**Characterization and Conservation of Wetlands with Global Change Dynamics:
A Case Study on Ratargul Swamp Forest, Bangladesh**

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ABSTRACT

Bangladesh is known as the largest delta in the world, where 50% of the total country's national land is wetlands. This wetland includes rivers, estuaries, mangroves, freshwater marshes, river marsh areas, water storage reservoirs, ponds and other seasonal flood areas. About 50% of people in this country are directly dependent on wetland resources for subsistence and 70% of animal protein in the country comes from fresh water fish. Moreover, 6-8% revenue comes from only marsh areas. However, most of these wetlands of Bangladesh are being destroyed due to the high population pressure and extreme level of resource extraction. A case study was completed in the Swamp Ratargul forest with the aim of characterizing the functions, values and services of the forest. This study also explores the dependence criteria of the local human population, disruption and optimal management option for this forest. To complete this study, approaches were followed by qualitative and quantitative research. The rural population was engaged in participatory tools to collect socio-economic information. GIS were used to detect changes in land use over time. The results showed that the forest is located 35 m above mean sea level. During the rainy season, the average height of the forest floor water level is 4 m. This forest provides various products and ecosystem services, which plays a key role in the livelihood of the local population. But, degradation and disturbance of the forest are significant. The study showed that the high-density forest was reduced in 18.40 hectares and the degraded area increased by 25.53 ha from 2005 to 2015. However, the participatory forest management approach could be an effective tool for sustainable management.

Keywords: Wetlands, Ecosystem Services, Global change, Human livelihoods, Sustainable use.

RESUMO

Bangladesh é conhecido como o maior delta do mundo, onde 50% da terra nacional total do país é de zonas húmidas. Esta zona húmida inclui rios, estuários, mangais, pântanos de água doce, zonas fluviais palustres, reservatórios de armazenamento de água, lagoas e outros áreas de inundação sazonais. Cerca de 50% das pessoas deste país estão diretamente dependentes de recursos das zonas húmidas para a subsistência e 70% de proteína animal do país vem de peixes de água doce. Além disso, 6-8 receita% provém apenas de áreas palustres. No entanto, a maioria destas zonas húmidas de Bangladesh estão sendo destruídas devido à alta pressão populacional a nível extremo de extracção de recursos. Um estudo de caso foi concluído no Pântano Floresta de Ratargul com o objectivo de caracterizar as funções, valores e serviços desta floresta. Este estudo também explora os critérios de dependência da população humana local, perturbações e opção de gestão optimizada desta floresta. Para concluir este estudo, foram seguidas abordagens de pesquisa qualitativa e quantitativa. A população rural foi usada em ferramentas participativas para coletar informações sócio-económicas. SIG foram usados para detectar mudanças no uso da terra ao longo do tempo. Os resultados revelaram que a floresta está localizada a 35 m acima do nível médio do mar. Durante a estação chuvosa, a altura média do nível de água do chão da floresta é de 4 m. Esta floresta fornece vários produtos e serviços do ecossistema, que desempenha papel fundamental na subsistência da população local. Mas, a degradação e distúrbios desta floresta são significativas. O estudo demonstrou que a floresta alta densidade foi reduzida em 18,40 ha e a área degradada aumentou em 25,53 ha, de 2005 a 2015. No entanto, a abordagem de gestão florestal participativa poderia ser um instrumento eficaz para a gestão sustentável.

 Palavras-chave: zonas húmidas, Serviços de Ecossistemas, alterações globais, subsistência humana, uso sustentável.

EXTENDED SUMMARY

Wetlands are considered an organic supermarket because of its rich biodiversity. They act as a buffer during the severe drought and flooding. They play a vital role in the development of human culture and society by providing tangible and intangible benefits and play a key role for the livelihood security of poor people in developing countries. However, the high rate of population growth and extraction of surplus resources are problems for sustainability. Geographically most areas of Bangladesh are the largest delta in the world where 700 rivers flow together. The total area of wetlands of Bangladesh is estimated at 70,000 to 80,000 km^2, about 50% of the country. These wetlands include rivers, estuaries, mangroves, freshwater marshes, swamps (haor), oxbow lakes (baor) and beel (bowl-shaped depression), water storage reservoirs, ponds, and other areas of seasonal flooding. Have great contribution to the ecological aspects of the country, economic, industrial, socio-economic and cultural of the country. For instance, wetlands of Bangladesh are helping to ensure better socio-economic life of millions of rural people by providing job opportunities, food and nutrition, fuel, fodder, transportation, irrigation, tourism and so on. About 70% of animal protein in the country comes from freshwater fish and 50% of people in this country are directly dependent on wetland resources for subsistence. In addition, 6-8% revenue come from haor areas of Bangladesh undoubtedly a great contribution to GDP. However, the wetlands of Bangladesh are under considerable threat due to high population growth, expansion of agricultural land, industrialization, poor management infrastructure, sedimentation, salinity, pollution, overfishing, poaching, lack of institutional coordination, conflict between sectoral laws and policies, lack of awareness, political unrest etc.

A case study was carried out in the Swamp Forest Ratargul located north eastern part of Bangladesh. This is just a new Bangladesh water swamp forest with special features, locally called the Amazon of Bangladesh. Ecologically this forest provides significant habitat for flora and fauna. The population of this public areas are wholly or partly dependent on this forest. However, the swamp forest has been degraded over time. The aim of this study is to define the features, functions, values and forest services. This study also explores dependence criteria of the local population, forest disturbances and options for their optimal management. A qualitative and quantitative research approach with participatory rural appraisal tools (PRA) were used to collect socio-economic information. PRA techniques include raising families, interviews with key informants, focus group with semi-structured questionnaires. Additional data were collected in two web-based engines: (i) Science Direct and (ii) ProQuest to find articles that describe the

value, importance and problems of wetlands in Bangladesh. GIS were used to detect changes in land use over time.

The forest floor is 35 m above mean sea level where the maximum areas are simple. In addition to the Shari-Goyain and Kafna rivers, there are lakes, natural depressions and channels inside the forest. The average river depth is 12 meters and the depth of the channels and ponds are 5 m and 2.5 m, respectively. The water level varies during the rainy season (May to September) and dry season (December to March). During the rainy season, the entire area is under water and the average height of the forest floor water level is 4 m. Due to precipitation and upstream flow, the water level increases to 7.5 m. On the other hand, in the dry season, the average water depth in rivers and channels are 3.5 m and 2 m, respectively. However, natural lakes and depressions can be completely dried. During the dry season the forest floor can also dry completely, but some bodies of rivers and canals. In the remaining months of the year, i.e in April, October and November on the forest floor are almost muddy. This cycle plays a role in the life cycle of the plant species and movement of aquatic and terrestrial animals. Four types of ecosystem function exist in this swamp forest - hydrologic, biogeochemical, ecological and atmospheric. The amounts and services are the result of four types of operation which includes environmental, economic (including direct, indirect, option, existence, bequest values), social and cultural, and soon, the maintenance of environmental quality. It was found that this region families are very poor (28%), poor (21%) and the average yield (42%). Live marsh that generates different income as a result of agriculture; fishing; collection of food, feed, fuel and medicinal plants, tourism. Approximately 90% of the very poor and poor households depend on fishing activities and tourism in the rainy seasons. In addition, 95% of these families are heavily involved collecting fuel wood. All families in this swamp forest area more or less dependent this forest for their livelihood. However, the swamp forest is being destroyed due to the high population pressure and level of resource extraction extreme, including level of extreme fishing, fuel wood collection, expansion of agriculture, illegal logging, irrigation, grazing, habitat human infrastructure, tourism activities, poaching, collection of medicinal plants and other forest non-wood products, pesticides and other activities. The impact of climate change includes irregular and heavy rainfall, increase in extreme events, etc. After analyzing two periodic images (2005 and 2015) it appears that the area was reduced by 4 h 2005 to 2015 (a total area of 208 ha forest). The total area of dense forest was 114.80 ha in 2005, but in 2015 was 96.40 ha. In 10 years the degradation of this area was significant. Approximately 94 species of fish live in the

Swamp Ratargul forest and 28 species are endangered, 14 are vulnerable, 10 are endangered and four are critically endangered.

The participatory forest management approach could be an effective tool to overcome the problems of Ratargul Swamp Forest. The structure of participatory management approach must be implemented by local communities, national and international NGOs, research organizations and forest department. To raise awareness about the importance of swamp forest, NGOs and other voluntary organizations should organize workshops for local and forest communities, and find alternative sources of income. The forest department set the forest boundary to protect, should be maintained forestry laws and policies. Furthermore, the forest department to proactively address the problem of species endangered and the real reasons behind forest degradation to rehabilitation. Working all together, sustainable management is possible for this swampy forest.

Keywords: Wetlands, Ecosystem Services, Global change, Livelihood security, Sustainable use.

RESUMO ALARGADO

As zonas húmidas são consideradas como um supermercado biológico por causa de sua rica biodiversidade. Actuam como um tampão durante o período de seca extrema e inundações. Desempenham um papel vital no desenvolvimento da cultura humana e da sociedade com o fornecimento de benefícios tangíveis e intangíveis. Desempenham um papel fundamental para a segurança da subsistência das pessoas pobres dos países em desenvolvimento. No entanto, a alta taxa de crescimento populacional e extração de recursos excedentes são problemas para a sustentabilidade. Geograficamente a maioria das áreas de Bangladesh encontram-se no maior delta do mundo onde 700 rios confluem. A área total das zonas húmidas de Bangladesh é estimada em 70.000 a 80.000 km2, cerca de 50% do país. Estas zonas húmidas incluem rios, estuários, manguezais, pântanos de água doce, pântanos (haor), lagos oxbow (baor) e beel (bacia em forma de depressão), reservatórios de armazenamento de água, lagoas, e outros áreas de inundação sazonal. Têm grande contribuição para os aspectos do ecológicos, econômicos, industriais, sócio-económicos e culturais do país. Por exemplo, as zonas húmidas de Bangladesh estão ajudando a assegurar uma r vida socioeconômica melho de milhões de pessoas rurais, oferecendo oportunidades de emprego, alimentação e nutrição, combustível, forragem, transporte, irrigação, turismo e assim por diante. Cerca de 70% de proteína animal do país vem de peixes de água doce e 50% das pessoas deste país estão diretamente dependentes de recursos das zonas húmidas para a subsistência. Além disso, 6-8 receita% vem de áreas haor de Bangladesh, sem dúvida, uma grande contribuição para o PIB. No entanto, as zonas húmidas de Bangladesh estão sob ameaça considerável devido ao elevado crescimento da população, expansão das terras agrícolas, industrialização, gestão deficiente de infra-estruturas , sedimentação, salinidade, poluição, sobrepesca, caça ilegal, a falta de coordenação institucional, conflito entre sectorial de leis e políticas, falta de consciência, agitação política etc.

Um estudo de caso foi realizado no Pântano Floresta Ratargul localizado parte oriental norte de Bangladesh. Esta é apenas uma nova floresta paludosa água de Bangladesh com características especiais, chamados localmente a Amazónia do Bangladesh. Ecologicamente esta floresta fornece habitats significativos para a flora e fauna. A população desta áre está, total ou parcialmente dependente desta floresta. No entanto, a floresta paludosa vem sendo degradada ao longo dos tempos. O objectivo deste estudo é definir as características, funções, valores e serviços da floresta. Este estudo também explora critérios de dependência da população local, perturbações da floresta e opções para a sua gestão optimizada. Em seguida

uma abordagem de pesquisa qualitativa e quantitativa com ferramentas de avaliação rural participativa (PRA) para coletar informações sócio-económicas. As técnicas de PRA incluem o levantamento de famílias, entrevistas com informantaes-chave, grupo de discussão com questionários semi-estruturados. Dados complementares foram recolhidos em dois motores baseados na web: (i) Science Direct e (ii) Proquest para localizar artigos que descrevem o valor, importância, e problemas de zonas húmidas em Bangladesh. SIG foram usados para detectar mudanças no uso da terra ao longo do tempo.

O chão da floresta é de 35 m acima do nível médio do mar onde as áreas máximas são simples. Para além dos rios Shari-Goyain e Kafna, existem lagoas e depressões naturais e canais no interior da floresta. A profundidade média do rio é de 12 metros e a profundidade dos canais e lagoas são 5 m e 2,5 m, respectivamente. O nível de água varia na estação chuvosa (maio a setembro) e estação seca (dezembro a março). Durante a estação chuvosa, toda a zona fica sob a água e a altura média do nível de água do chão da floresta é de 4 m Devido à precipitação e escoamento a montante, o nível de água aumenta até 7,5 m. Por outro lado, na estação seca, a profundidade média da água nos rios e canais é de 3,5 m e 2 m, respectivamente. No entanto, os lagos e depressões naturais podem ficar completamente ecos. Durante a estação seca o chão da floresta também pode secar completamente, exceto alguns corpos de rios e canais. Nos restante dos meses do ano, ou seja, em abril, outubro e novembro no chão da floresta permanecem quase lamacento. Este ciclo desempenha um papel no ciclo de vida das espécies de plantas e circulação de animais aquáticos e terrestres. Quatro tipos de função do ecossistema existem nesta floresta paludosa, - hidrológica, biogeoquímico, ecológica e atmosférica. Os valores e serviços são o resultado destes quatro tipos de funcionamento que inclui valores ambientais, econômicos (incluindo diretos, indiretos, opção, existência, valores legado), sociais e culturais, e logo, na manutenção da qualidade ambiental. Verificou-se que, as famílias desta região são muito pobres (28%), pobres(21%) e de médio rendimento (42%). Vivem do pântano que gera diferentes rendas, em resultado da agricultura; pesca; recolha de alimentos, forragens, combustíveis e plantas medicinais, turismo. Aproximadamente 90% das famílias muito pobres e pobres dependem das actividades de pesca e do turismo nas estaçõeschuvosas. Além disso, 95% dessas famílias estão fortemente envolvidos recolha de lenha de floresta. Todas as famílias desta área florestal pântano mais ou menos dependem desta floresta para sua subsistência. No entanto, a floresta paludosa está sendo destruída devido à alta pressão populacional e nível extremo de extracção de recursos, incluindo nível extremo de pesca, recolha de madeira de combustível, expansão da área agrícola, abate ilegal,

irrigação, pastagem, infra-estrutura de habitat humano, actividades de turismo, caça ilegal, recolha de plantas medicinais e outros produtos florestais não-madeireiros, uso de pesticidas e outras atividades. O impacto da mudança climática inclui precipitação irregular e pesada, aumento de eventos extremos, etc. Depois de analisar duas imagens periódicas (2005 e 2015) verifica-se que, a área foi reduzida em 4 ha 2005-2015 (área total de floresta 208 ha). A área total da floresta densa era 114,80 ha em 2005, mas em 2015 foi 96,40 ha. Em 10 anos a área degradadaaumentou significativamente. Aproximadamente, 94 espécies de peixes habitam no Pântano Floresta Ratargul e 28 espécies estão ameaçadas, 14 são vulneráveis, 10 estão ameaçadas de extinção e 4 estão criticamente em perigo.

