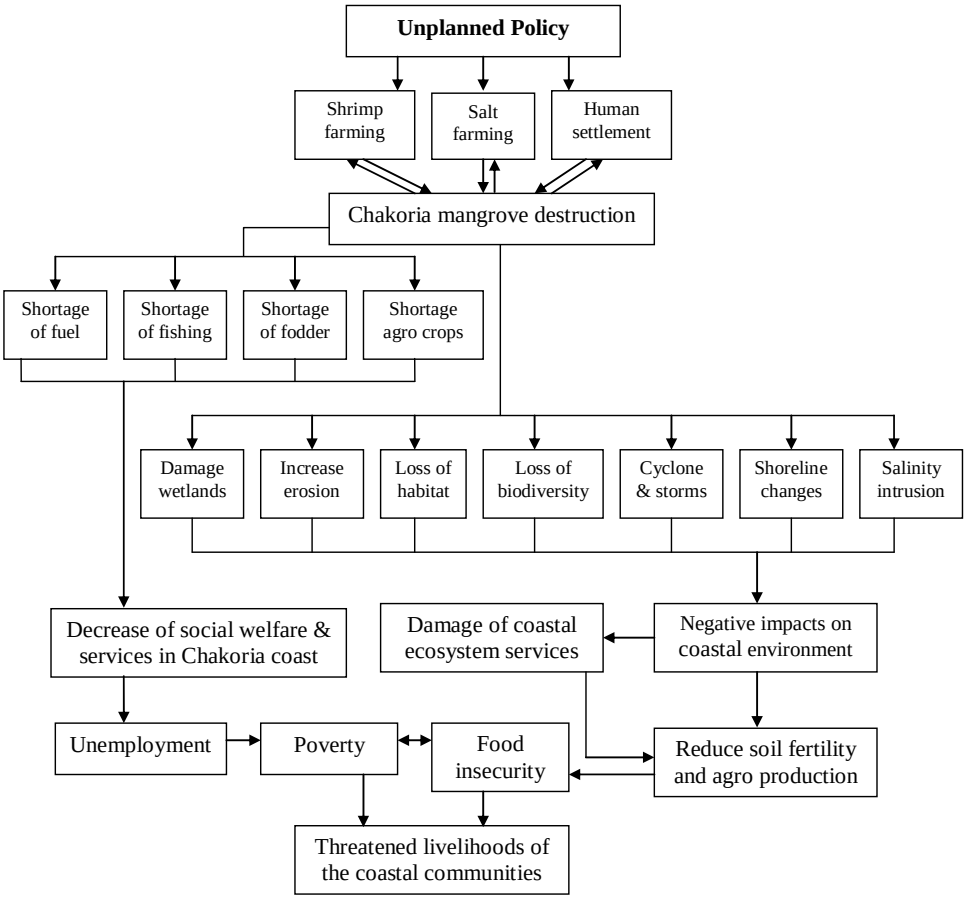
a Charandwip

b Rampur.

Charandwip again divided into 11 islands and Rampur into ten components in the delta of the Matamuhuri River. The mangrove wetlands forest used to cover an area about 8,020 ha as reserved in 1972 and 1,020 ha was protected area till 1977, when the process of releasing land from the forest department to the fisheries purposes started. Figure 3 shows the scenarios of the Chakoria Sundarban mangrove forest destruction and threatened mangrove wetland ecosystem in the south east coast of Bangladesh.

The main reasons of Chakoria mangroves destruction are motivation for shrimp farming, salt farming and human settlement development in the mangrove forest area which encouraged making unplanned governmental policy to destruct the mangrove forest. In Chakoria range, 18,200 ha were reserve forest and rest of land (2,520.45 ha) were protected forest in 1929. Then the British Government leased out 3,910 ha and later on more 162 ha land area among few families under the project name farmers' cooperative development. In 1977, for the first time, a very influential person got a lease of 563 ha of forest land for shrimp farming attributable to unplanned government policy of shrimp culture. Then in the following years the department of forest handed over 5,000 ha to the department of fisheries and 1,718 ha handed over in 1997. Figure 3 also shows that how unplanned policy has destructed a reserve forest which is linkage with coastal livelihoods. After destruction of Chakoria mangrove forest the following negative impacts have been seen over there such as shortage of fuel, fishing, fodder, and agro crops which has reduced ecosystem services, social welfare and promoted unemployment. On the other hand increased erosion, loss of habitat, loss of biodiversity, storms, cyclones, changes shoreline and salinity intrusion which has created negative impacts on ecosystem services and coastal environment. It has reduced the soil fertility in the Chakoria region which is the main reason of food insecurity, accelerated poverty and threatened livelihoods of the Chakoria coastal region. There were about 28 species of trees and none attained a height of more than 12 m and it was only very exceptional that an individual tree would grow to 20 m in height. The forests consisted mainly of two species, Ceriop decandra and Avicennia officinalis (Chowdhury, 1969; Siddiqi, 2001). Initial vegetation of the Chakoria Sundarban included 53 species belonging to 42 genera and 22 families (Cowan, 1926).

