

**APPLICATION OF GIS IN ECOTOURISM DEVELOPMENT:  
A CASE STUDY IN SUNDARBANS, BANGLADESH**

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By

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# **APPLICATION OF GIS IN ECOTOURISM DEVELOPMENT: A CASE STUDY IN SUNDARBANS, BANGLADESH**

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## **ABSTRACT**

GIS can be used in tourism as a decision supporting tool for sustainable tourism planning, impact assessment, visitor flow management, and tourism site selection. Therefore, the potential for GIS applications in tourism is significant. The purpose of the study was fixed to explore the potential of using GIS for planning resources pertinent to ecotourism development. The study investigated a case study in Sundarbans which is the largest mangrove forest region of the world, located in the southern part of Bangladesh and the Indian region of west Bengal. However, the current study considered only the Bangladesh part of Sundarbans for study and prepared ecotourism planning for this region. The Sundarbans plays an important role for the national economy of Bangladesh because of its natural resources and tourism activities. Moreover, this forest has been facing some problems due to unplanned development and tourism activities. The ultimate result of unplanned development is land use change, increasing deforestation, biodiversity losses and decreasing upstream flows. Therefore, the study considered this mangrove for ecotourism planning and development and GIS used as decision supporting tools. Moreover, this study tried to find some answers from the research questions. Tourism is a phenomenon, which often highlights that lack of planning and management in terms of environmental concern. For ecotourism planning this thesis quantifies land use change in the Sundarbans over 33 years (1977-2010) using Landsat TM, ETM & MSS satellite imagery and prepared vector maps based on LGED map for ecotourism mapping in Sundarbans, GIS assist in this process. The study found that, the land use of Sundarbans changed over the study period and the density of forest declined at the same time. However, the change occurred because of various human activities and climate change effects. Tourism has a little bit of contribution in the periphery area for this change but tourism has not yet been considered responsible for these effects largely as it is at a very early stage. This research proposed for community development and involvement for local people as a part of hospitality services in ecotourism industries in this region because they can assist tourists according to their experience as guides in the forest. Moreover, they can be employed in the service industries operating or accompanying jungle boat trips and wilderness trails and assisting in transport operation. For ecosystem protection in Sundarbans this study proposed a 300 meters buffer zone around the sanctuaries. Finally, this study proposed an outline for ecotourism planning in the Bangladesh part of Sundarbans where GIS assist in the planning process.

**KEY WORDS:** Ecotourism, planning, GIS, land use change, Sundarbans, Bangladesh

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**DEDICATED TO:  
MY PARENTS**

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## **CHAPTER 1**

### **1. INTRODUCTION**

This chapter describes the overall backgrounds of the study, objectives, research question, scope of the study, data and software used and research methods.

#### **1.1 Background**

For the sustainable development of a region, it is important to consider the interest of its local population. In terms of tourism development recently, researchers have begun to examine how local residents can be involved in tourism activities and get benefits from these. Due to the development of alternative forms of tourism these activities have begun attracting the interest of governments, communities and researchers. However, environmental conservation plays an important role in ecotourism development. ‘Many scholars now agree that ecotourism should require a two-way link between tourism and environmental conservation’ (Ryngnga, 2008, p. 50). So, tourism needs to be developed in a planned way and Geographical Information System (GIS) can assist as a decision support system with this planning process.

GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information (Environmental Systems Research Institute [ESRI], 2010). It has a wide range of uses. For instance, GIS has been adopted as a useful tool by a wide range of activities such as environmental planning, property management, infrastructure setting, emergence planning, automobile navigation systems, urban studies, market analyses, and business demographics (Chen, 2007). It can also be used to determine the best site for a newly built tourist destination. The application of GIS is limited in tourism but recently it has been used for park management, facility monitoring, visual resource assessment, and identifying suitable areas for developing tourism activities.

GIS also can be a valuable tool for investigating specific questions that pertain to tourism development including location, condition of the area, trends and changes, routing to and through the site, and patterns associated with resource use (Dye & Shaw, 2007). However, ‘currently no tourism research has taken a GIS approach to address land

use and land use change at the parcel level' (Allen and Potts, 2002, p. 288). Nevertheless, it has a strong relationship between tourism development and land use change.

The benefits of using GIS can be summarized in three ways (Wang & Stauffer, 1996) as follows:

- GIS helps to portray characteristics of the earth and monitor changes of the environment in space and time;
- GIS helps to deeply understand the meaning of spatial information and how that information can more faithfully reflect the true nature of spatially distributed processes;
- GIS helps to model alternatives of actions and process operating in the environment to anticipate possible results of planning decisions and to aid in making better decisions.

Moreover, by using this technology it is also possible to service management, visitor flow management, facility inventory and resource use management and assessing impacts of tourism development.

## **1.2 Scope of this research**

The use of Remote Sensing (RS) and GIS can certainly play an important role in ecotourism planning. In general, these geospatial technologies provide efficient tools to store manipulate and analyze a great variety of spatial data. More specifically, it can be used to map out land covers and habitats, monitor landscape changes, model species distribution and predict suitable habitats for different species. The availability of high resolution satellite imagery like IKONOS and Quickbird makes it easy to provide more detailed spatial information. These systems have been used for various applications and functions including: mapping of mangroves and wetlands tree species identification monitoring of natural vegetation studies of forest degradation and country park monitoring and management. These data certainly enhances the spatial database with more detailed and updated spatial information for management and planning (Fung & Wong, 2007).

Thus, nowadays because of impressive technological developments it is almost impossible to make a quick and suitable planning decision without utilizing support of

any technology. GIS can assist in a huge range of applications including ecotourism because of its large capacity. This technology uses spatial and non spatial data for making a quick decision a fact which is also important in sustainable ecotourism development.

Ecotourism itself is meant to be a sustainable form of natural resource-based tourism. It focuses primarily on experiencing and learning about nature, its landscape, flora, fauna and their habitats, as well as cultural artifacts from the locality. A symbiotic and complex relationship between the environment and tourist activities is possible when this philosophy can be translated into appropriate policy, careful planning and tactful practicum. So, simply GIS can help transfer recommendations for ecotourism development into an effective planning action for future sustainable development (Fung & Wong, 2007).