A abordagem de gestão florestal participativa poderia ser uma ferramenta eficaz para superar s problemas existentes de Ratargul Pântano Forest. A estrutura da abordagem de gestão participativa deve ser implementada por comunidades locais, ONGs nacionais e internacionais, organizações de pesquisa e departamento florestal. Para aumentar a consciência sobre a importância da floresta paludosa, as ONGs e outras organizações voluntárias devem organizar workshops para as comunidades locais e da floresta, e encontrar fontes alternativas de renda. O departamento florestal definir o limite da floresta a proteger, devem ser mantidas as leis e políticas florestais. Além disso, o departamento florestal deve lidar proactivamente com o problema das espécies ameaçadas de extinção e os motivos reais por trás da degradação florestal para a reabilitação. Trabalhando todos em conjunto, a gestão sustentável é possível para esta floresta pantanosa.

Palavras-chave: zonas húmidas, Serviços de Ecossistemas, alterações globais, segurança da subsistência, manejo sustentável.

CONTENTS   PAGE NUMBER

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ADB   Asian Development Bank

BHWDB   Bangladesh Haor and Wetland Development Board

DOE   Department of Environment

FAO   Food and Agriculture Organization

FD   Forest department

GOB   Government of Bangladesh

IUCN   International Union for Conservation of Nature

NWP   National Water Policy

USAID   United States Agency for International Development

WB   World Bank

NGOs   Non-governmental Organization

ECA   Ecologically Critical Area

LIST OF GLOSSARIES

Baor   Oxbow lake

Beel   Bowl-shape depression/ perennial water bodies

Haor   Marsh/ naturally depressed water basin

1. INTRODUCTION

1.1 General background

Wetlands are considered as the "Biological Supermarket" because of its rich biodiversity in the world (Nabahungu and Visser, 2011). The wetland ecosystem is the most diverse and productive entity which includes marshes, lakes, rivers, flood basins, estuarine deltas, ponds, rice fields, and marine water areas where the depth at low tide does not exceed to 6m (Lamsal, 2015). Moreover, wetland acts as a buffer during extreme drought and flood. In case of dry season, wetland gradually releases water and confirms water availability. Reversely, during rainy season wetland absorbs water and reduce the risk of flood (Nabahungu and Visser, 2011; Kangalawe and Liwenga, 2005). Both of the processes are significant for sustaining life on earth. Wetland plays a vital role in the development of human culture and society (Islam, 2010) with the provision of tangible and intangible benefits. For instance, wetland ecosystem is the magnificent source of fish, fiber, fodder, fuel, water supply, water purification, climate regulation, flood regulation, coastal protection, recreational opportunities, tourism and other services (Lamsal, 2015; Millennium Ecosystem Assessment 2005). Most importantly wetland resources play imperative role for livelihood security of poor and developing countries (Opio, 2011). However, high rate of population growth and excess resources extraction from the wetlands are the major problems for sustainability.

Geographically most of the areas of Bangladesh lie in the largest delta in the world. Therefore, the Bengal basin is formed by the Ganges i.e Brahmaputra, and Meghna river system (Talukder, 2009). About 700 rivers with tributaries flow across the country constitutes a waterway of total length around 24,140 km even it is very small country (1, 47,570 km^2). For this reason, Bangladesh is known as a 'land of river'. The total wetland areas of Bangladesh are estimated to be 70,000 to 80,000 km^2. It comprises about 50% of the total national land of the country (Islam, 2010; Khan et al., 1994). These wetlands include rivers, estuaries, mangrove swamps, fresh water swamp, marsh (haor), oxbow lake (baor) and beel (bowl-shape depression), water storage reservoirs, ponds, and others seasonal inundation areas. Broadly these wetlands can be classified into five distinct categories; such as- saltwater wetlands, freshwater wetlands, palustrine wetlands, lacustrine wetlands and man-made wetlands (Islam, 2010). Wetland areas of Bangladesh support rich biodiversity of flora and fauna. There are 5,000 species of flowering plants; 1,500 species of vertebrates including 750 species of birds; 500 species of coastal, estuarine, fresh-water fishes inhabit in the wetlands area. However, 400

species of vertebrates and 300 species of plants depend upon the wetlands for their total life cycle or part of life. Almost 260 species of fresh-water fishes exist in the wetlands (Bhuiyan, 2013).

Wetlands in Bangladesh have great contribution to the country's ecological, economic, industrial, socio-economic and cultural aspects (Islam and Gnauck, 2007). For instance, wetlands of Bangladesh are helping to ensure better socioeconomic life of millions of rural people by providing opportunities of employment, food and nutrition, fuel, fodder, transportation, irrigation, tourism and so on. Near about 70% of animal protein of the country comes from fresh water fishes (Bhuiyan, 2013) and 50% people of this country are directly depended on wetland resources for livelihood (Islam, 2010). In addition to this, 6-8% revenue comes from haor areas of Bangladesh, undoubtedly a great contribution to its GDP (BHWDB, 2012). However, the wetlands of Bangladesh are under considerable threat due to high growth of population, expansion of agricultural lands, industrialization, poor infrastructure management, sedimentation, salinity, pollution, over fishing, illegal hunting of birds, lack of institutional coordination, conflict between sectoral laws and policies, lack of awareness, political unrest etc. (Talukder, 2009). As a result, many species of flora and fauna living in wetlands are decreasing with the passage of time. Therefore, a negative change is appearing in life expectancy, cultural values and others socio-economic condition of local people.

The management of wetlands in Bangladesh is not well-organized and systematic. The wetlands of Bangladesh are overseen by Bangladesh Water Development Board (National Water Policy, 1999) with the objectives of sustainable management of wetlands resources (Talukder, 2009). The Ministry of Environment and Forestry, Ministry of Fisheries and Livestock and Ministry of Land are respectively working on wetlands (GOB, 1999). But in 2000, Bangladesh Haor and Wetland Development Board has been established under the Ministry of Water Resources. The main goals of this board are the production, protection and proper utilization of wetland resources. This board maintains collaboration with different project of national and international agencies in co-management planning approach (IUCN, 2007). However, the achievements are not satisfactory due to poor economic, social and political condition.

1.2 Research rationale

Wetlands of Bangladesh plays praise-worthy role in ecological, economic and social context. However, socio-economic aspects are more remarkable; because, most of the people directly

depend on wetland resources for their livelihood (Talukder, 2009). This research has been carried out on "Ratargul Fresh Swamp Forest" which is located north eastern part of Bangladesh. Geologically this wetland forest consists of part of two rivers with several channels and surrounded by seasonal rice lands, isolated hillocks and villages (Choudhury et al., 2004). This is only one fresh water swamp forest of Bangladesh with special features (Dey, 2013). These types of land setting are the principal reason for the rich biodiversity of this wetland area. About 73 species of plants, 26 species of mammals, 175 species of birds (including 46 migratory birds), 9 amphibians, 20 species of reptiles (4 species of snakes) exist in this wetland (IUCN, 2004). About 94 species of fish inhabit in the Ratargul Swamp Forest. Among them 28 species are threatened, of which 14 are vulnerable, 10 are endangered and 4 are critically endangered (Islam et al., 2016).

Surrounding people totally or partially depend on wetland in different ways. A handsome amount of rice, fodder and fuel comes from this wetland area. Many people collect patipata (*Schumannianthus dichotoma*) from this forest which is used for making handicrafts, thatching materials etc. Fishing is an important source for livelihood that is carried out during rainy season. Some people catch fish occasionally to meet only their demand and most of the people catch fish professionally. These fishes are sold in the market and earn cash money (IUCN, 2004). This wetland is 45 km away from Sylhet city. For this reason, every year a lot of tourists come from home and abroad to visit this unique place. Normally boats are used to visit this place in the rainy season. So tourism has considerable effect to change the lifestyles, economy and environment of local people (Brown, 2005). But the disturbances of this wetland area are high due to excessive population pressure, extreme level of resources extraction and some natural causes. For instance, huge people migrate to this wetland area from outside. These people illegally inhabit this area where totally or partly depend on wetland resources. The man-made disturbances include over fishing (complete fishing by dewatering, gearing and fencing), navigation, irrigation, agricultural land expansion, infrastructure, human habitat, deforestation, tourism activities, illegal hunting of birds and animal, use of pesticides and other activities. Moreover, some environmental factors such as irregular and heavy rainfall, extreme flood, and siltation are greatly affecting to wetland biodiversity of this area (Islam et al., 2016).

It is sure that if these disturbances continue for few years, the wetland resources of this area will be reduced in critical level. In this case, wetland dependent people will face serious problem regarding their livelihood safety. However, sustainable management is possible by identifying and analyzing the problems of this wetland. Therefore, it is high time to bring this wetland under

scientific management, since it is essential for ecological, economic, social as well as global climate change aspect.

1.3 Purpose and objectives of the research

The purpose of the research is to find out the value, importance and challenges of wetlands of Bangladesh. In order to complete this research a case study has been completed on "Ratargul Swamp Forest" i.e. the role on ecological, economic and social perspective. Moreover, it assessed challenges and best management options of this wetland.

1.3.1 General objectives

This study explores the characteristics, functions, values and services of "Ratargul Swamp Forest" that is playing vital role on local people and environment. Furthermore, it also detects the problems and optimum management opportunities for this swamp forest.

1.3.2 Specific objectives

1. To find out characteristics, functions, values and services
2. To explore the role of wetland on livelihood security of local people
3. To find out disturbances and the best management options

2. LITERATURE RIVEW

2.1 Designation of wetland

The RAMSAR convention has defined wetlands are the areas of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters (Sultana, et al., 2009). An area is also considered to be a wetland when it holds water for a significant period and sufficient to support organism and have ecosystem value. These areas could be lakes, rivers and coastal forest, fresh water swamp forest to deep water paddy fields and ponds (Sultana, et al., 2009; Khan et al., 1998).

2.2 Status of wetlands in Bangladesh

2.2.1 Location of major wetlands
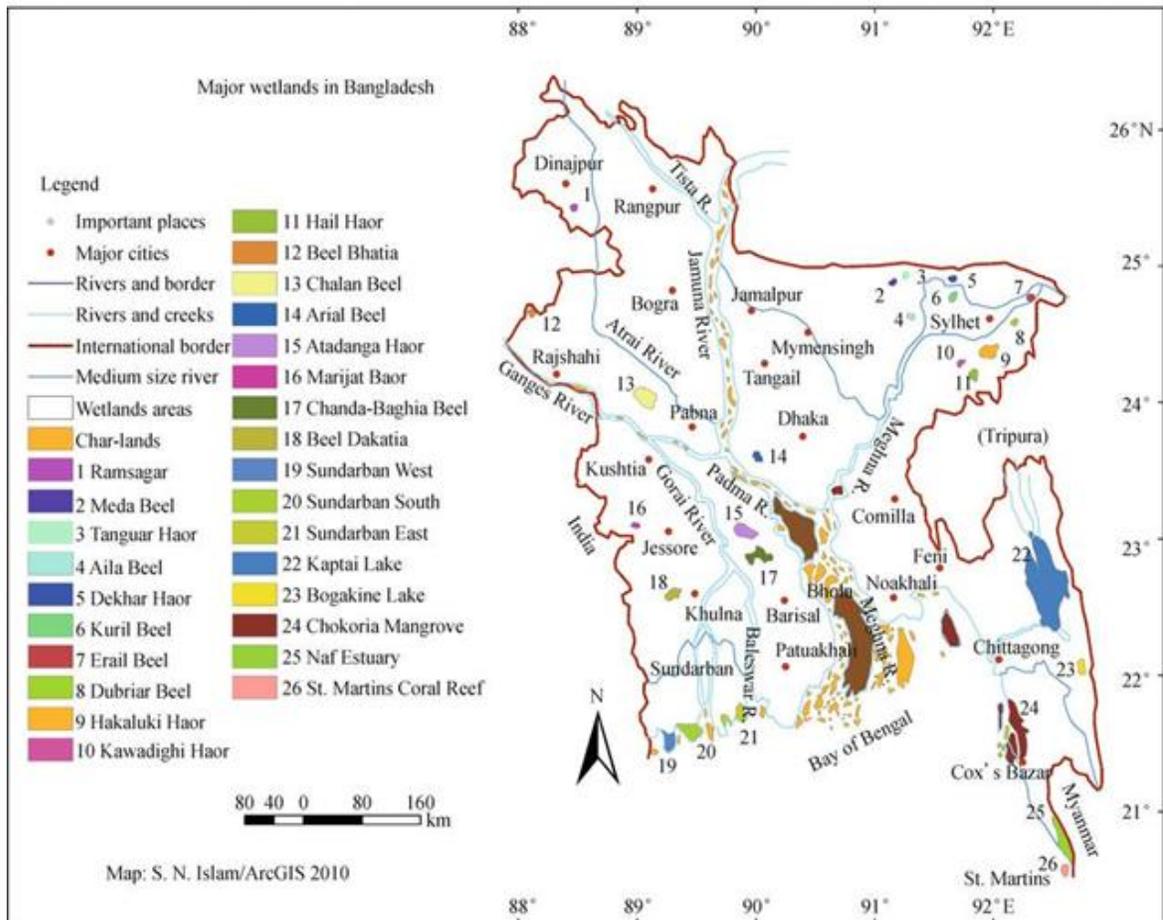
Figure 1: Distribution of major wetlands area in Bangladesh

Bangladesh is located in the South-Asia between 20°34' to 26°38' N latitude and 88°01' to 92°42' E longitude. The total area of Bangladesh is 147570 km^2. However, the population of the country is 160 million with a very low per capita Gross National Product (GNP) worth of US$ 1087 (WB, 2015). There are three major types of landscapes in Bangladesh; namely floodplains (80%), terraces (8%), and hills (12%) (Hasan and Mulamoottil, 1994). Terrace areas are located in the middle part and hilly areas are mostly in the eastern part of Bangladesh (Islam, 2010).