Figure 3 Chakoria Sundarban mangrove destruction and its negative impacts



According to Alam et al. (1990) and Hossain et al. (2001) mangrove floristic composition were categorised in 28 different species and some salt marsh (Jagtap, 1985; Abu Hena, 2013) are also included which has been recognised in 1991 and the following species are succeeding the flora and fauna like

1 Bio-kanka – *Acanthus ilicifolius* (Woody, thorny herb)

2 Lagolo – *Acrostichum aureum linn* (Fern)

3 Nunya – *Aegialitis rotundifolia* (Small tree)

4 Kasalong – *Aegiceras corniculatum* (Shrub or small tree)

5 Baen– *Avicennia spp* (Tree)

6 Lanceolata – *Brownlowia lanceolata* (Scandant shrub)

7 Natinga – *Bruguiera spp* (Tree)

8 Cuttya – *Ceriops decandra* (Shrub or small tree*)*

9 Shingra – *Cynometra ramiflora* (Shrub)

10 Chulya kanta – *Dalbergia spinosa* (Scandant, Amed shrub)

11 Gilalata – *Derris scandens* (Climber)

12 Gewa – *Excoecaria agallocha* (Tree)

13 Sundri – *Heritiera fomes* (Tree)

14 Balai – *Hibiscus tiliaceus* (Shrub or small tree)

15 Cogon grass – *Imperata cylindrica* (Grass)

16 Bahal – *Intsia bijuga* (Small tree)

17 Rohinya – *Kandelia candel* (Small tree)

18 Golpata – *Nypa fruticans* (Palm with recumbent stem*)*

19 Tateoka – *Porteresia coarctata* (Grass)

20 Kewa katta – *Pandanus foetidus* (Succulent crewpine*)*

21 Hantal – *Phoenix paludosa* (Thorny palm)

22 Karanja – *Pongamia pinnata* (Tree)

23 Hawa – *Rhizophora mucronata* (Tree)

24 Baolilata – *Sarcolobus globosus* (Climber)

25 Keora – *Sonneratia apetala* (Tree*)*

26 Nona jhau – *Tamarix indica* (Shrub)

27 Kampa – *Xylocarpus granatum* (Small tree*)*

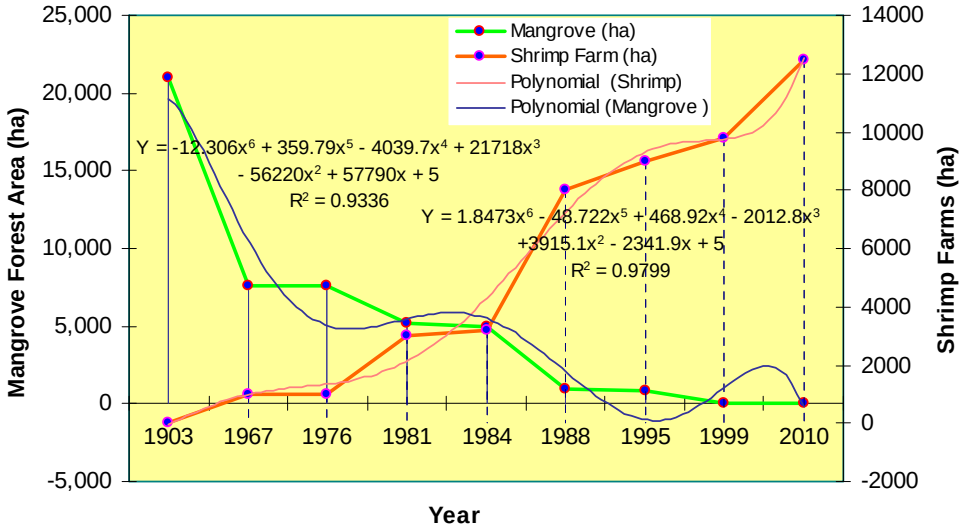
28 Ail – *Xylocarpus mekongensis* (Tree), etc. (Hossain et al., 2001; Abu Hena et al., 2007, Abu Hena, 2013).

On the other hand relatively high ground *Bruguiera caryophylloides* and on lower ground Kakra (*Bruguiera gymnorrhiza*) were found to occur along with Goran and baen. Sundri (*Heritiera fomes)* forms along with Gewa (*Excoecaria agallocha*) occur in th*e* places subject to tide water inundation for shorter periods. Hantal *(Phoenix palludosa*) occur in large number. *Avicennia tomentosa* is the commonest of the larger species. Salt marsh grass along the coast was the common scenic view; plants were particularly active in vegetation progradation during pre-monsoon period. *Porteresia coarctata* acts as pioneer species in the successional process leading to mangrove formation along the South Asian estuaries and coasts (Jagtap, 1985). The mangrove wetland forest was under sound management during the British period (1857 to1947) and until 1970.