The major importance of this research is to demonstrate the use of GIS in ecotourism planning. It will examine a case study where it will discuss how to plan the Sundarbans regions in Bangladesh by using GIS technology for the future development of ecotourism.

### **1.3 Research problem**

Decision-making in tourism development and planning is becoming increasingly complex because of the interrelationship with various phenomenon including local people, stakeholders, local culture and natural environment. Cost-benefit plays an important role to developing tourism in a sustainable manner. GIS can be considered as a toolbox that provides techniques and technologies to achieve sustainable tourism development (Bahaire & White, 1999). GIS is considered as a set of powerful tools to process spatially referenced data and this spatial data can be used to identify conflict, analyse impacts over time and find a suitable solution for a specific problem. Tourism activities generally can create various negative effects on surroundings. Impact assessment and simulation are increasingly important in tourism development and GIS can play a role in auditing environmental conditions, examining the suitability of locations for proposed developments site, identifying conflicting interests and modeling relationships (Bahaire & White, 1999). We need to use GIS in ecotourism development for some specific reasons such as follows:

- It can organize structured information about Ecotourism to planners and developers;
- We can use it to utilize and find locational suitability under conflicting demands;
- It can facilitate monitoring and controlling of ecotourism activities;
- It identifies how stakeholders can become responsible for ecotourism marketing;
- It analyzes different aspects of community involvement and participation time space management and visual impact;
- It can be also used to analyze the characteristics of potential customers;

This current research will be based on a case study of Sundarbans which is the largest mangrove forest region of the world located in the southern part of Bangladesh and the Indian region of west Bengal. This forest plays an important role for the national economy of Bangladesh because of its natural resources and tourism activities. Moreover, it has been recognized globally for its importance as a reservoir of biodiversity. However, it has been facing some problems due to unplanned development and tourism activities. These problems can be described as follows:

- Increasing deforestation;
- Biodiversity losses;
- Decreasing upstream flows;

Thus, it is very important to develop Sundarbans in combination with a clear-cut planning effort. To plan Sundarbans and hopefully, encourage the development of tourism in a manner that meets the tenets of sustainable development it is imperative to utilize GIS technology. Additionally, we can use GIS as a decision supporting tool for identifying problems and preparing systematic solutions.

#### **1.4 Research Objective**

The main purpose of the study is to explore the potential of using GIS and Remote Sensing for planning resources pertinent to ecotourism development in Sundarbans Bangladesh. Built on that, the study will be guided by the following specific objectives:

1. Describe the use of GIS & RS in ecotourism planning;

2. Identify land use change over the last 33 years using satellite data, (Landsat Thematic Mapper (TM) & Enhanced Thematic Mapper (ETM) since 1977-2010) in the Sundarbans mangrove Bangladesh;
3. Plan Sundarbans by using GIS technique to protect biodiversity and ecotourism development.

### **1.5 Research Question**

The following research questions need to be addressed in achieving the above mentioned objectives.

- What is the importance of GIS in ecotourism planning?
- How are local people involved in the planning process?
- How is it possible to plan for Sundarbans including its 2 million existing residents?
- What is the present land use and land cover in the study area?
- Which major land use and land cover types have changed in the area between 1977 and 2010?
- What is the relationship between tourism and land use change?
- Which factors are more responsible in terms of creating this change?

### **1.6 Data, Software and Materials**

Two important and relevant sets of data (Table 1) will be used in this research. Landsat satellite images from 1977 to 2010 will be used for land use classification and Local Government Engineering and Development (LGED), vector maps will be used as reference map when digital image classified. Moreover, image processing and GIS software (Table 2) should be used to create database, simple statistical analysis, and image processing.

Table 1. Data uses in this research

Ancillary data	Date	Raw satellite digital data	Date
LGED district planning vector map	1994	Landsat TM	March 2010
Census data	1985-2010	Landsat TM	July 2006
Secondary data	---	Landsat ETM	November 2000
		Landsat TM	January 1989
		Landsat MSS	January 1977

Table 2. Software used in this research

Image processing and analysis	Statistical analysis	Word processing/ Report writing
IDRISI Anders	SPSS	MS Word
ERDAS IMAGINE 9.2	MS Excel	
Arc GIS 9.3	-----	

## **1.7 Method used**

### **1.7.1 Introduction**

There were several attempts to measure land use change in Sundarbans through the use of remote sensing and GIS data. The GIS technology has been used in Sundarbans to measure land use change based on different objectives for instance, climate change and its impacts measurement, salinity, shrimp culture and its effects and so on. However, application of GIS in ecotourism planning is new in this region because tourism is poorly developed in the Bangladesh part of Sundarbans and mass tourism has not yet begun even though there has been a great possibility to develop ecotourism. I used Landsat satellite raw data to identify present land use and its change over the time (33 years).

### **1.7.2 Research stages**

This research mainly describes the importance of GIS as a decision supporting tool in ecotourism planning and how GIS can assist in a planning process. Image processing is an important part of this process and to achieve the objectives of this research the methodology consists of four stages, namely: (1) preparation stage (2) processing and description stage (3) mapping, analysis and evaluation stage and (4)

reporting stage (Figure 1 presents the flow chart of the methodology which is implemented in this research).

**1.7.2.1 Preparation stage:** After findings the study problems, the related literature was reviewed, followed by the collection of necessary satellite images and LGED vector map of Sundarbans. This stage has been completed in computer lab in Mid Sweden University (MIUN) Sweden, also used personal computer and software to assist this research.