Geographical setting depicts that most of the areas of Bangladesh lie in the largest delta in the world. Generally, the Bengal basin is formed by the Ganges, Brahmaputra, and Meghna river system (Talukder, 2009). Approximately700 rivers have flowed across the country and the total length is around 24,140 km. For this reason, traditionally Bangladesh is known as land of river. The total wetland areas of Bangladesh are estimated to be 70,000 to 80,000 km^2. It includes about 50% of the total national land of the country (Islam, 2010; Khan et al., 1994). All the areas of Bangladesh comprise small or big wetlands (Fig. 1). Almost 6.7% of Bangladesh remain always under water, 21% is deeply flooded, and 35% experiences shallow inundation (FAO, 1988). However, North-eastern and southern parts are best known for wetlands area. North-eastern part of the country is famous for haor. That is why this region is called haor basin of Bangladesh. The haor areas are covering about 25% of the entire region (Rahman and Ahmed, 2002). Southern part is famous for the world largest mangrove forest of the world.

2.2.2 Categorization of wetlands

Wetlands in Bangladesh are perennial (Nishat, 1993) and changing scenario of wetlands is obvious in different seasons. Broadly the wetlands of Bangladesh can be classified in five types; such as- saltwater wetlands, freshwater wetlands, palustrine wetlands, lacustrine wetlands, and man-made wetlands (Islam, 2010). However, a significant part of the total country is covered by seasonal flood land which stands 37%. A Part from this, 27% is covered by swamp forest; 14% is covered by rivers, canals, and estuaries; 8% is covered by mangrove forest; 7% is covered by beels and haors; 2% is covered by ponds; 1.5% is covered by natural depressions and the remaining 3% is covered by peat land, oxbow lakes, reservoirs, and brackish water farms (Tab. 1) (Gopal and Wetzel, 1995).

6

Table 1: Wetlands area of Bangladesh (Gopal and Wetzel, 1995)

Types of wetlands	Area (km^2)	% of area
Rivers, canals and estuaries	10300.00	13.77
Natural depressions	1141.69	1.52
Ponds	1619.43	2.16
Ox-bow lakes	544.88	0.73
Reservoirs	688.00	0.92
Seasonal flood lands	28000.00	37.42
Brackish water farms	873.00	1.17
Mangrove wetlands	6100.00	8.15
Beel and haor	5000.00	6.68
Peat land	155.00	0.21
Swamp forest	20400.00	27.27
Total	**74 822.00**	**100.00**

2.2.3 Floral and faunal of wetlands

The wetlands of Bangladesh are rich with diversified floral and faunal composition. There are 5,000 species of flowering plants; 1,500 species of vertebrates including 750 species of birds (approximately 400 species of migratory birds); 500 species of coastal, estuarine, fresh water fishes inhabit in the wetlands area. However, 400 species of vertebrates, 300 species of plants largely depend upon the wetlands for their total life cycle or part of life. Almost260 species of fresh water fishes abide in the wetlands (Bhuiyan, 2013).

The only one fresh water swamp forest located in the north-eastern part of Bangladesh is called Ratargul Swamp Forest. The area of swamp forest is about 204 ha. About 118.50 ha were declared as a reserve forest (Choudhury et al., 2004). Approximately 73 species of plants, 26 species of mammals, 175 species of birds (include 46 migratory birds), 9 amphibians, 4 species of snakes, 20 species of reptiles live in this wetland (IUCN, 2004). About94 species of fish inhabit in the Ratargul Swamp Forest. Among them 28 species are threatened, of which 14 are vulnerable, 10 are endangered and 4 are critically endangered (Islam et al., 2016).

The saline water wetlands are located in the south part of Bangladesh along the Bay of Bengal. Sundarban is the world largest mangrove forest of the world that is inundated by saline water from the Bay of Bengal. The total area is 10000 km^2. However, 62% of this mangrove forest is located in Bangladesh and the rest is in India. In 1998, Sundarban has been declared as world

heritage site by UNESCO. The floristic composition of the Sundarban has reached compared to many mangrove forests of the world. There are 334 species of plants belonging to 245 genera and 75 families; 50 species of mammal;315 species of birds, including about 95 species of waterfowl and 38 species of raptors; 53 species of reptile and 8 species of amphibians. But2 amphibians, 14 reptiles, 25 birds and 5 mammals are endangered (Siddiqui, 2012; Sarker, 1993).

2.3 Importance of wetlands

2.3.1 Function of wetlands

The functions of wetlands have been described differently in the available literature. According to Groot, wetlands function can be categorized into four distinct classes (Groot, 1992). These are: (1) Regulation functions, ecosystems regulate ecological processes that contribute to a healthy environment. For instance, maintenance of hydrological cycle, water storage and discharge, flood control and regulation, biodiversity protection etc. (2) Carrier functions where ecosystems provide space for activities; like-human settlement, extension of urbanization, cultivation and energy conversion, field of education and research, employment opportunity and others activities.(3) Production functions, ecosystems provide resources for humans; like food, water, grazing, livestock, fuel and others raw materials. (4) Information functions where ecosystems contribute to mental health by providing scientific, aesthetic and spiritual information. For example- recreation and ecotourism, cultural and natural heritage, cultural landscapes and beauty, religion values, ethical values etc.

The function of wetlands can be divided into major three groups such as hydrological function, biogeochemical function, and ecological function (Fig. 2). Consequently, these three functions provide socio-economic benefits and services to the society. These tangible and intangible benefits are important to sustain better life of the local community and stakeholders who are living surrounding the wetlands (Islam, 2010).
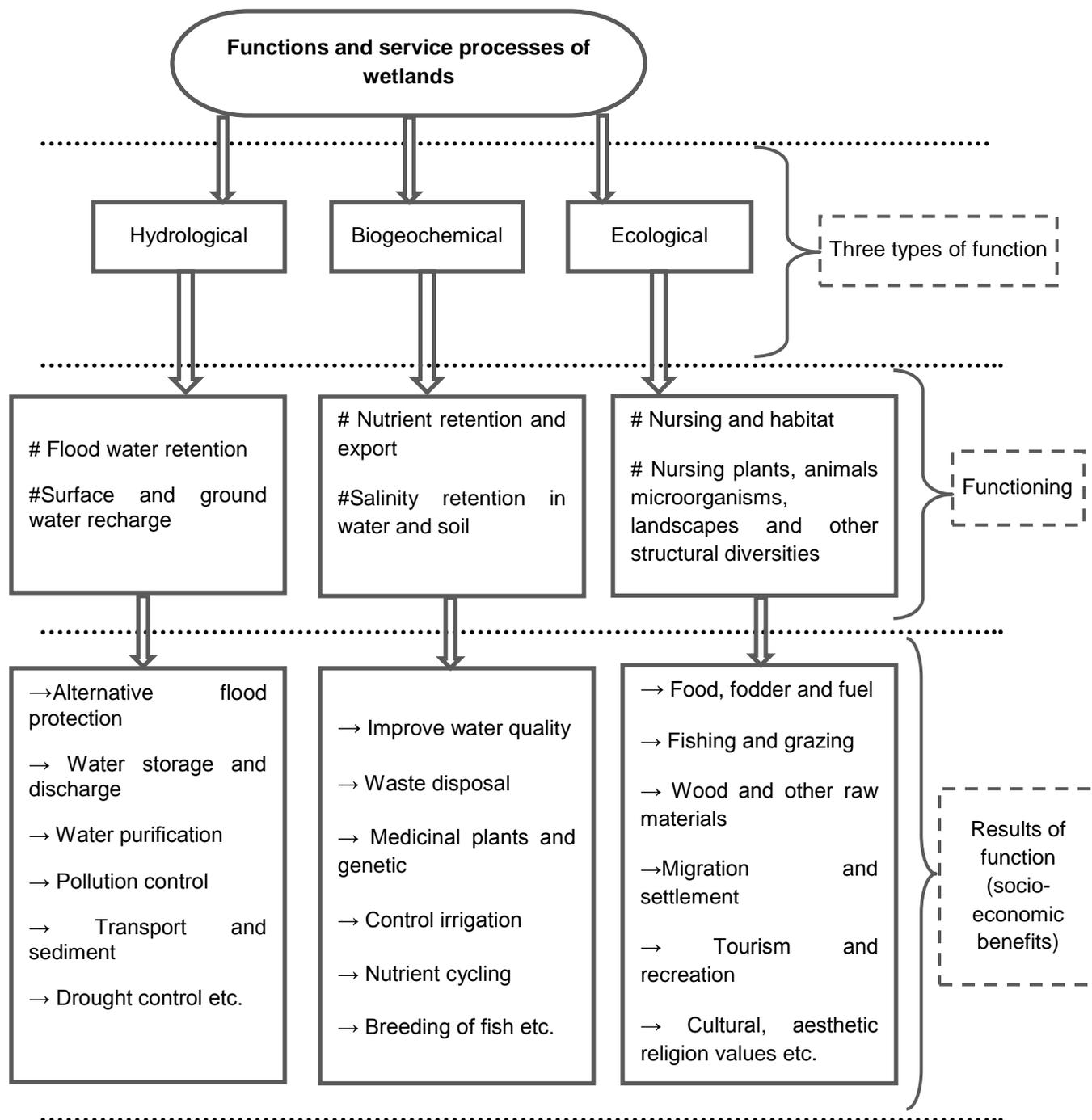
Figure 2: Functional processes and services of wetlands

2.3.2 Wetland value and ecosystem services

Wetlands are the most productive ecosystems which cover huge species of plants and animals. The value of wetlands in Bangladesh are categorized into four types; such as- environmental, economic (including direct, indirect, option, existence, bequest values), social and cultural value

(Islam, 2010). Based on this values wetlands provide several service to human being (Tab. 2). Environmental services refer to qualitative functions of natural non-produced assets of land, water and air (including related ecosystem) and their biota. However, the environmental services of wetland of Bangladesh play significant role in maintenance of hydrological cycle, water storage and drainage, flood control, purification of water and others ecological function. Local people easily can imagine the influence of direct economic values of wetlands. About 80% of rural households catch fish for food or sale (Flood Action Plan, 1995), and about 70% of animal proteins come from fish (Bhuiyan, 2013). Climate change is an environmental, social and economic challenge on a global scale (Scholze, et al., 2006; Mendelsohn, et al., 2006). It is seen that every year a huge number of family migrate to the wetlands area for livelihood security. The cultural value includes ecotourism and recreation, cultural landscapes and beauty, cultural value, aesthetic value, religious value, spiritual value, ethical value etc. (Tab. 2). For instance, ecotourism can have significant impact on the society with the change of lifestyles, economy, environment and so on (Islam, 2010).

Table 2: Wetlands values and ecosystem service (Islam, 2010).

Wetland value		Types of ecosystem services
Environmental		Maintenance of hydrological cycle, water storage and discharge, flood control and regulation, transport of sediments, reduce salinity intrusion, purification of water, pollution control, reduce of erosion, soil formation, food chain and habitat maintaining, biodiversity protection, maintenance of landscapes and balance of ecology etc.
Economic		
	Direct value	Agriculture, forestry, fishing, hunting, wild food, grazing, livestock, fuel, fodder, honey, fruits and wood (swamp forest), supply of raw materials and other direct values.
	Indirect value	Benefits from improvement of water quality, flood prevention, pollution control, drought control, provision for medicinal plants etc.
	Option value	Benefits from ensuring the option for a future use.
	Existence value	Benefits from conserving or willingness to sacrifice a part of one's income in order to conserve resource especially natural amenities.
	Bequest value	Benefits from ensuring that certain goods will be preserved for future generations.
Social		Navigation and social network, provision of settlement, migration, extension of urbanization, field of education and research, employment opportunity and livelihood security and others social activities.
Cultural		Ecotourism and recreation, cultural heritage, natural heritage, cultural landscapes and beauty, cultural values, aesthetic values, religion values, spiritual values, ethical values etc.