7 Results and discussion

The coastal morphology and characteristics of the water resources are changing with changing land-use patterns, one factor here being the expanding areas allocated to shrimp cultivation, salt production and settlement development, which are growing at rates of 0.50%/yr to 18%/yr, respectively (PDO-ICZMP, 2005; FAO, 2007). The investigation result shows that the settlement area was only 827 ha in 1972 whereas in 1999 the settlement land was 14,120 ha which is 17.07 times more than in 1972. In general the annual growth rate (from 1972–2009) of settlement in the Chakoria region is 58% which is the rapid increasing rate in the whole Chakoria upazila. Figure 4 shows the Chakoria Sundarban mangrove wetlands and its present scenarios. The last portion of Chakoria mangrove wetlands (825 ha) were handed over to the shrimp farmers in 1982. Figure 4 states that the greatest concern for mangrove of Chakoria Sundarban is the uncontrolled exploitation of the forest (FAO, 2007). It has been identified the conversion of mangroves to shrimp farms and salt production which was primarily an economic improvement project for the local coastal communities.

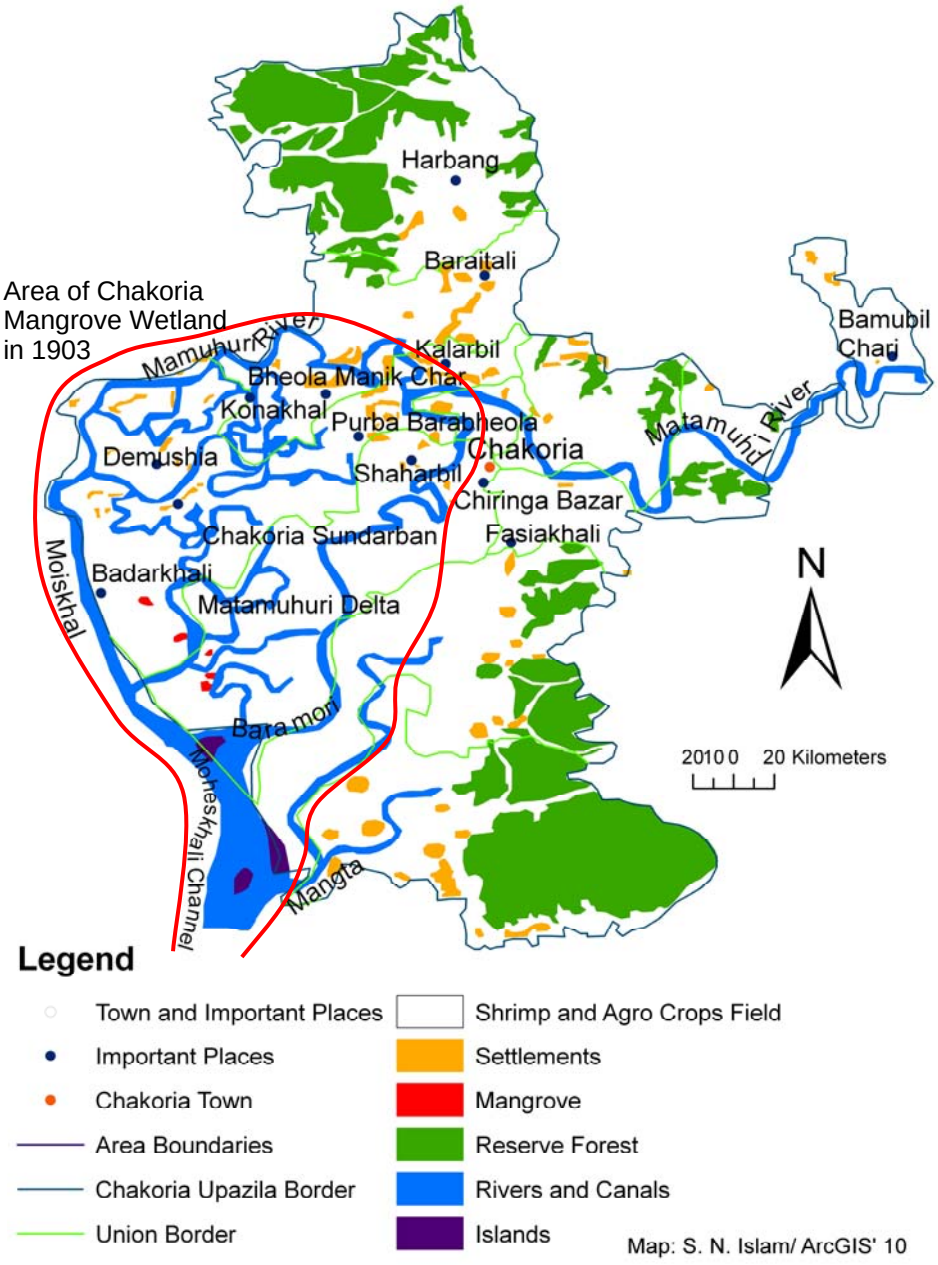
Figure 4 Mangrove forest destruction and increase shrimp farming in Chakoria (see online version for colours)