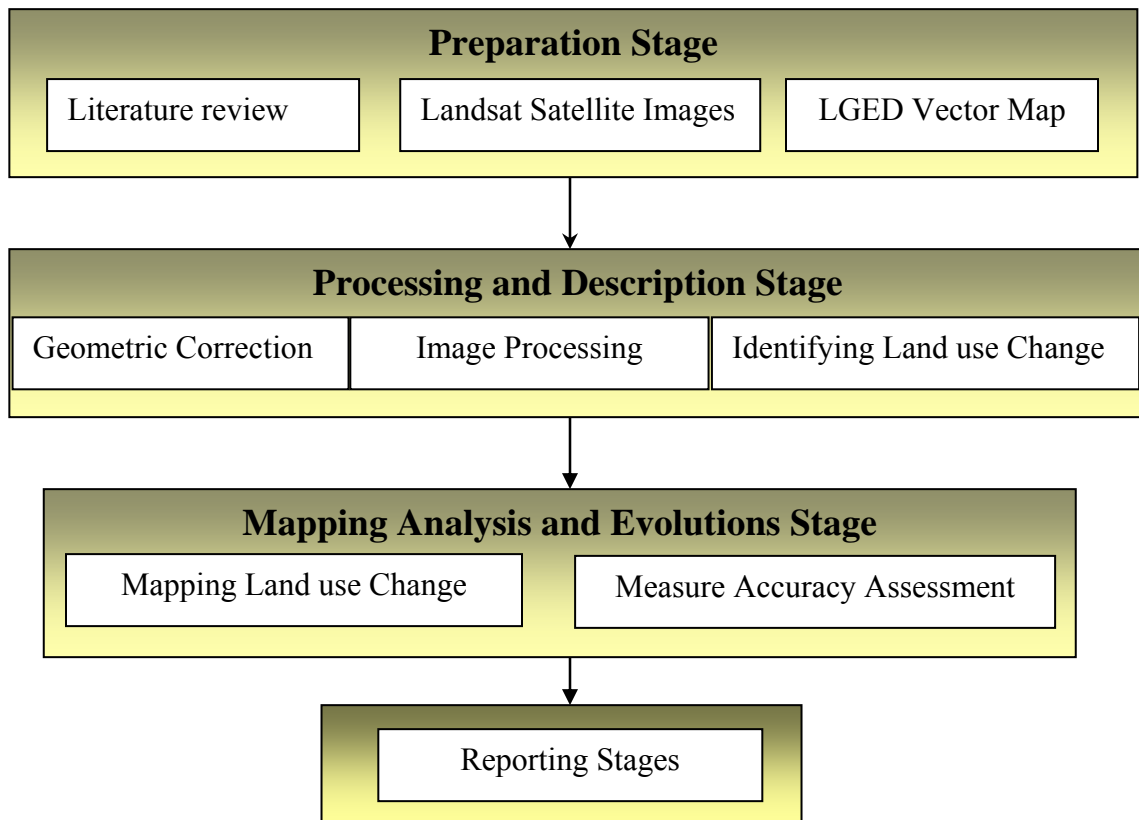


Figure 1. Flowchart of the research methodology

**1.7.2.2 Processing and description stage:** This stage included all the stages related to satellite image processing, including geometric correction, features extraction, geo-processing, resampling, and image filtering of raw satellite images. Finally image classification will be performed to identify land use changes.

**1.7.2.3 Mapping, analysis and evaluation stage:** On this stage vector maps are prepared by the Arc view 3.2a and Arc GIS 9.3 software and digital images processing,

accuracy assessments and data analysis performed by the ERDAS IMAGINE 9.2 and EDRI SI Andes image processing software.

**1.7.2.4 Reporting stage:** This is the final stage of this research and this stage prepares final report, maps and diagramed for final result of this thesis.

## **CHAPTER 2**

### **2. REVIEW OF LITERATURE AND CONCEPTUAL BACKGROUND**

This chapter provides brief descriptions of the review of literature and the applications of GIS in tourism planning. Moreover, the conceptual background of GIS has also been illustrated in this chapter.

#### **2.1 GIS application in tourism**

The application of GIS in tourism research has been minimal though GIS technology has been discussed in the tourism literature for over a decade (Gunn and Larsen, 1988). This technology has been used in tourism research including that which relates to ecotourism planning, visual resource assessment and management, recreation and park management, facility monitoring, suitable location identification. Additionally and very recently, analysts have begun using GIS in a limited fashion in applications relating to tourism marketing. Although, GIS has only a recent and limited use in leisure and tourism research, it has already achieved a good reputation in this research. Mainly, this technology uses tourism research to drive specific benefits as a supporting tool of decision making process. The benefit of using GIS in tourism and leisure research is that GIS has the ability to manipulate both data, spatial and attributes. Moreover, it has provided necessary value added information (Bahaire and White, 1999). It can minimize conflict in the case of allocating resources between what are often conflicting demands to identify, needs and data change over time, and their ability to identify patterns or relationships based on particular criteria and support in this way of decision-making.

Moreover, GIS can be used to provide a more holistic approach towards problem solving in which qualitative and quantitative information has to be processed. Generally, this technology is used for collecting spatial information, storage, analysis, and display of results in the form of graphs or maps which are more effective to be understood by users. It is also used to promote participation at decision-making level. An integration of RS and GIS can also play an important role in ecotourism planning because this technology is considered to act as effective tools for storing, manipulating and analyzing a great

variety of spatial data. More specifically, 'GIS can be used to map out land covers and habitats' 'monitor landscape changes' 'model species distribution' and 'predict suitable habitats for different species' (Fung & Wong, 2007, P. 88).

Points, lines and polygons are three important elements which are used to represent spatial information and these three terms are often used in GIS to represent spatial data. In tourism research GIS is used to characterize tourism destinations by using points, lines and polygons especially different landscape. Point features represent individual tourist attractions, for example, a campground in a park, or a historic site along the highway. Coastal beaches and resorts often follow a linear pattern, while big theme parks or natural parks are characteristics of a polygon feature (Giles, 2003).

However, due to the lack of budget and lack of proper databases these technology applications in ecotourism are limited. For instance, there is very little site-specific information about sources of visitors origin and destination, travel motivation, spatial patterns of recreation and tourism use, visitor expenditure patterns, levels of use and impacts, and suitability of sites for recreation/tourism development - all of which are suitable application areas of GIS. Therefore, GIS application in ecotourism development has been limited to tourism-based land management, recreational facility inventory, visitor impact assessment, recreation-wildlife conflicts, mapping wilderness perceptions, tourism information management system and decision support systems (Giles, 2003).