2.3.3 Wetlands and livelihood security

Wetlands provide direct and indirect benefits to the people. About 50% of the total national lands of Bangladesh are wetlands (Islam, 2010; Khan et al., 1994). However, wetlands of Bangladesh are diverse, and each has some distinct features in terms of physiography, seasonality, and use patterns (Rahman, 1995). These wetlands are the most important sources of livelihood mainly for cultivating agricultural crops, fodder, fuel, fishing, wetlands forest product and others resources (Khan et al., 1994). More than 50% people of this country directly depend on wetland resources for livelihood (Islam, 2010). For instance, 6-8% revenue comes from haor areas of Bangladesh which is a great contribution for GDP (BHWDB, 2012). The livestock of wetlands areas include cattle, buffaloes, goats, sheep, chickens, ducks etc. These animals directly depend on wetland resources. For instance, 22% of total cattle of the country are in the haor regions which produce 0.90 MT (metric ton milk), and 0.1 MT meat (BHWDB, 2015).

Rice (*Oryza sativa*) is the main food of Bangladesh where wetlands area produces a significant amount. For example, only hoar areas produce 18% of rice of the country (BHWDB, 2015). A green vegetable locally called *Kachu* (*Aponogetom spp.*) is naturally grown in the waterlogged and wet areas (Alam and Chowdhury, 2003). Therefore, it is also cultivated after the harvesting of rice in low-lying and wetlands areas. The green vegetable Kachu tubers yield milky white flour having nutritious value like potatoes (Islam, 2010). The trees such as hizal (*Barringtonia acutangula*), tamal (*Diospyros cordifolia*), barun (*Crataeva nurvala*), madar (*Erythrina variegate*) are important for fuel and low class timber. The gab (*Disopyros peregrine*), dumur (*Ficus hispida*), chalta (*Dillenia indica*), dehua (*Artocarpus lacucha*), and pine-apple (*Ananas comosus*) are regarded as fruits for human and other wildlife (Alam and Chowdhury, 2003; Talukdar et al., 2008). During rainy season these types of trees provide ideal habitat of fishes. Indigenous people collect some medicinal plants locally known as akhanda, kalmi, helencha, and bishkatali, paddo. The flowers and seeds of paddo (Indian lotus) are prescribed for piles, as for cardiac tonic and for elimination of ringworm. The flowers of water lilies are used for vegetables and medication of heart ailments (Khan et al., 1994; Rahaman, 1995). Patipata (*Schumannianthus dichotoma*) is another important plant which grows naturally on the bank of the wetlands. This plant is harvested by the local people that are used for making handicrafts, thatching materials etc.

About 260 species of fresh-water fishes inhabit in the wetlands of Bangladesh (Bhuiyan, 2013). Fisheries are vital source of livelihoods and food for the rural poor who are living around the

wetlands area. Approximately 80% of rural families catch fish for food or sale (Thompson and Hossain, 1998) and 70% of animal proteins of the country come from fresh water fishes (Bhuiyan, 2013). During rainy season a huge number of tourists come from home and abroad to visit the famous wetlands area. Normally traditional boats are used to visit such places. In this time local people earn additional money by boating and selling handicrafts, traditional foods. So tourisms have considerable effect to change the lifestyles, economy and environment of local people (Brown, 2005). However, government aims to increase present GDP rate of tourism sector from 0.70% to 2% by 2015 (BHWDB, 2015).

The wetland forest plays imperative function not only protection but also production (Annunzio et al., 2005). Forest goods and services generate the income of local people. In some areas, forest resources contribute second or third income sources after agricultural production (Babulo et al., 2009). The Sundarban plays a vital role in the economy of the southwestern region of Bangladesh as well as in the national economy. The direct benefits from Sundarban comprises timber, fuelwood, pulpwood and non-wood forest products such as thatching materials, honey, beeswax, fish etc. The non-wood products are collected by the local people with nominal fees. About 41% of total forest revenues come from Sundarban (FAO, 1995).

Different types of mineral resources are deposited in the wetland areas of Bangladesh. These include natural gas, crude oil, limestone, peat, coal, gravel, white clay, glass sand etc. Up to 2010 the volume of extracted gas is 5,694 BCF (billion cubic feet) and reaming reserve is 11, 149 BCF (BHWDB, 2015). The other services of wetlands include flood control, irrigation, water purification, recreational and cultural facilities improve the quality of life of community people.

2.4 Problems of wetlands in Bangladesh

2.4.1 Anthropogenic causes

Wetlands of Bangladesh are being destroyed due to high population pressure and extreme level of resources extraction. Every year huge people migrate to the wetlands area from the other parts of the country. These people illegally inhabit in this area where totally and some are partly dependent on the wetland resources. The man made disturbances include over fishing (complete fishing by dewatering, gearing and fencing), navigation, irrigation, agricultural land expansion, infrastructure, human habitat, deforestation, tourism activities, illegal hunting of birds and animal, use of pesticides and other activities (Islam et al., 2016). Deforestation and poor land use management practice create soil erosion, landslides and siltation. Consequently, every

year the depth of tributary is decreasing and changing the direction of stream flow (Alam and Matin, 2013). Other important reason is embankment for wetland disturbances. For instance, India has made "Farakka Barrage" on Ganges river (Bangladesh it is called Padma river) in 1975. For this reason, average flow of this river is decreasing from 1975 to present (Islam, 2010). As a result, during the dry seasons water deficiency is very common in the north-western part of Bangladesh. Moreover, saline water enters into inland of the river mouth which harms largely the Sundarbans mangrove wetlands ecosystem. South-eastern wetlands (Chokoria Sundarban) of Bangladesh are converting into saline-desert. About 45% of mangrove wetlands have been destroyed due to anthropogenic shrimp farming (Khan et al., 1994). Industrial discharges and agro-chemicals are the problem of Bangladesh wetlands. Rampal power station is being established near the boundary line of Sundarban that is leaving serious impact on Sundarban wetlands. Flood embankment and water control structure make block for the movement of fishes and others aquatic animals. As a result, there is a problem in breeding of fishes as well as aquatic animals. To cope up with the population growth, most of the urban wetlands area of Bangladesh is being converted for settlement and industry (Sulltana at el., 2009).

2.4.2 Natural causes

Bangladesh is one of the world's most vulnerable countries to climate change and natural calamities. The wetlands of Bangladesh affecting climate change impact such as irregular and heavy rainfall, flood, flash flood, salinity intrusion (south part), extreme temperature and drought (North part), cyclones, storm surges sea-level rise, siltation etc. In the last 30 years, Bangladesh have faced about 200 of climate change related disasters which have killed thousands of people, destroyed home, fisheries, agriculture and sources of others livelihood which loss stands $16 billion (Raillon, 2015). Moreover, pest and diseases are responsible for losses of wetlands biodiversity in Bangladesh.

2.5 International issues of wetlands disturbances

Bangladesh is small country where three sides are bounded by India and Myanmar lies in the south-eastern part. Geographically Bangladesh formed land downhill sides of India. For this reason, some big rivers (Padma, Brahmaputra, Surma, kushiara etc) and catchments have entered in Bangladesh from Indian uphill sides. These are the main sources of fresh water wetlands of Bangladesh. This water is used for agriculture, fisheries, transportation and so on. However, India made "Farakka Barrage" on Ganges river in 1975 (Fig. 4). The average flow of

this river was 3700 m^3/s in 1962 and it has reduced to 364 m^3/s in 2006 (Islam, 2010). As a result, saline water has entered into inland of the river mouth which harms largely the Sundarban mangrove wetlands ecosystem. Another river Teesta has entered into Bangladesh from the north side which is also an important source of water (Fig. 4). There is an agreement between Bangladesh and India for sharing of water of Teesta. But Indian government disagrees to share water of Teesta. Moreover, India has taken an initiative in 2013 to make a dam (Tipaimukh dam) on Barak river that is in the north-eastern side of Bangladesh (Fig. 4). Bangladeshi experts have immediately said that the massive dam will disrupt the seasonal rhythm of the river and have an adverse effect on downstream agriculture and fisheries. At present the project of Tipaimukh dam is postponed. If this dam is constructed, the wetlands of north-eastern part of Bangladesh will face serious impact in terms of ecology, economy and other social-cultural aspects (Daily Star, 2013). Rampal power station (coal based) is going to be established near the boundary of Sundarban (Fig.4). It is a joint partnership between Bangladesh and India (50:50 benefit sharing). This plant needs 4.72 million tons of coal per year. The coal-carrying vehicles will travel inside the Sundarban. These vehicles are leaving and will leave fly ash, coal dust, sulfur and other toxic chemicals those are threats for Sundarban wetlands area. Therefore, environmentalists have expressed concerns about this plant which violates provisions of the Ramsar Convention (New Nation, 2015; DOE, 2013).

2.6 Present management scenarios of wetlands

The management scenarios of wetlands in Bangladesh are not clear and specific. The wetlands of Bangladesh are managed by "National Water Policy, 1999" with the broad objectives of sustainable management of wetlands resources (Talukder, 2009). The Ministry of Environment and Forestry, Ministry of Fisheries and Livestock and Ministry of Land of Bangladesh are respectively working on wetlands (GOB, 1999). In addition to this, in 2000, Bangladesh Haor and Wetland Development Board (BHWDB) was established under the Ministry of Water Resources. This board is working on the basis of six objectives such as economic development, food security, descent standard of living for the people, poverty alleviation, public health and safety, protection of natural environment (BHWDB, 2015). In order to accomplish these objectives, this board maintains collaboration with different project of national and international agencies that is called co-management planning approach (IUCN, 2007). However, the achievements of these bodies are not satisfactory due to poor economic, social, political condition.

At present, 43 sites have been identified in Bangladesh as wetlands and protected areas, and most of these areas are ecologically sensitive sites (Fig. 3). Among them 15 sites are declared as protected area by the Ministry of Environment and Forest of Bangladesh (Islam, 2010; Talukdar et al., 2008). The other important wetlands and sensitive sites are Banur Bogdeo beel, Beel dakatia, Marijatbaor, Chanda-Baghiabeel, Sonadia island, Hatiya island, Monpura char, Char Kukuri Mukuri, Sundarban Ramsar Site, Arial beel, Ashuhila beel, Rainkhyongkine lake, Bogakine lake, Sundarban south, Sundarban north, Sundarban east, Ratargul swamp forest etc. (Thompson et al., 2003; Talukdar et al., 2008) (Fig.3).
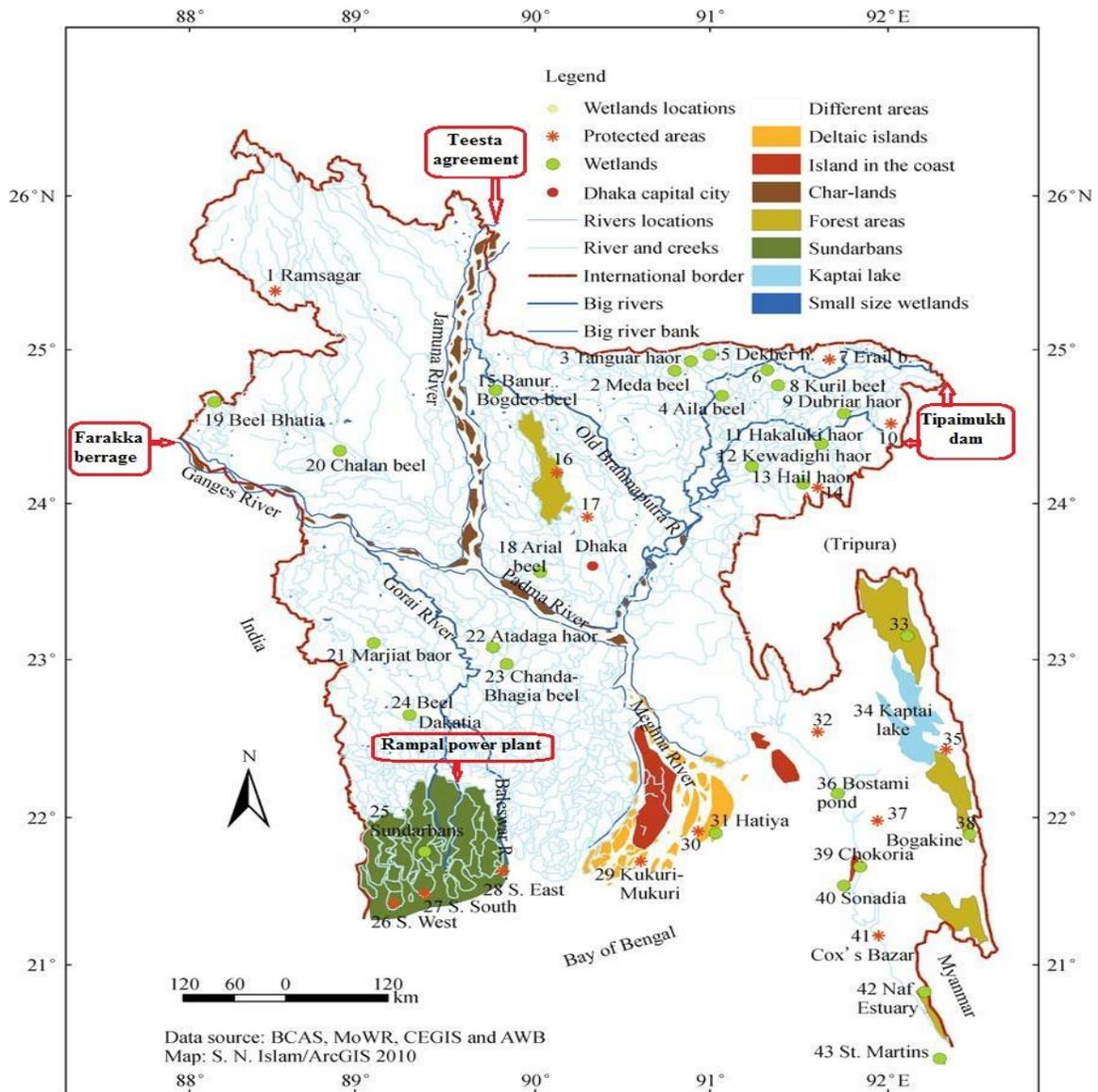
Figure 3: Location of wetlands, ecologically sensitive sites, dam and power plant

Conducting household survey and focus group discussion

3. MATERIALS AND METHODS

3.1 Study site

3.1.1 Location and area

Ratargul Swamp Forest is located at 25°00.025′N latitude and 91°58.180′Elongitude in Gowainghat upazilla, Sylhet, Bangladesh (Fig. 4). The total area of swamp forest about 204 ha. Approximately118.50hawere declared as a reserve forest (Choudhury et al., 2004).