Source: Siddiqi (2001), FAO (2007), Musa (2008)

Figure 4 also shows a relationship between mangrove forest destruction and expansion of shrimp farms in the Chakoria Sundarban region. In 1903 the mangrove forest area was 21,000 ha, in 1972 it was 8,020 ha, 7,939 ha in 1976 and in 1999 the entire mangrove forest is disappeared, only some mangrove plants are standing as memory of Chakoria Sundarban mangrove forest which is 0.5 ha only in 2010 (Musa, 2008). Initially there was no shrimp farm in 1903, but in 1967, 1,000 ha shrimp farm was developed and it was the same figure until 1976. The shrimp farms have been expanded to 8,255 ha in 1988, and 9,000 ha in 1995 and over 13,000 ha in 2010 (Chowdhury et al., 2009).

Figure 5 The present landscape pattern of Chakoria Sundarband mangrove forest area (see online version for colours)



Source: Musa (2008), Chowdhury et al. (2009)

For mangrove forest destruction considering the polynomial approximation the curve shows the normal behaviour, where the regression value is R^2 = 0.9336 which is considerable value for scenario consideration. Conversely in view of shrimp cultivation

the polynomial curve shows the normal increase tendency, where the regression value R^2 = 0.9799 this is acceptable value of increasing tendency, but it is abnormal situation when it could be realised as reality. The expansion of shrimp farms and the rate of destruction of mangrove forest is an alarming condition and it is threat for ecosystem services and livelihoods sustainability for the coastal community in the Chakoria region. The whole region has been converted into shrimp farms and salt beds which are showing as like a saline lake. Figure 5 shows the present scenarios of the Chakoria Sundarban mangrove wetland landscapes and land use pattern. In the initial stage some part of mangrove forest has disappeared due to urbanisation and settlement development. Table 2 shows the landscape and land use changing pattern of the Chakoria Sundarban region. The mangrove area was 8,020 hectare in 1972, now this shape has reduced with 60% loss of reserve forest and 99 % loss of mangrove forest (GOB, 2001; Khan et al., 1994).

Table 2 Land use and Shrimp culture in Chakoria Sundarban from 1972–1999

Historical land use pattern in Chakoria Sundarban region			
Year	*1972 (ha)*	*1989 (ha)*	*1999 (ha)*
Land use and shrimp	3,585.2	4,534.4	8,542.0
Water and shrimp	6,316.4	8559.6	15,779.6
Salt bed	631.6	7,504.4	5,177.6
Forest	40,777.6	22,002.0	18,167.6
Mangrove Wetland	8,020.0	1,020.0	03.0
Settlement	826.8	3,455.2	14,120.0

Source: GOB (2001), DoF (2003), Islam (2006)

The Chakoria Sundarban was previously used for agriculture and mangrove forest, at present it is often used for shrimp farming, salt bed and settlement development. The land is now wide-scale land use conflict emerged and created social vulnerability. Shrimp farming is an important industry contributing 5.2% of GDP in Bangladesh (Hossain et al., 2001; GOB, 2001; DoF, 2003; Islam, 2006). The shrimp farming has been gradually changed the land-use and landscape pattern of the surrounding farm transforming agriculture and mangrove areas into shrimp farming area (Islam, 2006). Shrimp and salt bed development in Chakoria Sundarban on a commercial scale, has brought now a large scale ecological degradation. The shrimp farms and salt beds retain water as a result the salinity seeps on to adjacent farm and penetrated soil salinity (Islam, 2006). The loss of mangrove areas to aquaculture is a common feature, with Chakoria Sundarban being classic example (Chowdhury et al., 1994). The destruction of mangrove forest in the Chakoria region is a great loss of coastal ecology and threats for community livelihoods sustainability (Chowdhury et al., 1994; Brown, 1997; Islam, 2006; Islam and Gnauck, 2008).

7.1 Causes and impacts of mangrove wetlands degradation

There are so many social and political causes of destruction and degradation of mangrove wetlands ecosystem and ecosystem services. The following activities are the core reasons of mangrove destruction in the Chakoria Sundarban region.

- population growth and urbanisation
- settlement development
- salt bed development
- shrimp farming
- over-felling of mangrove trees
- over fishing and associate disturbances;
- siltation due to degradation of the watershed areas which are often transboundary in nature
- indiscriminate regulation of flows of the river systems in the upper riparian areas
- pollution of water due to industrial, urban, agrochemical and other types of pollutants including pollution from transboundary sources.

Due to destruction of mangrove forest and degradation of its wetland ecosystems the following actions are occurred in the mangrove damaged areas.