### **2.1.1 GIS application in tourism planning**

'The use of GIS in regional tourism planning is illustrated by Culbertson *et al.* (1994) in the case of Banff, Canada and Colorado, USA. Culbertson *et al.* (1994) note the great potential for GIS technology in planning for sustainable development, as an extension of its traditional use in environmental analysis. Berry (1991) provides an early illustration of the utility of this kind of map analysis in the US Virgin Islands' (Bahaire & Elliot-White, 1999, p. 163).

Site selection, is also an important use of GIS in tourism planning. For instance, by using suitable location identification tools and topology it is simply possible to identify potential areas for further tourism development. These tools are also used to

define conservation and recreation areas, facility monitoring, and visitor management and so on. Best locations have been determined according to engineering, aesthetics, and environmental constraints. Similarly, Boyd and Butler (1996) demonstrated how GIS was used to identify areas suitable for ecotourism in Northern Ontario. Williams et al. (1996) also used GIS to record and analyze tourism resource inventory information in British Columbia.

Bahaire and Elliott-White (1999) has provided a brief description of various applications of GIS in tourism planning in the United Kingdom. These applications included data integration and management (for example data on tourism destination types and accommodation), landscape resource inventory, designation of tourist areas in terms of use levels, tourism suitability analysis, and pre- and post-tourism visual impact analysis. The capability of a GIS to allow rapid modification, addition or removal of constraints and to investigate the complex interrelations between the thematic layers is attractive for resource management and planning problems (Beedasy & Whyatt, 1999).

Farsari and Prastacos, (2004) mentioned some practical opportunities for using GIS in tourism planning. For instance, these are related to visitor flow management, facility inventory and resource use, assessing impacts of tourism development, and retailed management related to tourism. They described that GIS can identify principal tourist activity spaces within a destination and the flows among destinations and authorities may implement strategic plans for superior infrastructure. Moreover, this technology can be used to minimize conflict in terms of resource management because unbalanced tourism development for a region is not a good sign if tourism development may not benefit all segments of society equally. However, GIS can be used to demonstrate tourism impacts on various industrial sectors in a time-series and spatial format (Chen, 2006).

### **2.1.2 Application of GIS in ecotourism planning**

Boyd and Butler (1996) demonstrate the application of GIS in the identification of areas suitable for ecotourism in Northern Ontario, Canada; in particular natural areas, containing rare or endangered species or habitats in remote/peripheral areas. Basically they produce an inventory of various characteristics associated with natural landscapes.

GIS was used for inventory mapping, buffering (identifying areas of human intrusion) and overlays mapping (Bahaire & White, 1999, p. 163). GIS used for identifying location suitability and resource inventories according to environmental concern. Ecotourism development is a very sensitive issue in a particular destination in terms of complex ecosystem and local population habits. To identify untouched areas GIS can play an important role. By analyzing satellite images it is possible to identify complex areas inside the deep forest or trained mountain region even in the deep ocean where a general survey method is almost impossible. Impact analysis is related to this application as GIS can be used to evaluate potential impact of tourism development on the natural environment (Bahaire & White, 1999).

In ecotourism planning the first issue that emerges is the environment and its conservation. An ecotourism destination must in no way be developed without planning in terms of environmental concern. Referring to the Gray rocks reservoir in Wyoming US, for example Gribb (1991) described a planning endeavor where the aim was to come up with a recreation development plan that would contribute at the same time to environmental conservation of the reservoir.

### **2.1.3 Application of GIS in tourism service management**

The use of GIS has a potentiality in tourism service management especially tourism business related shopping center. It can be used for displaying large volumes of diverse data. In the United Kingdom (UK) for instance, fifty-three percent of the major retailers had adopted GIS by 1998 (Hernandez et al., 1999). Brick and mortar businesses can use GIS applications to compete with the convenience of Internet retailing (Chen, 2007). To an extent the idea, Chen, (2007) has provided some good examples relating to uses of GIS in service management. According to her opinion, ‘a retailer can develop a map of its store using GIS software to calculate the actual dimensions of a store. This can even handle multilevel stores and shelf depths. When a retailer has the store mapped, a consumer can view the map on a live website, and know the exact location of the item within the store. While using the virtual map, the consumer can see how many items are in stock, detailed information about the product, and any associated items that are on sale or available for purchase’.

The smart card is another important use of GIS in service management. This card is considered a computer-enhanced shopping cart and it is designed with a map or database of the store in which a customer can query a specific item as they walk through the store (Chen, 2007). The smart cart will locate the item within the store, direct the customer to that item using a map, provide additional information about the item, and offer supplementary items needed and their locations.

Day by day, people depend more on the internet to collect information before visiting a tourist site. Thus, it is also important to provide the right information according to visitor requirements. GIS has been used in tourism for providing useful and accurate location based information to the visitor for example, by web based GIS spatial and attribute information can possible to put in internet. Recently, the web based GIS have started to deliver tourism related information via the internet. The US National Park Service, for instance, maintains an Internet GIS web site known as Interactive Map Center (<http://www.nps.gov/gis/index.html>) that allows users to find information about national park locations and navigation to and within the national parks. Environmental Systems Research Institute (ESRI, Redlands, CA) also hosts an Internet GIS tourism site for San Diego, California (<http://maps.esri.com>) (Dye & Shaw, 2007).

#### **2.1.4 GIS Applications in tourism resource inventories**

Tourism resource inventories have been developed to offer organized, structured information about parameters, which are of interest for tourism planners and developers (Farsari, 2004). Tourism resources include natural resources, especially sea beaches, natural forests, mines, mountains, rivers and channels, waterfalls, national parks, safari parks and so on. They also include tourism infrastructure, historical places, demographics, natural and cultural heritage sites. GIS is capable of capturing, analyzing and displaying both spatial and non spatial (attribute) data related to tourism resources. Additionally, by analyzing both types of data it is possible to make a prediction for a destination hypothetically and examine its future from the lab before tourism development. Resource inventories are useful as well as tourism planning, identification of locational suitability, impact assessment for natural resource uses, examine conflicting

demand and so on. For example, Boyd and Butler (1996) used a resource inventory to identify potential ecotourism sites in Northern Ontario in Canada.