Figure 4: Location of Ratargul Swamp Forest
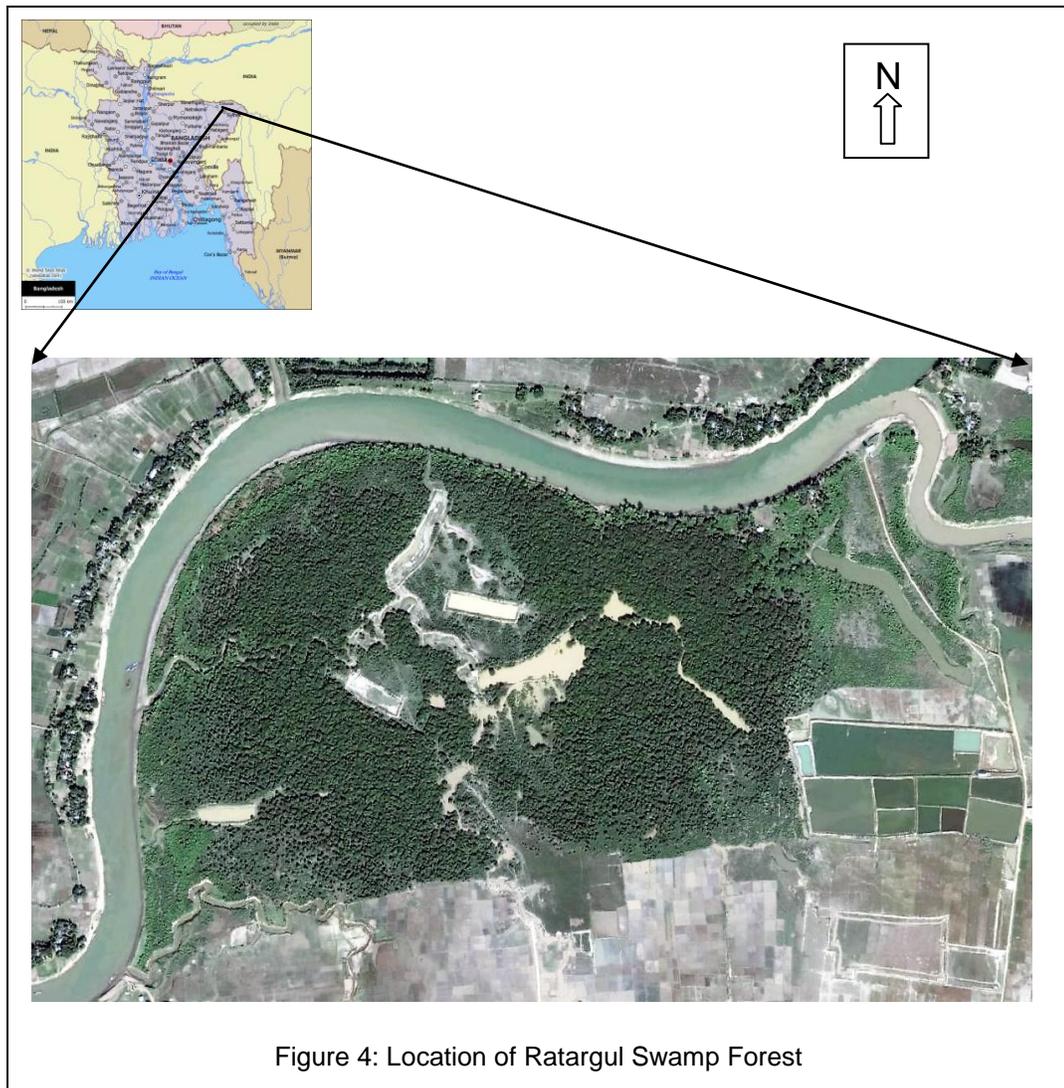
3.1.2 Climatic scenario

The climate is usually sub-tropical in this area; usually it receives heavy rainfall during the rainy season. The average annual rainfall is about 4162 mm. The maximum rainfall occurs in July with average 1250 mm. But there is no or very less rainfall in December. May and October are the hottest months having the maximum temperature around 32°C, while January is the coldest month when the minimum temperature drops to 12°C. Relative humidity is about 74% during December while it is over 90% during July-August (Choudhury et al.,2004).

3.1.3 Soil properties

Soils are different in different part of this area. The soils are gray, heavy, silt-clay loam with clays that predominates. Soils under the condition of vegetation cover are mostly clay loam to clay in texture. Soils are more clay in the river and depression sites. However, soils become dry and forms heavy cracks after rainy season. The characteristics of soils are sandy to sandy-loam along the river side whereas agricultural land contains loamy soils (Roy et al., 2011).

3.1.4 Topographic settings

Topography of this area is not same. Maximum lands are plain lowland which is used for rice cultivation. The remaining area consists of river basin, forest, small hillocks and others. The elevation of this area is about 35 feet above from the sea level (Choudhury et al., 2004).

3.1.5 Flora and fauna

Approximately 73 species of plants, 26 species of mammals, 175 species of birds (including 46 migratory birds), 9 amphibians, 4 species of snakes, 20 species of reptiles exist in this wetland (IUCN, 2004). About 94 species of fish inhabit in the Ratargul Swamp Forest. Among them 28 species are threatened, of which 14 are vulnerable, 10 are endangered and 4 are critically endangered (Islam et al., 2016).

3.2 Research method

A qualitative research approach (Nelson, 1991) was followed in this case study. However, this study also followed quantitative approach where data were possible and attainable. Therefore, this research was conducted on the basis of primary and secondary data. The GIS tool was used to collect primary information and analysis of data.

3.2.1 Primary data collection

To collect socio-economic information, a number of Participatory Rural Appraisal (PRA) tools were used that gathered primary data for this study. The PRA is an important approach where local people are able to share, enhance and analyze their knowledge concerning to lifestyle, condition and to plan and act (Chambers, 1994). The PRA techniques include households survey (Angrosino, 2002), key informant interviews, focus group discussion with semi-structured questionnaires (Morgan et al., 2008). Interview with semi-structured is a guided discussion in which only the topics are pre-arranged and new questions or insights arise as a result of the discussion and visualized analysis (Pretty et al., 1995). In this research, 5 villages were selected purposively which are located around the Ratargul Swamp Forest area. The people of these villages have access to extract wetland resources. To collect data, 30 house-holds survey, 5 key informant interviews and 2 focus group discussions were conducted in each village. With these PRA techniques, data was collected in terms of family size, education, occupation, benefit of wetland resources, income sources, and problems of wetland, prospects of wetland and other in depth technical questions in order to fulfill the objectives of this study. In addition to this, 50 tourist surveys were made with focusing on tourist value of this area. To obtain more reliable information, assistance was perused from the government and non-government organizations who are working in the relevant field. Direct field observations, personal perceptions of interviewers were also considered for more accuracy. This survey was completed from April to May in 2016.

3.2.1.1 Households survey

Households of 5 villages were selected randomly. For each village, 30 households survey was carried out with semi-structure questionnaire. During the interview of these households, it equally considered male, female, aged persons and other informants. Different people have different idea and opinion about the wetland. This survey is important to understand the real situation of local people. However, the survey provided information regarding the use of wetland resources and their dependency, present status and problems of wetland, types of occupations, education, demography and others socio-economic data.

3.2.1.2 Key informant interviews

The purpose of key informant-interview is important to collect in-depth information about a wide range of people and their community. Key informant-interviewers are including community

leaders, professionals, or residents who have first-hand knowledge about the community. These community experts, with their specific information and understanding, can provide perception on the nature of problems and give recommendations for solutions (Uddin, 2011). In this research, 5 key informants from each village were selected purposively in order to obtain maximum reliable information. Semi-structure questionnaire and the personal opinion of informants were considered to find out information regarding this wetland area. During the study, a total number of 25 key informant interviews were completed for 5 villages.

3.2.1.3 Focus group discussions

Focus group discussion is an approach that aims to generate conversation and collaboration within small groups of local people. Basically the size of focus group is 6 to 12 where people and participants share their experiences and information with interviewers (Uddin, 2011). However, the main benefits of this approach are the truthfulness of the information and the speeds of generation are higher when they come from groups (Grenier, 1998). To complete this research a total number of 14 group discussions were made and 2 group discussions were for each village. During group discussions male and female of different ages, occupations were present.

3.2.2 Secondary data sources

Secondary data is important to compare with primary data which improves the research. During this study, two web-based engines were searched: (i) Science direct (ii) Proquest to locate peer-reviewed journal articles that describe value, importance, problems of wetlands in Bangladesh. Moreover, secondary data is collected from the record books, articles of government and non-government organizations. These organizations include Forest Department (FD), Department of Environment (DOE), Department of Fisheries (DOF), Bangladesh Haor and Wetland Development Board (BHWDB), Bangladesh Bureau of Statistics (BBS), Bangladesh Small and Cottage Industries Corporation (BSCIC), Country office of FAO and others non-governmental organization who are working on wetlands of Bangladesh.

3.2.3 Remote sensing and GIS approaches

Remote sensing and Arc-GIS approaches were used to compare changing patterns of wetland area and water level over three periods. To accomplish this approach, two satellite images of 2005 and 2015 were collected. Afterwards, geo-referencing was completed to render real world

coordination to the images to avoid geometric distortion. Then these images were digitalized and made map with different data layer.

3.2.4 Data analysis and report writing

Data analysis was completed using different software like Microsoft Excel and Microsoft Word and Arc-GIS software.

4. RESULTS AND DISCUSSIONS

4.1 Characteristics, function, values and services of Ratargul Swamp Forest

4.1.1 Landscape setting and variation of water level in different seasons

Ratargul Swamp Forest is the only fresh water swamp forest in Bangladesh. Locally this forest is called the "Amazon" of Bangladesh. It is located in the north-eastern part of the country. The total area of swamp forest is about 204 ha. However, approximately 118.50 ha has been declared as the "reserve forest" (Choudhury et al., 2004). The floor of this forest is 35 m above from the mean sea level where maximum areas are plain. One river named Shari-Goyain has crossed the boundary line of this forest area. Another river named Kafna has just flowed outside of this forest. In addition to this, there are several ponds and natural depressions and canals inside the forest.
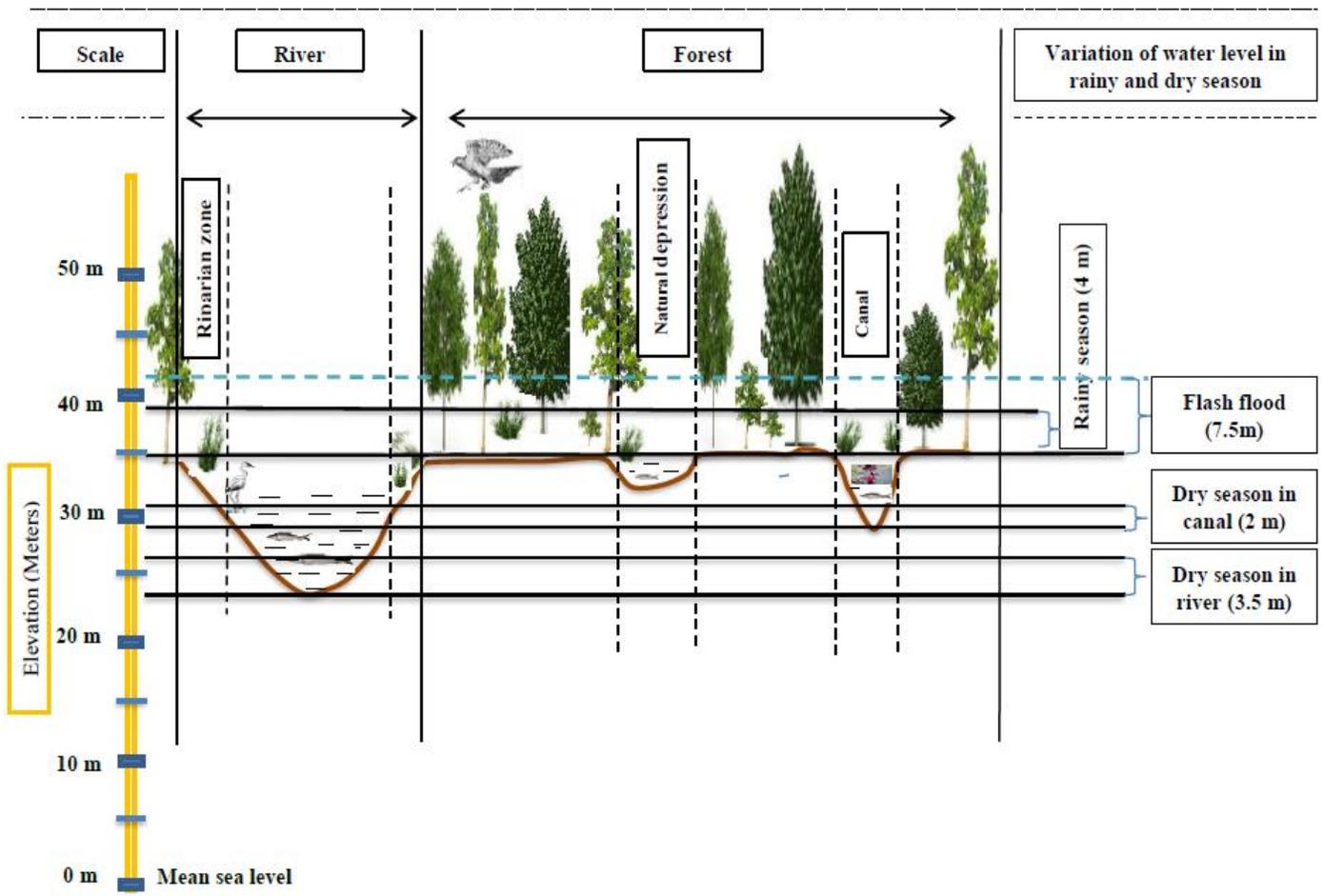