- loss of mangrove biodiversity
- a serious reduction of fish habitat, fish population and diversity
- many species of flora and fauna are threatened with possibility of extinction
- indigenous varieties of rice are disappearing
- increase in the recurrence of flash floods
- loss of natural soil nutrients and fertility
- loss of natural water reservoirs and of their resulted benefits
- degradation of mangrove wetland-based ecosystems
- changes of coastal community's occupation
- living conditions of local people are deteriorating as livelihoods socio-economic institutions and cultural values are affected.

7.2 Degraded mangrove ecosystem and threatened community livelihoods

The present mangrove ecosystem has degraded owing to anthropogenic influences on mangrove resources in the Chakoria Sundarban mangrove forest region. Considering the definition of ecosystem it can be stated that ecosystem mean the function of biotic and abiotic characteristics; on the other hand it is the function of water, soil, energy, culture, plants and animals and microorganism in soil. The environmental benefits of mangroves, as well as their commercial uses, have made mangrove forests very important ecosystems. The benefits of mangrove forests serve as diverse habitat for many species, including fish, birds, reptiles, amphibians, mollusks, crustaceans and many other invertebrates. Mangroves produce little leaf and detritus matter, from the leaf of the mangrove trees is valuable sources of food for animals in coastal waters. Chakoria mangrove was a rich of fish diversity and satisfying the local demand. Fishing was very

important issue and activity in the Chakoria Sundarban. Brackish water fisheries for prawns and Hilsha in the Cox's Bazar region are described in previous studies. Around 20 fish species were available in the region whereas at present the shrimp and some sea fish species are available. The fish production has been reduced as the land use and landscape has been changed which is not suitable for fish cultivation. At present the area is providing only shrimp and some marine fish species in the offshore area. Up to 80% of global fish catches are directly or indirectly dependent on mangrove wetlands (Fujimoto, 2000; Chowdhury et al., 2009). The Sundarbans mangrove forest produced an average of 600 tons of nutrient /hectare is released per year to provide a great source of natural food in the coastal offshore area. It is a good service and poles for fish traps. Fish, crustaceans and mollusks can be harvested from mangroves. Aquaculture and commercial fishing also depend on mangroves for juvenile and mature fish species. They are source of tannin, alcohol and medicine. The Chakoria Sundarban mangrove forest had a great economic importance for east coast and provides livelihoods options for 336,000 people (Hossain, 2001; Miah et al., 2010).

By reason of excessive human interference and extension of shrimp farming the entire mangrove forest has been cleared, except a remainder of only 0.5 ha forest which has some *Heritiera fomes* trees (Hussain and Samsuddoha, 2008). Clearance of Chakoria mangrove in the south east causes a loss of coastal habitat, aquatic resources increases erosion and vulnerability to natural disasters (Hossain et al., 2001). The coastal communities are coping with the threats by their resources. The livelihood assets such as physical asset, financial asset, human asset, natural asset, economic asset, social asset and cultural and heritage assets were interconnected for maintenance of local coastal communities' livelihoods.

After clearance of Chakoria Sundarban mangrove forest almost 400,000 people and their livelihoods were under threat. Assess to these resources often influences livelihoods of the people to a significant extent. Coastal community of mangrove area gets more benefits than any other coastal area of country (Hossain and Lin, 2002). In general mangrove vegetation act as a barrier against natural disaster, but at present this area is more vulnerable to the coastal people. Coastal water resources have been supporting the livelihoods of the poorer sections of society. The Matamuhuri River also plays a potential role, by enormous opportunities for varies fisheries, aquatic resources, riverine transportation and mangrove forest goods and services.

However, this river and fresh water channels are now fully dead because of anthropogenic activities (Miah et al., 2010). The salinity problem is further severely aggravated by the long nature of brackish water shrimp farming. Gradually, salinity has penetrated beyond tolerable limits for agricultural crops and other vegetation (Miah et al., 2010). The river water salinity shows that the upper limit (30–45 dS/m during the peak period) is beyond the tolerable limits for crops and vegetation. It has recognised that water salinity of 7.5 dS/m and above which is harmful for rice and vegetable cultivation in the Chakoria Sundarban coastal region (Hossain and Lin, 2002; Miah and Bari, 2002; Miah et al., 2010). The most alarming threat to the Chakoria Sundarban is destruction of fauna flora, because 10,000 fishermen and coastal community are directly dependent on the mangrove coastal natural resources. Encroachment of the mangrove forest created multifarious impacts on both resources and livelihoods of the local inhabitants (Chowdhury et al., 2009). Diverse livelihood activities of the local inhabitants in its vicinity were lost. Thus, preserve has been building on the remaining reserved forest resources (Miah et al., 2010).