### **2.1.5 GIS application to location suitability under conflicting demands**

To develop tourism, local people's interest is an important factor for sustainable tourism planning and development. Similarly, the local cultural and natural environments are other important issues to be considered in the planning process and overall sustainable development. By contrast, nowadays tourism has been considered one of the largest industries throughout the world because it makes money from small-scale to large-scale places; sometimes a country's GDP depends heavily on tourism as is the case in Nepal (7.4%) and Indonesia (7.9%). Due to increasing mass tourism, impact assessment and simulation are increasingly important to tourism development on nature based tourism and GIS can play a role in examining the suitability of locations for proposed developments, identifying conflicting interests and modeling relationships. Systematic evaluation of environmental impact is often hindered by information deficiencies. This is in order to manage and control tourism development considering conflicting or complimentary land uses and activities, infrastructure available, natural resources and therefore define the capabilities and capacities of an area (Butler, 1993). It would be a potential case if GIS can be used to identify areas suitable for ecotourism development. For example, Boyd et al. (1994) and Boyd and Butler (1996) illustrate a methodology for identifying areas with potential for ecotourism in Northern Ontario, Canada. At first, a resource inventory and a list of ecotourism criteria were developed. The next stage GIS techniques were used to measure the ranking of different sites according to the set criteria and, therefore, identify those with the best potential (Farsari, 2003).

### **2.1.6 Monitor and control tourism activities**

Tourism is an activity which is related to the complex interaction among all related participants as well as stockholders, local peoples and the local cultural and natural environment. Naturally tourism needs to control for further degradation by this activities especially local cultural and natural environment. GIS can be used to

monitor and control tourism activities through time and across space. In a tourist destination, carrying capacity is an important factor, because over crowdedness is not a good sign for a tourist region because, it can destroy the local environment. Indeed, tourism needs to developed planned way and GIS can assist in planning process, because GIS has integration capacity. Butler (1993) mentioned that the integration capabilities of GIS can facilitate the identification and monitoring of indicators related to tourism. Moreover, exploitation of its analytic techniques may provide more complex measures which are often required for monitoring sustainable development.

### **2.1.7 Application of GIS in tourism marketing**

At its core, the tourism industry sells images of the geography of different parts of the world. Before visiting a destination nowadays, tourists in most of the cases try to collect information through the internet to recognize the tourism and leisure related facilities of that region. So, the demand for marketing in tourism sector has increased and GIS can play an important role in tourism marketing. Beaumont (1991) argues that the use and popularity of GIS for marketing goods and services is the primary reason that GIS has now become central to much geographical research. In tourism marketing both are important, not only tourism marketers but also their client because tourist movement depends on geodemographic characteristics, experience, cultural similarities even time space factors. Elliot-White & Finn (1998) advocate, geodemographics and lifestyle analysis which can be performed by a GIS, could have a significant contribution in the needs of post-modern tourism marketing. So, it can use to locate and analyze the characteristics of potential customers.

Moreover, by using GIS software it can possible to make a Digital Elevation Model (DEM) for a particular landscape and also possible to linkage between digital maps in internet and 3D model using hot link tools. So that, before visiting the destination tourist can visit through internet virtually for his/her future destination.

### **2.1.8 Use of GIS in visual impact analysis in tourism research**

Visual impact analysis is increasingly playing a significant role in contributing to environmental impact assessments. Mainly, it can assist in guiding newly proposed

tourism destination developments as well as predicting the impact of proposed structures into the planning process. GIS is capable for analyzing the visibility of a proposed destination by using visual impact analysis tools. This technology has also 3D tools which is very effective to analyze visual impact on the earth virtually. 3D tools can perform 3-D visualization of an existing area as well as to simulate a proposed development and visualize it in the context of the existing setting. Visual impact analysis is important in tourism research due to sustainable development. This analysis can prove very useful for tourism planning especially in the case of scenic or of high aesthetic value environments. Selman *et al.* (1991) produced a Digital Terrain Model (DTM) for the Aonach Mor in Scotland. This was used to provide a visibility analysis of a skiing facility development.

### **2.1.9 Use of GIS community involvement and participation in tourism research**

Decision making in tourism planning is really complex in terms of multiple interactions among all responsible organization, stakeholders and local community peoples. However, local community involvement in decision making process provides an opportunity to sustainable way of planning. The participatory research methods offer opportunities to bring research and action, researcher and participant together in quite a different way.

These approaches emphasize the process rather than the product of research (Milne et al, 2005). It is a method to give chance to the community to express their thought and experience. Its extensive and growing menu of methods includes visuals such as mapping and diagramming. Hasse & Milne, (2005) noted that these approaches have a lot to offer the tourism planning process and can contribute to better-informed decision-making that serves the needs of local communities. They have also divided two categories of participatory techniques: (1) diagramming, which includes making maps, models and seasonal calendars; and (2) ranking techniques and scoring exercises, which include matrix ranking to explore local criteria for choices and preferences.

Mowforth and Munt (1998) illustrated that, community participation is seen as important for asserting some degree of local control over decisions on development plans and for enhancing commitment to their implementation. Not only community

involvement is necessary to planning process but also all stakeholders, responsible agencies and organizations participation of group or individual from different disciplines are required to make a sustainable plan.

#### **2.1.10 GIS uses as a decision supporting tools in tourism research**

GIS has a great ability of querying spatial relationships and analyzing attributes and spatial data. Moreover, by analyzing spatial data it can also display results by graphical arrangement and thematic approach in a map to produce a final modeling. Therefore, this technology is considered as a decision supporting tool in various planning processes.

Mainly, this tool is used for capturing various spatial data and storing, manipulating, analyzing and displaying this in the process of decision making. Although, this system is not a Decision Support System (DSS) itself, it can function as a decision support system as with its functions and applications (such as those preceding) can provide the necessary information in different forms (tabular, maps etc), perform calculations, visualize results and therefore, support a number of decisions (Farsari, 2003). Overall, GIS can assist as a supporting tool in decision making process. For example, Beedasy and Whyatt (1999) developed a decision support system (SpaME) to assist tourism planning in Mauritius. SpaME is designed to take into account all criteria simultaneously and to facilitate a user's understanding of the decision problem as well as of the interactions which may take place between these criteria on a dynamic environment.