Figure 5: Landscape and water level situation

The average depth of the river is 12 m and the depth for canals and ponds are 5 m and 2.5 m respectively. The level of water varies in the rainy season (May to September) and dry season (December to March). During rainy season, the bank of rivers, canals, ponds and natural depressions go down under water. On the other hand, in the dry season the average depth of water in the rivers and canals is 3.5 m and 2 m respectively (Fig. 5). However, the ponds and natural depressions are seen completely dry or occasionally reserve water for few days based on rainfall. Therefore, during dry season the forest floor is also dry completely except some bodies of rivers and canals. In the rainy season, the level of water depends on the rainfall and upstream flow. Sometimes, the forest floor goes under water early or little bit late. During the rainy season, the average height of water level from the forest floor is 4 m. However, due to heavy rainfall and upstream flow, the level of water raises 7.5 m (Fig. 5). In the rest of the months of the year i.e. in April, October and November the ground of the forest remain almost muddy. For this three distinct conditions namely wet, dry and muddy- the forest possesses a unique ecosystem that is different from others forest, mangrove, river or other ecosystems. That is why the succession of plant communities and movement of animals vary in different seasons (Tab. 3).

During rainy season, there is no distinct riparian zone. Because, the whole areas go under water. In contrary, other two conditions (muddy and dry) are visible in the riparian zones (Fig. 5). This riparian area is extremely important for healthy watershed and ecological function. For instance, riparian zone reduces soil erosion, act as a filter for water purification and important habitat for wildlives (Angela et al., 2012). In all conditions two plant species such as *Clinogyne dicotoma* and *Calamus guruba*can survive in the riparian zone. *Nymphaea nouchali, Aponogetom spp, Sccharum spontanium* are the emerging species in the muddy condition. During wet condition, forest floor is covered by several tree species such as *Pongamia pinnata, Barringtonia acutangulata, Syzygium formosanum* etc. Nevertheless, there are no herbs. In the muddy and dry condition, the tree species are same as wet condition. Moreover, several types of herbs and grasses appear during muddy and dry condition (Tab. 3).

The water level and apparent of plant species play role on the movement of aquatic and terrestrial animals. The changes of these animals are not only in terms of species but also in the number of individuals. A huge difference is found for fish species. During rainy season i.e. the wet condition, 94 species of fish inhabit in this swamp forest. However, fish species reduce considerably during muddy (10-15 spp) and dry (5-10 spp) condition. Maximum birds are found in the muddy condition (175 spp). During this period, it is winter in Bangladesh and a huge

23

number of migratory birds adapt in this swamp forest. Terrestrial animals are the highest in muddy and dry condition. But some mammals such as fox, mongoose, monkey etc. cannot adapt in the wet or rainy season (Tab. 3).

Table 3: Variation of plants and animals with different seasons (IUCN, 2004)

Condition	Variation of plant communities		Movement of animals	
	Riparian zone	**Forest floor**	**Aquatic**	**Terrestrial**
Wet	*Clinogyne dicotoma, Calamus gurubaetc* (survive under water).	Trees: *Pongamia pinnata, Barringtonia acutangulata, Syzygium formosanum, Lagerstroemia speciosa, Strebulus asper, Artocarpus lacucha, Crataeva nurvala* etc. Shrubs: *Salvador apersica, Glochidion lanceolarium etc.* Herbs: (No herbs) Climbers: *Calamu sguruba* Grasses: *Clinogyne dicotoma*	1. 94 species of fish 2. Less than 175 species of birds (few migratory birds) 3. Less than 9 amphibians 4. 4 species of snakes 5. Less than 20 species of reptiles.	1. 26 species of mammals (no fox, mongoose, monkey etc.).
Muddy	*Nymphaea nouchali, Aponogetom spp Clinogyne dicotoma, Calamus guruba, Sccharum spontanium etc.*	Trees: (Same as wet) Shrubs: (Same as wet) Herbs: *Eupatorium odoratum, Ipomoea fistulosa, Polygonum viscosum, Asparagus Racemosus, Centella asiatica etc.* Climbers: *Calamus guruba* Grasses: *Clinogyne dicotoma, Cynodon dactylon, Sccharum spontanium etc.*	1. 10-15 species of fish in river, canal and pond 2. 175 species of birds (including 46 migratory birds) 3. 9 amphibians 4. 4 species of snakes, 5. 20 species of reptiles	1. 26 species of mammals (fox, mongoose, monkey etc. are immigrant.)
Dry	*Clinogyne dicotoma, Calamus guruba etc.*	Trees: (Same as wet and muddy) Shrubs: (Same as wet and muddy) Herbs: *Eupatorium odoratum, Ipomoea fistulosa etc.* Climbers: *Calamus guruba* Grasses: *Clinogyne dicotoma, Cynodon dactylon, Sccharum spp* (Irregular).	1. 5-10 species of fish in river, canal, pond 2. 175 species of birds (less migratory birds) 3. Less than 9 amphibians 4. 4 species of snakes 5. 20 species of reptiles	1. 26 species of mammals (fox, mongoose, monkey etc. are immigrant.)

4.1.2 Functions of swamp forest

The functions and ecosystem services of Ratargul Swamp Forest are diverse. It acts as a forest, wetland and often wetland-forest. The function of this swamp forest can be divided into four major groups, such as: hydrological, biogeochemical, ecological and atmospheric function (Fig. 6). However, the function of wetland can be categorized into three types, such as: hydrological, biogeochemical and ecological (Islam, 2010). So, it is found that the function of swamp forest is more compared to single terrestrial forest or wetlands in term of atmospheric function which regulate atmospheric gases and temperature. For instance, trees of swamp forest maintain the balance of CO_2, O_2, N_2, humidity and others in the atmosphere. Moreover, trees store carbon for long term. Because, these tree are not suitable for furniture or other valuable uses. That is why trees remain for long time in this swamp forest. According to Groot, wetlands function can be categorized into four distinct classes (Groot, 1992). These are: (1) Regulation functions: ecosystems regulate ecological processes that contribute to a healthy environment. For example, maintenance of hydrological cycle, water storage and discharge, flood control and regulation, biodiversity protection etc. (2) Carrier functions: ecosystems provide space for activities; like human settlement, extension of urbanization, cultivation and energy conversion, field of education and research, employment opportunity and others activities. (3) Production functions: ecosystems provide resources for humans; like food, water, grazing, livestock, fuel and others raw materials. (4) Information functions: ecosystems contribute to mental health by providing scientific, aesthetic and spiritual information. For example, recreation and ecotourism, cultural and natural heritage, cultural landscapes and beauty, religion values, ethical values etc. These functions provide tangible and intangible benefits to surrounding communities of wetlands which are important to sustain better life (Islam, 2010).

4.1.3 Different values and services of swamp forest

Swamp forest is the most productive ecosystem that accommodates huge species of plants and animals of tropical area. Like wetlands, the value of Ratargul Swamp Forest can also be categorized into four types. These values are environmental, economic (including direct, indirect, option, existence, bequest values), social and cultural (Islam, 2010). Based on this values wetlands provide several service to human beings (Fig. 6). Environmental services refer to qualitative functions of natural non-produced assets of land, water and air (including related ecosystem) and their biota. However, the environmental services of swamp forest play significant role in maintenance of hydrological cycle, water storage and drainage, flood control,

Function and service processes of Ratargul Swamp Forest

Four types of functions

| Hydrological | Biogeochemica | Ecological | Atmospheric |

Results of functioning (values & services)

| Values of swamp forest	Types of ecosystem services
Environmental	Maintenance of hydrological cycle, water storage and discharge, flood control and regulation, transport of sediments, purification of water, pollution control, reduce of erosion, soil formation, food chain and habitat maintaining, biodiversity protection, maintenance of landscapes and balance of ecology etc.
Economic	
Direct value	Agriculture, forestry, fishing, hunting, wild food, grazing, livestock, fuel, fodder, honey, fruits and wood, supply of raw materials and other direct values.
Indirect value	Benefits from improvement of water quality, storm and flood prevention, pollution control, drought control, provision for medicinal plants etc.
Option value	Benefits from ensuring the option for a future use.
Existence value	Benefits from conserving or willingness to sacrifice a part of one's income in order to conserve resource especially natural amenities.
Bequest value	Benefits from ensuring that certain goods will be preserved for future generations.
Social	Provision of settlement, migration, field of education and research, employment opportunity and livelihood security and others social activities.
Cultural	Ecotourism and recreation, cultural heritage, natural heritage, cultural landscapes and beauty, cultural values, aesthetic values, spiritual values, ethical values etc.

Figure 6: Functions, values and services of Ratargul Swamp Forest

purification of water, balancing of atmospheric gases, carbon sink and others ecological function. In fact, local people easily can imagine the influence of direct economic values of wetlands. The economic values of this forest includes fisheries, forestry, agriculture, fuel, fodder and other indirect, option, existence and bequest values (Fig. 7). About 80% of rural households of Bangladesh catch fish for food or sale (Flood Action Plan, 1995), and about 70% of animal proteins come from fish (Bhuiyan, 2013). Climate change is an environmental, social and economic challenge on a global scale (Scholze, et al., 2006; Mendelsohn, et al., 2006). It is seen that every year a huge number of family migrate to the wetlands area for livelihood security. The main cultural value of Ratargul swamp forest are ecotourism and recreation, landscapes and beauty, aesthetic value, religious value, spiritual value, ethical value etc. (Fig. 6). However, ecotourism plays significant role on the society that changes lifestyles and economic conditions (Islam, 2010).

4.2 Socio-economic status and dependency of local people of swamp forest area

4.2.1 Social and economic condition

In order to find out socio-economic condition and dependence of local people, data has been collected from five villages, which are located near the Ratargul Swamp Forest. The average numbers of family member are 6.50 where 2 of them are fulltime earning member. It is found that maximum people of this study area finished primary education (48%), 27% of them are illiterate and the number of graduated and post-graduated are very few (Fig. 7). Because, most of the family are not able to send their children to school due to poverty, awareness and so on. The occupational status of this area is diverse. Most of the families are professional or partly related to agriculture (40%) (Fig. 8). The rest of the families are depended on fishing, day labor, poultry farming, remittance, government or non-government services and others (Fig. 8). However, the monthly income of these families depends on the type of occupation and number of earning member. On the basis of monthly income, families of this study area can be grouped into very poor ($ 0-100), poor ($ 101-150), middle class ($ 151-200), rich ($ 201-250), very rich ($ 200+) (Fig. 10). It is found that 28% families are very poor and 21% are poor. Furthermore, the highest number (42%) of families of this area belonged to middle class and only 2% is rich (Fig. 9).
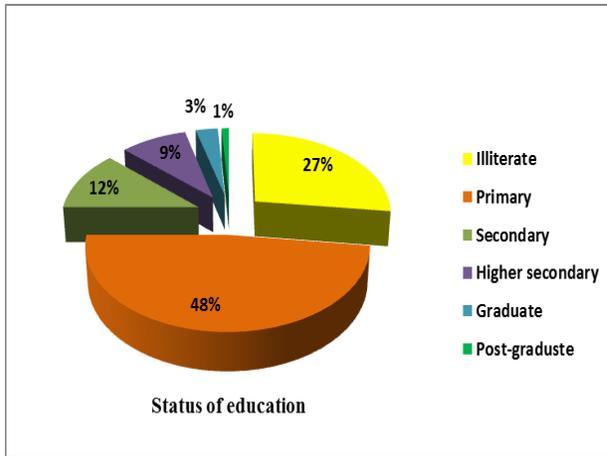
Figure 7: Status of education   Figure 8: Status of occupation
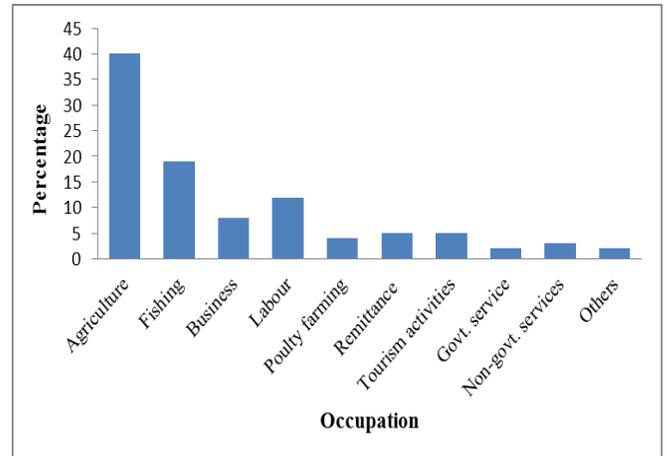
4.2.2 Criteria of dependency for livelihood

The study found that the maximum families of this area are poor, very poor and middle class (Fig. 9). However, these families are involved in swamp forest for their income generation in different ways of provision. For instance, it is found that a single family involved in different types of occupation (Fig. 10). The extracted resources and income sources in swamp forest area are agriculture, fishery and fishing, collection of food, fodder, fuel and medicinal plants, income from tourism activities and from forest related work (forest guard, labor etc.). The time of resource extraction and income sources are different. Middle class (85%) and rich people (65%) are largely engaged in agriculture where very poor and poor are in the similar in trend (Fig. 10). The locals take the lease of land from the forest department. They mainly cultivate rice (*Oryza sativa*), main food of Bangladesh. The wetland areas of Bangladesh produce a significant amount of rice. For instance, only hoar areas produce 18% of rice of the country (BHWDB, 2015). A green vegetable locally called Kachu (*Aponogetom spp.*), the additional crops, is cultivated after the harvest of rice in low-lying and wetland areas (Alam and Chowdhury, 2003). The green vegetable Kachu tubers yield milky white flour having nutritious value like potatoes (Islam, 2010).