There are not enough initiatives or policies to protect mangrove ecosystems in the south east coast of Bangladesh. At present in many countries in Asia, Africa and Latin America where mangroves have been destroyed due to deforestation, shrimp culture, salt bed, tourism and settlement development. The unplanned policy has created crucial problems on coastal ecosystems and threat for community livelihoods. Especially the coastal indigenous people, who were totally dependent on mangrove resources are facing critical problem for their livelihoods from natural hazards and cyclones. In Mexico, Nicaragua, Ecuador and Panama the indigenous people in the coastal regions are demonstrating for the protection of mangroves. The demand of mangrove protection is getting popular in India, Srilanka and other parts in Asia pacific zone too. There is an example that the government of India and Ecuador has banned the further cutting of mangroves for shrimp farms, but in Ecuador 127.5 km^2 of mangroves were illegally cut after the ban. This type of illegal activities is continuing in many countries even in Bangladesh. Therefore a common universal policy and guideline framework is necessary to protect the mangrove forests which will secure the livelihoods of the coastal community.

8 Conclusions and recommendations

Mangrove wetlands are most valuable ecosystems of the world which have been subject to severe threats related to global change. Many of mangrove wetlands worldwide have been already lost and some are seriously degraded due to anthropogenic influences and natural disasters. It is important and necessary to manage them wisely, but this can only be achieved if their functioning is well understood. The mangrove wetland landscapes are of inferior quality in Bangladesh. Coastal people are using the mangrove goods in a very crucial way and damaging its biodiversity and ecosystems services are already degraded due to unpredicted anthropogenic influences. The Chakoria Sundarban once was very rich with various resources such as fertile agricultural land, mangrove forests, coastal wetlands, fisheries, salt marshes, livestock, poultry, rivers and canals. The Chakoria mangrove forest covers 3.5% of the main Sundarbans mangrove forest, but presently the whole Chakoria Sundarban mangrove has disappeared because of anthropogenic influences. The natural resources have been getting depleted on account of unplanned destruction of mangrove forest and developing shrimp farming, salt bed and settlement development. As a whole the deteriorating of the natural resources of Chakoria Sundarban, the coastal livelihoods are under threat because the livelihoods assets are not functioning properly (Samsuddoha and Chowdhury, 2009). Therefore the elements of livelihoods assets such as human capital, natural capital, financial capital, physical capital, socio-economic capital and cultural capital should available considering the present ecological landscape scale which could ensure coastal community livelihoods sustainability in the south east coast of Bangladesh. The following potential steps should be taken into consideration urgently to create alternative livelihoods opportunities to the coastal communities for sustainability.

- Mangrove wetland ecosystems have historically been considered as wastelands unworthy of consideration for conservation. As a result, wetlands have frequently been altered or lost because their ecological functions and values to society have not been understood; therefore it should be introduced to the people as a common

property, its importance and community rights (Rahman and Haque, 2003; Islam, 2007).

- Based on the present degraded environmental condition, the coastal zoning approach should include and that could improve land use planning, minimise conflicts over land tenure and identify in appropriate areas for shrimp cultivation and that areas need to be protected. There is also need for improve information system to manage and plan for future growth.
- To improve existing mangrove wetland resource related policies, strategies and common conflicts in the areas where rural communities are dependent on the mangrove ecosystems services.
- Capacity building up environmental awareness and institutional organisations development in international level with legislation to regulate all activities (Nishat, 2003).
- Shrimp farming at the coastal mangrove wetlands areas should be stopped and initiatives are needed to protect the destruction of mangrove wetlands and forest in the south and southern region of Bangladesh.
- Political commitments and wills for the better management and conservation of mangrove wetlands are necessary and essential for Bangladesh context.
- The destruction of sensitive mangrove ecosystem and coastal habitats causes threats to aquatic biodiversity. Significant socio-economic costs must be balanced against the direct economic benefits from the shrimp cultivation and salt beds development.
- An integrated mangrove wetland ecosystems management plan and policy guideline should be developed based on the findings of this study. The findings and recommendations could be implemented for the future development and protection of mangrove forest and its ecosystem services in the coastal region of Bangladesh, which could ensure the livelihoods of the coastal poor dwellers in Chakoria coastal area as well as other parts of the coastal mangrove regions in Bangladesh.

References

Abu Hena, M.K. (2013) 'Seasonal changes in *Porteresia Coarctata* (Tateoka) beds along a subtropical coast', *Chines Journal of Oceanology and Limnology*, Vol. 31, No. 1, pp.1–9.

Abu Hena, M.K., Short, F.T., Sharifuzzaman, S.M., Hasan, M., Rezowan, M. and Ali. M. (2007) 'Salt marsh and sea grass communities of Bakkali Estuary, Cox's Bazar', *Est. Coast. Self Sci.*, Vol. 75, Nos. 1–2, pp.72–78.

Alam, M.S., Shamsuddin, S.D and Sikder, S. (1990) 'Application of remote sensing for monitoring shrimp culture development in coastal mangrove ecosystems in Bangladesh', *Proceedings of the Twenty Third International Symposium on Remote Sensing of Environment*, Bangkok, Thailand, 18–25 April, pp.109–119.