To create links between spatial and attribute data and prepare topology in spatial features it is possible to make a feature layer, as an overlay within the feature, analyze, search, select by theme and so on. These kinds of characteristics make us use GIS as a tool of decision support such as location analysis, land use plan, and tourism development plan. The overall conclusion is that, GIS is an efficient and effective means of helping the various stakeholders examine the implications of land-use decisions in tourism development (Giles, 2003). The conceptual role of tourism knowledge system (Figure 2) illustrated by Kim (2002) which is follow:

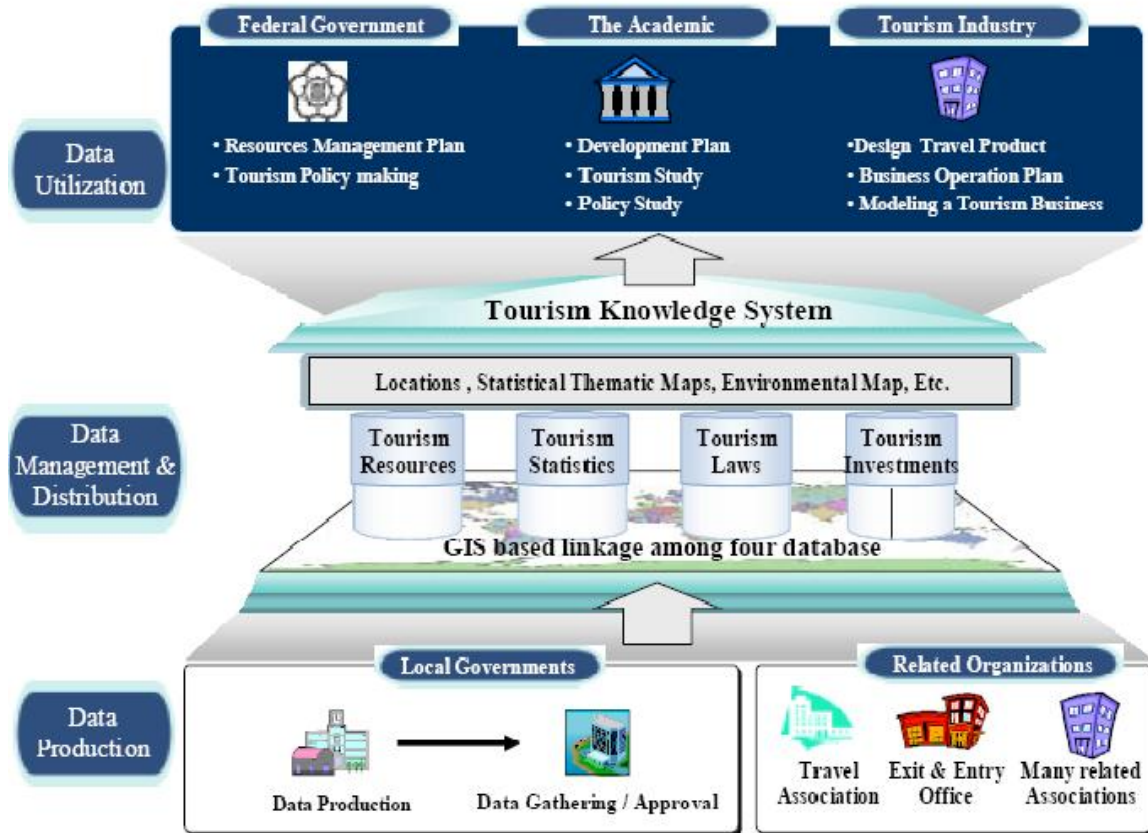


Figure: 2. Conceptual Role of Tourism Knowledge System (Kim, 2002)

## 2.2 Conceptual background of Geographical Information System (GIS)

### 2.2.1 Basic concept of GIS

GIS is a computer-based tool for mapping and analyzing feature events on earth. GIS technology integrates common database operations, such as query and statistical analysis, with maps (figure 3). GIS manages location-based information and provides tools for display and analysis of various statistics, including population characteristics, economic development opportunities, and vegetation types. GIS allows us to link databases and maps to create dynamic displays. Additionally, it provides tools to visualize, query, and overlay those databases in ways not possible with traditional spreadsheets. These abilities distinguish GIS from other information systems, and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

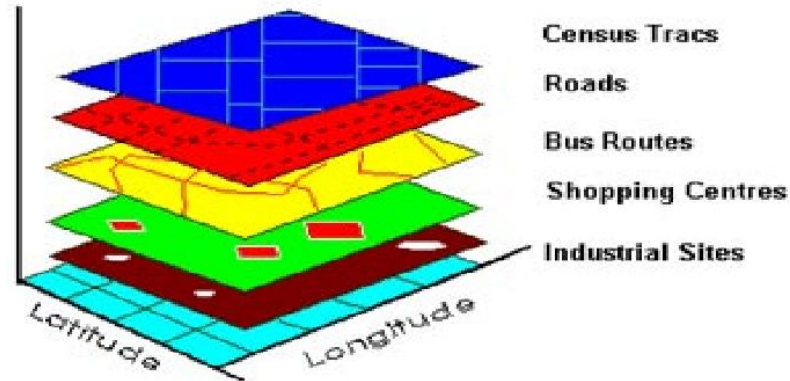


Figure 3. GIS is an integrating technology

### 2.2.2 Definitions of GIS

GIS is a computerized information system. However, there is an important difference between other databases and a GIS is that all information in the GIS must be linked to a geographic (spatial) reference (latitude/longitude or other spatial coordinates) (figure 4). The United States Geological Survey (USGS) defined ‘a GIS as a computer hardware and software system designed to collect, manage, analyze and display geographically (spatially) referenced data’. According to ESRI webpage, GIS as an organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display geographically referenced information. In terms of geographical information geographically referenced information is a must.