During the rainy season, fishing and tourism activities is the highest of this swamp forest area. Very poor and poor families are widely related to these seasonal activities. About 90% of very poor and poor households are depended on the income from fishing and tourism activities (Fig. 10). Fisheries are the vital source of livelihoods and food for the rural poor who are living around the wetlands area. Approximately 80% of rural families of this country catch fish for food or sale

28

(Thompson and Hossain, 1998) and 70% of animal proteins come from fresh water fishes (Bhuiyan, 2013). In the rainy season, a huge number of tourists come from home and abroad to visit this famous wetland forest. But, in the weekend the number of tourist is more compare to other days (Redowan et al., 2013). Normally traditional boats are used to visit this place. In this time, local people earn additional money by boating and selling handicrafts and traditional foods. So tourisms have considerable effect to change the lifestyles, economy and environment of local people (Brown, 2005). Therefore, government aims at increasing present GDP rate of tourism sector from 0.70% to 2% by 2015 (BHWDB, 2015). After rainy season, the poor and very poor families shift to another occupation to sustain their life.
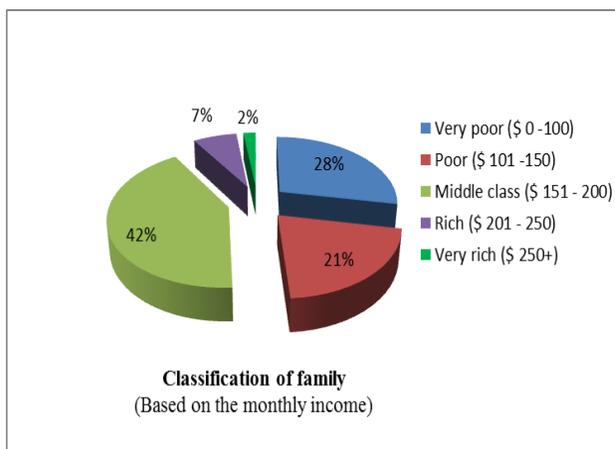

Figure 9: Categories of family based on monthly income
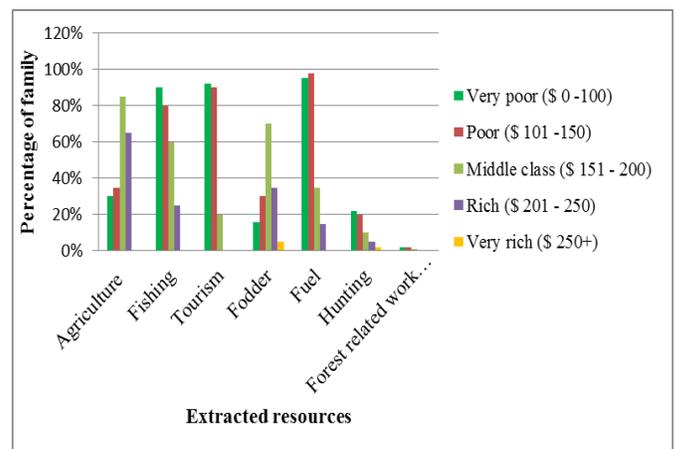
Figure 10: Alternative occupation and income sources related to swamp forest

The study also found that middle class family (65%) collects maximum fodders and collection of other families is low. This research also found that about 95% poor and very poor families depended on this swamp forest for their fuel wood (Fig. 10). However, other groups are not fully depended. A good number of rich and very rich people use this swamp forest area for recreational purposes. Furthermore, hunting is an important source for additional income of poor and very poor people. They collect some medicinal plants locally known as akhanda, kalmi, helencha, and bishkatali, paddo. The flowers and seeds of paddo (lotus) are prescribed for piles, as for cardiac tonic and for elimination of ringworm. The flowers of water lilies are used for vegetables and medication of heart ailments (Khan et al., 1994; Rahaman, 1995). Patipata (*Schumannianthus dichotoma*) is another important plant which grows naturally on the bank of the wetlands. Local people harvest this plant that is used for making handicrafts, thatching materials etc. Moreover, poor and very poor people are engaged in the forest related job, such as: forest guard, labor etc. Finally, this socio-economic study reveals that all classes families of

this swamp forest area more or less depend on this forest for their livelihood. Nevertheless, the poor and very poor people are massively depended on this swamp forest in different seasons of the year.

4.3 Problems and best management options

4.3.1 Existing problems in Ratargul Swamp Forest

Ratargul Swam Forest is maintained under the title of reserve forest where everything is prohibited unless it is permitted. However, owing to high population pressure and extreme level of resource extraction the swamp forest is being tarnished. Every year a huge number of people migrate to this wetland area from the other parts of the country. These people are totally or partly depended on the wetland resources. The man made disturbances include fuel wood collection (Fig. 11), illegal felling (Fig. 12), over fishing (by dewatering, gearing and fencing) (Fig. 13), irrigation, grazing and agricultural land expansion (Fig. 14), infrastructure, human habitat, tourism activities, illegal hunting (birds, animal, medicinal plants and other non-timber forest products), use of pesticides and other activities. Further, excess fishing, fuel wood collections, agricultural expansions are the top most reasons for the degradation of forest. This swamp forest is also being affected by the impact of climate change, such as: irregular and heavy rainfall, flood, flash flood, storm, certain variation temperature, siltation etc.

Figure 11: Fuel wood collection

Figure 12: Illegal felling

Figure 13: Extreme fishing

Figure 14. Grazing and agricultural expansion

30

4.3.2 Consequence of problems based on periodic GIS map analysis

Two types of problems have been found due to anthropogenic and natural causes in this forest. These problems are regarding to forest area and species of plants and animals. Two periodic images (November, 2005 and November, 2015) have been studied to find out different land use change over time (Fig. 15 and 16).
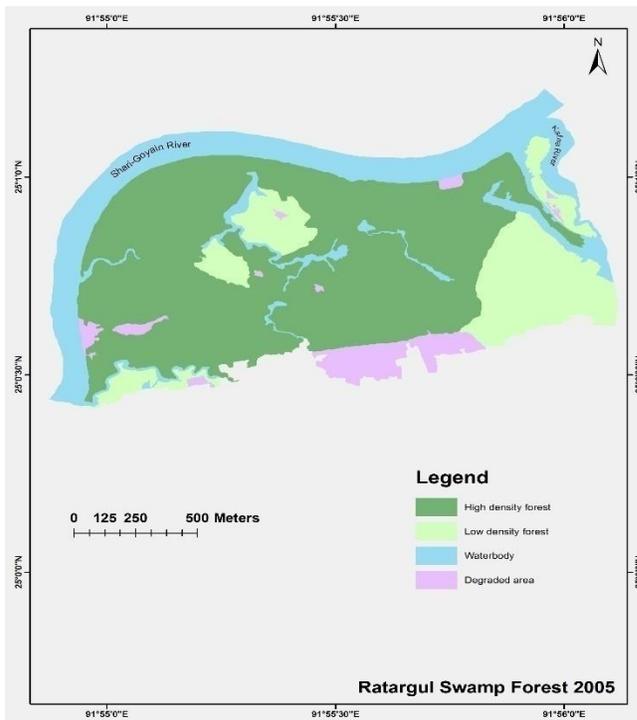

Figure 15: Land use patterns 2005   Figure 16: Land use patterns 2015
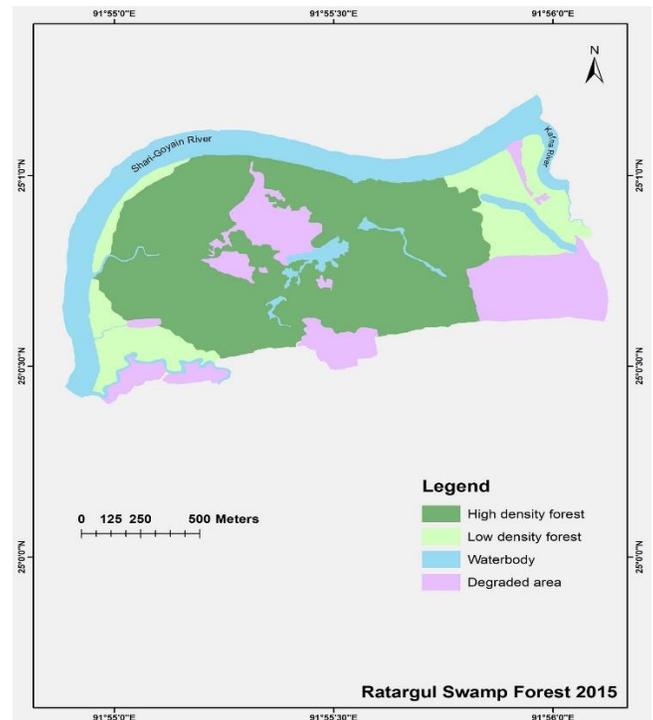
There are two rivers in the north and north-east side of this swamp forest. During rainy season, the whole forest is seen to be submerged by water. However, in the dry period there are some water bodies inside the forest. During rainy season, the volume of water of these water-body depend on rainfall and temperature. In 2005, the water-body and reservation of water was more compared to the year of 2015 (Fig. 15 and 16). The water-body has decreased by 4 ha from 2005 to 2015 (Fig. 17). A significant change is found for the high-density forest and completely degraded area (Fig. 15 and 16). The total area of the high-density forest was 114.80 ha in 2005 whereas it has been 96.40 ha in 2015. It reduced by 18.40 ha within 10 years. The area of low-density forest also reduced in different parts of the forest (Fig. 17). This high and low-density forest is converted into complete degraded area including agricultural lands, artificial ponds and forest roads. The degraded area has increased by 25.53 ha from 2005 to 2015 (Fig. 17). A momentous change is found in the middle of the forest where there was no degradation in 2005.

31

Notwithstanding in 2015, the degraded area has been significant due to making artificial ponds. In the dry season, people catch fishes by completely removing water from water-bodies. Therefore, there are no fishes and enough water for breeding. Moreover, the forest department also created more artificial ponds in the south-east corner of the forest. For this reason, there is no vegetation in this part (Fig. 16). The forest is faced with more disturbances in the south, east and some parts of west (Fig. 17). Because, these areas are more accessible by the local people for the collection of fuel wood, fodder, fishes, medicinal plants and other non-timber forest products. The south part of this forest is mainly converted into agricultural lands. It is not only reducing forest area but also different plants and animal species. Approximately, 94 species of fish inhabit in the Ratargul Swamp Forest. Among them, 28 species are threatened, of which 14 are vulnerable, 10 are endangered and 4 are critically endangered (Islam et al., 2016).

	Waterbody (with river)	High density forest	Low density forest	Degraded area
■ Area in 2005 (ha)	44,74	114,8	34,83	10,03
■ Area in 2015 (ha)	40,27	96,4	26,47	35,56

Changing parameters
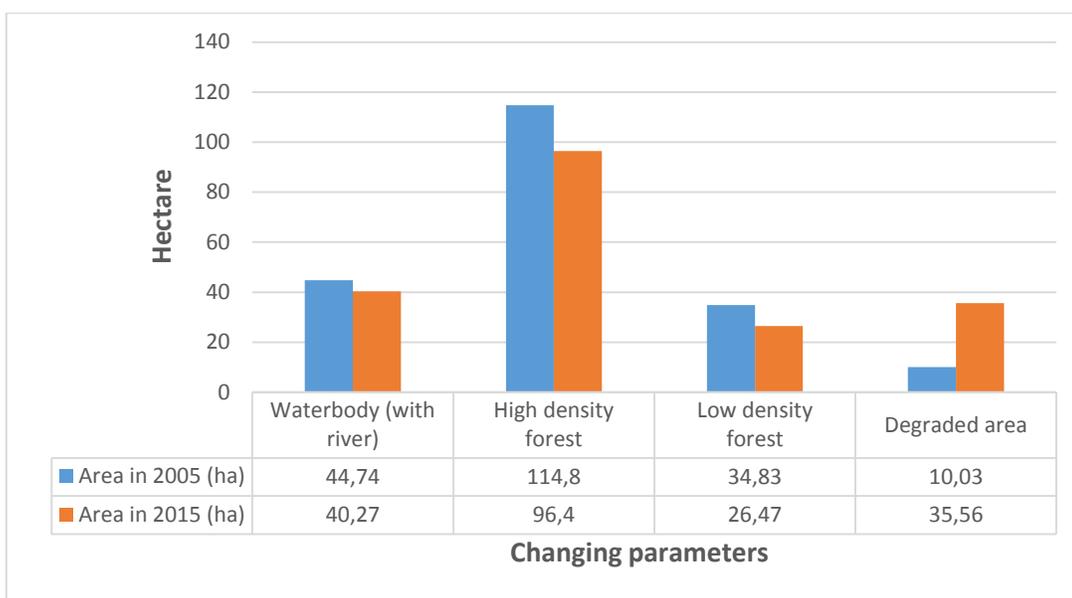
Figure 17: Criteria of land use change between the year of 2005-2015