Brown, B.E. (1997) 'The conversion of mangroves for shrimp aquaculture development', *Integrated Coastal Management: South Asia*, University of Newcastle, Newcastle, UK, Vol. 4, pp.1–19.

Chowdhuary, M.S.N., Nabi, M.R. and Das, N.G. (2009) 'Socio-environmental support of mangroves in the Teknaf peninsula, Bangladesh', Hossain, M.S. (Ed.): *Climate Change Resilience by Mangrove Ecosystem*, pp.19–23, PRDI, Dhaka, Bangladesh.

Chowdhury, A.M., Quadir, D.A. and Islam, M.J. (1994) 'Study of Chakoria Sundarbans using remote sensing techniques', ISME (International society of Mangrove Ecosystems), Japan, Technical Report 4, pp.1–33.

Chowdhury, M.U. (1969) 'Working plan of Cox's Bazar forest division for the period from 1968–69 to 1977–78', Government of East Pakistan Forest Department, Dhaka.

Cowan, J.I. (1926) 'The flora of the Chakoria Sundarbans', *Records of the Botanical Survey of India, Calcutta*, pp.197–226.

Deb, A.K. (1997) 'Fake blue revolution: environmental and socio-economic impact of shrimp culture in the coastal area of Bangladesh', Community Development Centre (CDC), Canada.

DoF- (Department of Fisheries) (2003) 'Fishery statistical year book of Bangladesh: 2002–2003', Department of Fisheries, Dhaka, Bangladesh, pp.1–44.

FAO (Food and Agricultural Organization) (2007) 'The world's mangroves 1980–2005', FAO Forestry Paper No. 153, Rome.

Farley, J. Batker, D. Terre, I.D.L. and Hudspeth, T. (2010) 'Conserving mangrove ecosystems in the Philippines: transcending desiciplinary and institutional borders', *Environmental Management*, Vol. 45, No. 1, pp.39–51.

Fujimoto, K. (2000) 'Beloground carbon sequestration of mangrove forests in the Asia-Pacific region', *Proceedings of Asia Pacific Cooperation on Research for Conservation of Mangroves*, Okinawa, Japan, pp.87–96.

GOB – Government of Bangladesh (2001) 'Coastal and wetland biodiversity management at Cox's Bazar and Hakaluki haor project documents', Ministry of Environment and Forests, Government of Bangladesh, Dhaka.

Hossain, M.S. (2001) 'Biological aspects of the coastal and marine environment of Bangladesh', *Ocean and Coastal Management*, Vol. 44, Nos. 3–4, pp.261–282.

Hossain, M.S. and Lin, C.K. (2002) 'Land suitability analysis for integrated coastal zone management in Cox's Bazar, Bangladesh: a remote Sensing and GIS approach', *Proceedings of the Coastal Zone Asia Pacific Conference*, Bangkok, Thailand, May 2002.

Hossian, M., Lin, S. and Hussain, M.Z. (2001) 'Goodbye Chakoria Sunderban: the oldest mangrove forest', *SWS (Society of Wetland Scientists) Bulletin*, Vol. 18, No. 3, pp.19–22.

Hussain, M.S. and Shamsuddoha, M. (2008) 'Improving coastal resource management of socio-economic development of rural communities in Cox's Bazar: a participatory appraisal', *The Chittangong University Journal of Social Sciences*, Vol. 20, No. 10, pp.1–20.

Iftekhar, M.S. (2006) 'Conservation and management of the Bangladesh coastal ecosystem: overview of an integrated approach', *Natural Resources Forum*, Vol. 30, No. 3, pp.230–237.

Islam, S. (Ed.) (2006) *Encyclopedia of Bengal*, Asiatic Society of Bangladesh, Asiatic Civil Military Press, Dhaka.

Islam, S.N. (2007) 'Water salinity and thresholds for the protection of mangrove wetland ecosystems in the Sundarbans region', in Ganuck, A. (Ed.): *Modellierung und Simulation von Ökosystemen (Modelling and Simulation of Ecosystems Journal)*, pp.187–201, Shaker Verlag. Aachen, Germany.

Islam, S.N. (2010) 'Threatened wetlands and ecologically sensitive ecosystems management in Bangladesh', *Front. Earth Sci. China*, Vol. 4, No. 4, pp.438–448.

Islam, S.N. and Gnauck, A. (2008) *Mangrove wetland ecosystems in Ganges-Brahmaputra delta in Bangladesh. Frontiers of Earth Science in China*, pp.439–448, Higher Education Press and Springer-Verlag Berlin.

Islam, S.N. and Gnauck, A. (2009a) 'Threats to the Sundarbans mangrove wetland ecosystems from transboundary water allocation in the Ganges basin: a preliminary problem analysis', *International Journal of Ecological Economics & Statistics (IJEES)*, Vol. 13, Vol. W09, pp.64–78.