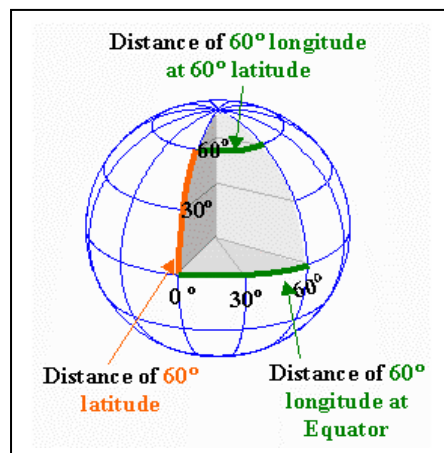


Figure 4. Geographic referencing/coordinate systems (ESRI, 2010)

Grimshaw, (1993) provides an overall definition of GIS which is ‘GIS is simplest level a technology that enables decision-makers to explore the geographical dimension of data’. Basically, definitions of GIS fall into one of the five categories as follows (Table 3):

Table 3. Definition of GIS

Properties of GIS		GIS Analytical Functions
A process	A system for capturing, storing, checking, manipulating, analyzing and displaying data which are spatially referenced to the earth (DoE, 1987: 132).	Presentation and thematic mapping Data Query Spatial Query Database
A toolbox	Containing tools for collecting, storing, retrieving, transforming and displaying spatial data (Burrough, 1986: 6).	integration Route finding
A data base	Of spatially referenced entities (Smith <i>et al.</i> , 1987).	Point in polygon analysis Overlays
An application	Cadastral information system, marketing information system, planning information system, etc.	Buffering Visualization and 3D modelling
A decision support system	Integrating spatial data within a problem solving environment (Cowen, 1988).	

Source: Bahaire & White, 1999, p. 161

### 2.2.3 Capacity of GIS

GIS has a remarkable capacity to capture, manipulate, analysis spatial referenced data and it can display the result within a map or graphs. Moreover this technology can create links between various databases to assist a decision-making process. There are five basic questions GIS can provide answers to. These are as follows:

What exists at a particular location? GIS can give the answer with a geographic reference; it must describe the features of that location. Another important question which can be solved by GIS relates to where can specific features be found? This is the converse of the first question for example, where are the districts with rainfall greater than 500 mm and less than less than 750 mm? The third question is what has changed over time? This involves answering both questions above. For instance, at what locations is the forest showing change or declining over the last five years. What spatial patterns exist? And what- if? GIS can give answer by analysis and modeling.

In tourism research, tourism resource inventories have often been used for a specific region. These aim at identifying the most suitable locations for development, tourism impact assessment, and visitor flows management, analyze relationships associated with resource use, and assess potential impacts of tourism development. Common tourism-related issues and GIS applications are tourism development as follow (table 4 and table 5):

Table 4 Capacity of GIS

Functional Capabilities of a GIS	GIS Basic Questions		Tourism Applications
Data entry, storage and manipulation	Location	What is at?	Tourism Resource Inventories
Map production	Condition	Where is it?	Identify most suitable locations for development
Database integration and management	Trend	What has Changed?	Measure tourism impacts Visitor management/flows
Data queries and searches	Routing	Which is the best route?	Analyze relationships associated with resource use
Spatial analysis	Pattern	What is the pattern?	Assess potential impacts of tourism development
Spatial modeling	Modelling	What if...?	
Decision support			

Source: Bahaire & White, 1999, p. 159

Table 5. Common tourism-related issues and GIS applications

<b>Problems</b>	<b>GIS Application</b>
Benchmark/database	Systematic inventory of tourism resources
Environmental management	Facilitating monitoring of specific indicators
Conflicts	Mapping recreational conflicts: recreation-wildlife; user conflict
Tourism behavior	Wilderness perceptions
Carrying capacity	Identify suitable locations for tourism/recreation development
Prediction	Simulating and modeling spatial outcomes of proposed tourism development
Data integration	Integrating socio-economic and environmental datasets within a given spatial unit
Development control and direction	Decision support systems

Source: Adapted from Butler 1993, p. 33 (cited in Bahaire and White, 1999, P.162).

The above mentioned capacity of GIS and application of GIS in tourism gives us a general idea about the demand of GIS in tourism. However, GIS is not common tools in tourism field but it has enough potentiality to use in tourism planning as a decision supporting tools for sustainable tourism planning and development.

## CHAPTER 3

### 3. STUDY AREA DESCRIPTION

This chapter deals with the description of the area where this research was conducted. The description includes the geographical location and setting, biodiversity and tourism facilities of the study area.

#### 3.1 Introduction

Bangladesh laying  $23^{\circ} 42' 0''$  N, &  $90^{\circ} 21' 0''$  E which is a country in South Asia situated north of the Bay of Bengal, on land it borders India and Myanmar, and it is a close neighbor to China, Thailand, Nepal and Bhutan (Appendix A) and this country is a heavily populated country (162,221,000 population, &  $1,099.3/\text{km}^2$ ). This country has the small extent of forested land. Out of a total land (approximately  $144\ 000\ \text{km}^2$ ), only 15% is classified as government forest land. However, the actual forested area is only 9% (FAO, 1998). The Sundarbans mangrove reserve forest (Figure 5) is the largest single forest resource in the country, representing 51% of the country's total reserved forest estate. It contributes about 41% of total forest revenue and 45% of all timber and fuel wood. At least 2 million people live within the proximity of the boundary and this number is doubling every 34 years (FAO, 1998).



Figure 5. Satellite map of Sundarbans (Landsat 7, November, 2000)

Sundarbans situated in the southern part of Bangladesh along the cost of Bay of Bengal (Figure 6). This mangrove forests is an excellent example of a rich biodiversity and ongoing ecological processes, displaying the effects of monsoon rains, delta formation, tidal influence and plant colonization. This mangrove is famous for its wide range of fauna including birds, reptiles, the Royal Bengal tiger and other threatened species, such as the estuarine crocodile and then Indian python (Salam et al, 2000). The total area of Sundarbans is 272,510 hectares: 139,500 hectors are in Bangladesh and the remaining 133,010 hectares form the Indian part. In 1947, the area was divided into two parts by international boundaries. Bangladesh received 2/3 of the forest and the rest is on India side (West Bengal). The Sundarbans (Bangladesh part) was designated as a world heritage sites in 1997 by the UNESCO. However, it has been reducing day by day due to climate change effects economic and tourism activities. Climate change is a big threat to this forest because Sundarbans is only 3m above from the sea levels in Bangladeshi side and 10m at almost in India side.