4.3.3 Proposed management approach to overcome existing problems

Ratargul Swamp forest is regarded as a reserve forest. According to definition of reserve forest (Forest Act, 1927), people have no right to do anything without permission (USAID, 2005). However, the degradation of forest is increasing day by day (Fig. 15 and 16). There are several reasons for this disturbances including lacking of clear boundary, scarcity of surrounding people, encroachment, absence of implementation of existing law and policy and others administrative problems. In this case, the participatory forest management approach can be an effective tool to overcome present problems of Ratargul Swamp Forest. Participatory forest

management has become increasingly common in the last 25 years. It is known in different names in different countries such as: community forestry, social forestry, adaptive co-management, community based natural resource management and so on (Shepherd, 1990).
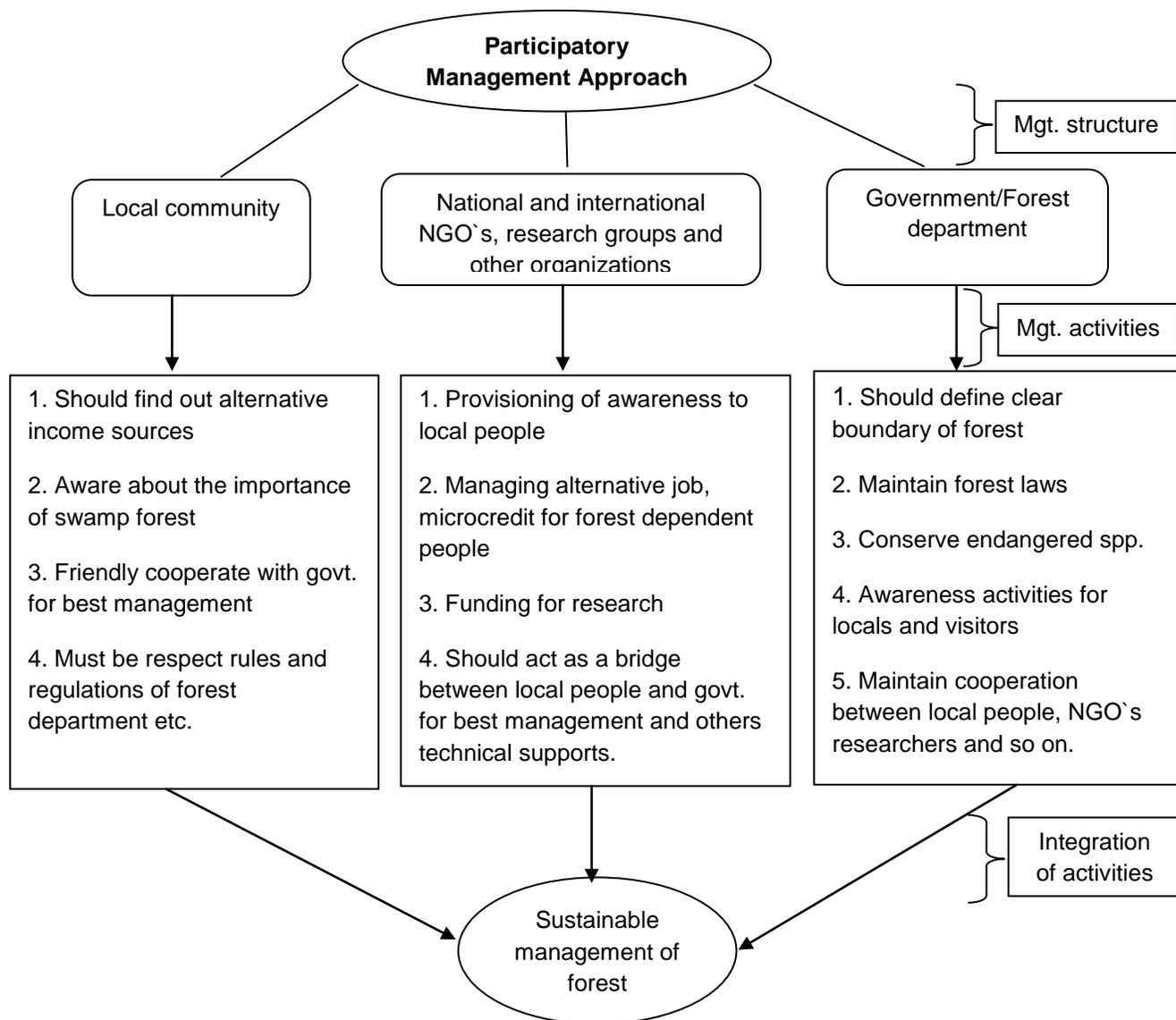
Figure 18: Sustainable management approach

Ratargul Swamp Forest is highly affected by local people. The structure of participatory management approach must be implemented by local community; national and international NGOs, research organizations and forest department. Participation of local communities is important, because they are better informed about the community forest, its history, evolution and development. For sustainable management, local communities should be aware about the importance of swamp forest and have to find out alternative income sources. It is important to

reduce pressure on swamp forest in terms of resources extraction and forest degradation. To increase awareness, NGOs, forest department and other volunteer organizations should organize workshop for local communities and forest depended people. Moreover, it is needed to manage alternative income sources for poor local people with providing microcredit. The alternative income sources could be poultry farming, business and other jobs outside of the forest area. The forest department should be clearly defined the forest boundary, must be maintained forest laws and policies. Furthermore, forest department have to address the endangered species and actual reasons behind forest degradation for rehabilitation. If these stakeholders i.e. the local communities, NGOs, forest department etc. work together, sustainable management is possible for this swamp forest. It is found that participatory forestry management has covered 25% forest of worldwide (White and Martin, 2002). Most of the countries of Africa and many countries of Asia are promoting participatory approach of forest management (Wily, 2002).

Sometimes, participatory management approach is challenging in resources sharing, nature conservation and biodiversity management, because, local participants are not aware about ecosystem (Leena, 2004). Local communities always try to receive more resources within a short period. For instance, community people do not prefer long rotation species and they expect early returns to meet their daily needs. However, forestry plan makers try to have plantation with their preferable species. In many countries, the participation of local people is quite challenging owing to long tradition of top–down management approach and a strong bottom–up dependence on public provisioning (Atmisa, 2007). Participatory based forest management is really a difficult task in terms of consistency, structuring, systematic planning and analysis (Guillermo et al., 2015). At present integration of scientific method with traditional knowledge is a new strategy to improve participatory forestry (Jun et al., 2009). For instance, remote sensing (RS) and geographic information system (GIS) is an effective tool for multiple land use management planning relating to spatial context such as watershed areas, landslides areas, detect deforested places, identify community adjacent areas etc. (Leman et al., 2015).

5. CONCLUSION

Bangladesh is considered as the largest delta of the world. The total wetland area of Bangladesh is estimated to be 70,000 to 80,000 km^2. It comprises about 50% of the total national land of the country (Islam, 2010; Khan et al., 1994). Therefore, wetland includes rivers, estuaries, mangrove swamp, fresh water swamp, marsh (haor), oxbow lake (baor) and beel (bowl-shape depression), water storage reservoirs, ponds, and others seasonal inundation areas. Wetlands in Bangladesh have great contribution to the country's ecological, industrial, socio-economic and cultural aspects. About 50% people of this country are directly depended on wetland resources for livelihood (Islam, 2010) and 70% of animal protein of the country comes from fresh water fishes (Bhuiyan, 2013). In addition to this, 6-8% revenue comes from only haor areas of Bangladesh (BHWDB, 2012). However, wetlands of Bangladesh are being destroyed because of high population pressure and extreme level of resources extraction.

The results of the case study on Ratargul Swamp Forest found that the forest is located 35 m above from mean sea level. Physically this forest consists of parts of two rivers, several canals, natural depression and with artificial ponds. However, the level of water of this forest varies in different seasons and periods. During rainy season, the bank of rivers, canals, ponds and natural depressions goes down under water. But, in the dry season the average depth of water in the rivers and canals are 3.5 m and 2 m respectively. In the rainy season, the average height of water level from the forest floor is 4 m. Sometimes it raises 7.5 m due to heavy rainfall and upstream flow. The water level plays significant role on the apparent of plant species, movement of aquatic and terrestrial animals. The research found that four types of ecosystem function exist in this swamp forest such as hydrological, biogeochemical, ecological and atmospheric function. The values and services are the result of these four types of functioning which includes environmental, economic (including direct, indirect, option, existence, bequest values), social and cultural values. These services are playing vital role to the local communities directing to livelihood security and to maintain environmental quality. The study also found that the maximum families of this area are very poor, poor and middle class type. These families are involved with swamp forest for their income generation in different ways of provision such as agriculture; fishing; collection of food, fodder, fuel and medicinal plants, tourism and forest related activities. About 90% of very poor and poor households are depended on the income from fishing and tourism activities in the rainy seasons. Moreover, 95% of these households are massively involved in fuel wood collection from this forest. However, the swamp forest is being destroyed owing to high population pressure and extreme level of resources extraction. The

human related disturbances are extreme level of fishing, fuel wood collections, agricultural expansions, illegal felling, irrigation, grazing, agricultural land expansion, infrastructure, human habitat, tourism activities, illegal hunting of medicinal plants and other non-timber forest products, use of pesticides and other activities. The climate change impact includes irregular and heavy rainfall, flood, flash flood, storm, siltation etc. For this consequences the water-body decreased by 4 ha from 2005 to 2015 (total area 208 ha). This study also found that the total area of the high density forest was 114.80 ha in 2005 whereas in 2015 it was 96.40 ha. It has reduced by 18.40 ha within 10 years. The degraded area has increased by 25.53 ha from 2005 to 2015. A remarkable change is found in the middle of the forest where there was no degradation in 2005. But in 2015, the degraded area was significant for making artificial ponds. About 94 species of fish inhabit in the Ratargul Swamp Forest where 28 species are now threatened, 14 are vulnerable, 10 are endangered and 4 are critically endangered (Islam et al., 2016).

There are several reasons for these disturbances including lack of clear boundary, scarcity of surrounding people, encroachment, absence of implementation of existing law and policy and others administrative problem. However, the participatory forest management approach (working together with local community, forest department, national and international NGO`s, research organizations, and others volunteer organization) could be effective tool to overcome existing problems of Ratargul Swamp Forest.

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ANNEX 1

Questionnaire for household survey and key informant interview to obtain information about Ratargul Swamp Forest, 2016

1. Respondents General Information

1.1 Name:

1.2 Age:

1.3 Occupation:

1.4 Sex:

1.5 Indigenous/migrant:

1.3: Name of village/community/Para:

2. Demographic information

2.1 Family size:

Age class (years)	>10	11-20	21-30	31-40	41-50	51-60	60+
Male							
Female							

2.2 Educational status:

Sex	Illiterate	Primary	Secondary	Higher secondary	Graduate	Post-graduate
Male						
Female						

2.3 Sources of income (Occupation/livelihood activities in %):

Farmer	Fisherman	Poultry farmer	Businessman	Govt. service	Others

3. Specific information on Swamp forest

3.1: Do you think swamp forest is important?

Ans: ………………………………….

3.2 Why important?

Ans: ………………………………….

3.3: Are you imagining biodiversity is reducing?

Ans: ………………………………….

3.4 Why the reasons?

Ans: …………………………………….

3.5 What are the climatic factors are responsible for wetlands destroying/degradation?

Ans: …………………………………….

3.6 What types of resources are collected by the people?

Ans: …………………………………..

3.7: In which seasons or time they collect fishes, fuel or other resources?

Ans: …………………………………….

3.8 Are you prefer to collect fishes/fuel from this forest?

Ans: …………………………………….

3.9: Have you observed any change in this forest over time relating to forest area/birds/fishes/plants so on?

Ans: ……………………………………

3.10: What types of change?

Ans: ……………………………………

3.11: In which season water is maximum/minimum in the forest?

Ans: ……………………………………

3.12: Do you have any idea in water quality of this forest?

Ans: ……………………………………

3.13: Why changing the water quality?

Ans: …………………………………...

3.14: Do you thing agricultural activities could be reason for water pollution and biodiversity loss?

Ans: ……………………………………

3.14 Have any idea, how many people come to visit in the forest?

Ans: …………………………………...

3.14: How tourist play role in your life and society?

Ans: …………………………………...

3.15: Could you tell five problems of this forest?

Ans: ……………………………………

3.16: What is your suggestion to overcome these problems?

Ans: ……………………………………

ANNEX 2

Questionnaire for focus group discussion to obtain information about Ratargul Swamp Forest, 2016

Name of the community:

1. What are the education status (in percentages)?

Ans: ………………………………

2. What are the occupation patterns (in percentages)?

Ans: ……………………………….

3. Do you think swamp forest is important and how?

Ans: …...

4. Why biodiversity destroying and what are the main reasons?

Ans: …………………………………...

5. What types of resources are collected by the people?

Ans: …………………………………

6. Who collect the resources?

Ans: ……………………………….

7. Do you have idea about water level in the forest in different seasons?

Ans: …………………………………

8. What types of resources are collected by the people?

Ans: …………………………………

9. How many tourists come every year and what are the purposes?

Ans: …………………………………

10. Could you tell five problems of this forest that's you are observing?

Ans: ……………………………….

11. What is your suggestion to overcome these problems?

Ans: ……………………………….

12. How you can help to sustainable management of this forest?

Ans: …………………………….....