Islam, S.N. and Gnauck, A. (2009b) 'The Coastal mangrove wetland ecosystems in the Ganges Delta: a case study on the Sundarbans in Bangladesh', in *Proceeding of American Association of Petroleum Geologist-AAPG Hedberg Conference on Variations in Fluvial-deltaic and Coastal Reservoirs Deposited In Tropical Environments*, Jakarta, Indonesia, 29 April–2 May, 2009, pp.26–29.

Jagtap, T.G. (1985) 'Ecological studies in relation to the mangrove environment along the Goa coast, India', unpublished PhD thesis, Shivaji University, Kolhapur, India.

Katebi, M.N.A. (2001) 'Sundarbans and forestry', In Haider (Ed.): *Cyclone'91 – An Environmental and Perceptional Study*, .pp.79–100, BCAS, Dhaka.

Khan, M.S., Haq, E., Huq, S., Rahman, A.A., Rashid, S.M.A. and Ahmed, H. (Eds.) (1994) *Wetlands of Bangladesh*, BCAS, Dhaka, Bangladesh.

Miah, M.G. and Bari, M.N. (2002) 'Ecology and management of the Sundarbans mangrove ecosystems, Bangladesh', in *Managing Transboundary Nature Resources: Case Studies on Sundarbans Mangrove Ecosystems*, pp.1–44, Occasional papers, UNESCO, New Delhi.

Miah, M.G., Bari, M.N. and Rahman, M.A. (2010) 'Resource degradation and livelihood in the coastal region of Bangladesh', *Front. Earth Sci. China*, Vol. 4, No. 4, pp.427–437.

Musa, K.B. (2008) 'Identifying land use changes and its socio-economic impacts; a case study of Chakoria Sundarban in Bangladesh', MSc thesis in the Dept. of Computer and Information Science (IDA), pp 1–103, Linköping University, Sweden.

Nair, K.S. (2004) 'Wetlands management to meet the food and water crisis- example from a tropical region', in *Abstracts Book of 7th INTECOL International Conference on Wetlands*, Utrecht, the Netherlands, 25–30 July 2004, p.217.

Naylor, R., Goldberg, R., Mooney, H., Beveridge, M., Clay, J., Kautsky, C., Lubchenco, N., Primavera, J. and Williams, J. (1998) 'Nature's subsidies to shrimp and salman farming', *Science*, Vol. 282, No. 5390, pp.883–889.

Nishat, A. (2003) 'Management of fresh water wetlands in Bangladesh: issues and strategy', [online] http://www.doe-bd.org/cwbmp/inception_report/ (accessed on 03 March 2010).

PDO-ICZMP (Program Development Office for Integrated Coastal Zone Management Plan), (2005) 'Coastal land use and indicative land zones', PDO-ICZMP, Water Resources Planning Organization, Dhaka, Bangladesh, pp.1–64.

Primavera, J.H. (1993) 'A critical review of shrimp pond farming in the Philippines, *Reviews in Fisheries Science*, Vol. 1, No. 2, pp.151–201.

Primavera, J.H. (1997) 'Socioeconomic impacts of shrimp culture', *Aquaculture Research*, Vol. 28, No. 10, pp.815–827.

Pustry, K.B.A., Chandra, R. and Azeez, P.A. (2010) 'Macronutrients along the sediment profile in a subtropical monsoonal wetland in India', *Wetlands Ecology Management*, Vol. 18, No. 1, pp.91–105.

Rahman, A.A. and Haque, N. (2003) 'Poverty reduction and sustainable livelihoods in Bangladesh – mainstreaming natural resource management into policies, institutions and process', pp.1–14, BCAS, Dhaka.

Rahman, M.M. (1995) 'Wetlands and biodiversity: a case study of common property resources in Bangladesh', paper presented at the *5th Annual Common Property Conference*, Bodo, Norway, 24–28 May 1995, pp.1–10.

Rönnbäck, P. (1999) 'The ecological basis for economic value of seafood production supported by mangrove ecosystems', *Ecological Economics*, Vol. 29, No. 2, pp.235–252.

Rosamond, L. (2002) *Effects of Aquaculture on World Fish Supplies*, Internet publication.

Rosenberry, B. (Ed.) (1998) 'World shrimp farming 1998', *Shrimp News International*, Vol. 12, No. 11, pp.1–328.

Samsuddoha, M. and Chowdhury, R.K. (2009) 'Destruction of Chakoria Sundarban: a case of ecological debt in Bangladesh', In Hossain, M.S. (Ed.): *Climate Change Resilience by Mangrove Ecosystem*, pp.31–22, PRDI, Dhaka.

Siddiqi, N.A. (2001) 'Mangrove forestry in Bangladesh', Institute of Forestry and Environmental Science, University of Chittagong, Chittagong, pp.1–183.