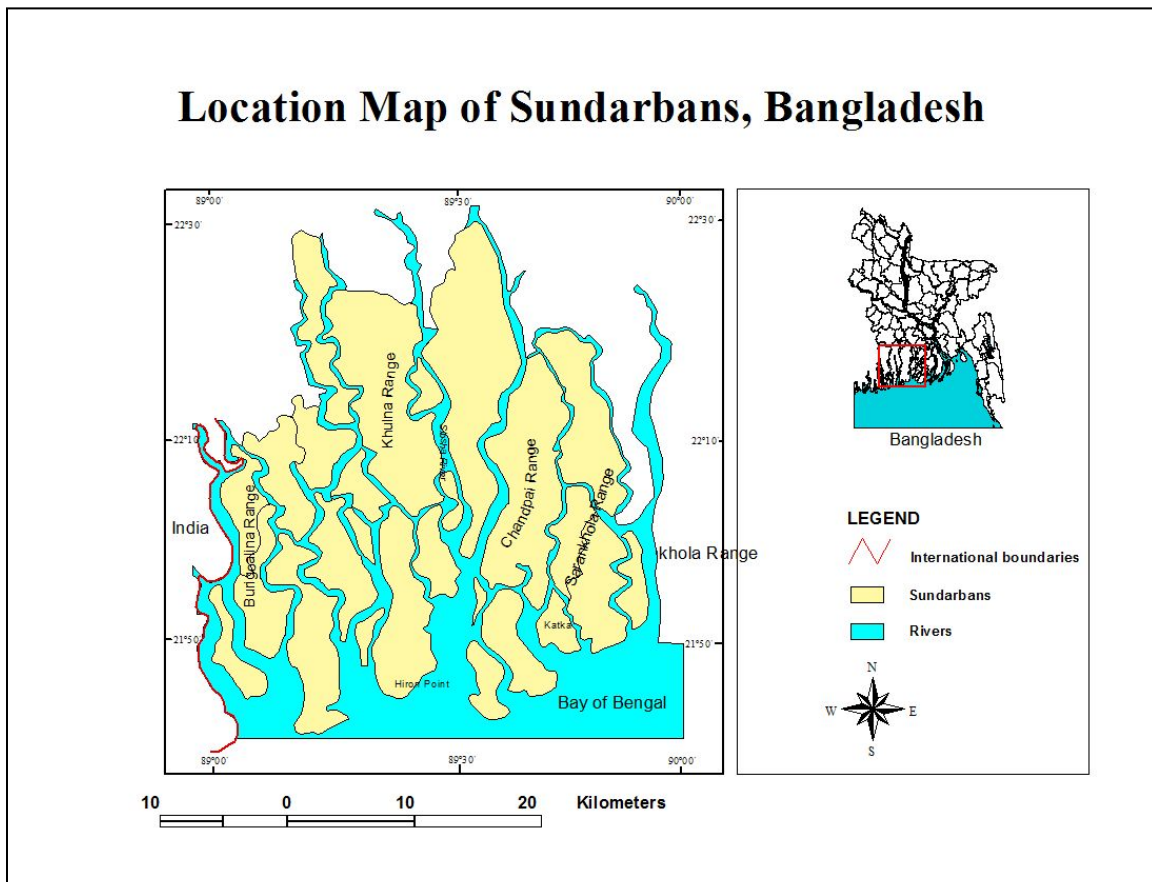


Figure 6. Location map of Sundarbans, Bangladesh

### **3.2 Geographical location**

The Sundarbans forest is situated a little to the south of the Tropic of Cancer and is bounded by the northern limits of the Bay of Bengal between the latitudes 21°30'N and 22°30'N, and the longitudes 89°00'E and 89°55'E. This forest is a part of World Heritage Sites and it consists of three wildlife sanctuaries (Sundarbans West, East and South) lying on deltaic islands in the Sundarbans Forest Division of Khulna district, close to the border with India and just west of the main outflow of the Ganges, Brahmaputra and Meghna rivers (Encyclopedia of earth, 2010).

### **3.3 Physical feature**

The Sundarbans, covering some 10,000 square kilometers (sq.km) of land and water, is part of the world's largest delta (80,000sq.km) formed from sediments deposited by three great rivers, the Ganges, Brahmaputra and Meghna, which converge on the Bengal Basin (Encyclopedia of earth, 2010). This mangrove forest consists of 200 islands, separated by some 400 interconnected tidal rivers, creeks and canals. However, this region is known to be of relatively recent origin, and the extent of its coverage has changed considerably since its formation (Iftekhar and Islam, 2004). This change has been occurring due to a complex interaction of sea level change sedimentation rates, and neo-tectonic subsidence (Islam and Tooley, 1999).

The landscape is one of low-lying forested alluvial islands (56 in the Indian sector), muddy banks with sandy beaches, and dunes along the coast. The forest swamp is extensively embanked and empoldered and is an essential buffer for inland areas against the ravages of frequent cyclones from the Bay of Bengal (UNEP, 2008).

The soil type and its present distribution and thickness formed during Holocene era by the cause of deposition and neo-technique activities. The sediment composition of the Sundarbans originates from alluvial sand from the Gangetic plain and silt from the Bay of Bengal deposited through prevailing ocean currents (Barlaw, 2009).

The physical features map of Sundarbans, Bangladesh is following (Figure 7)



Figure 7. Physical features map of Sundarbans, Bangladesh (MODIS, NASA, 2001)

### **3.4 Climate**

The Sundarbans climate can be classified as maritime, humid, and tropical, where seasonality is very strong. The humidity (80%) and rainfall is very high due to the proximity of the Bay of Bengal. Maximum rainfall happening during the monsoon which is almost 80% of annual rainfall and this monsoon start from early June and continuing until September. Others seasons can be describe as dry (December-February), pre-monsoon (March-May), and post-monsoon (October-November) (Iftekhar and Islam, 2004). During the monsoon the weather is characterized by a warm, wet and humid season in this region when 77-80% of annual rainfall occurs but in winter very little rainfall falls while this part of the year has the lowest temperature and humidity. The pre-monsoon season has the highest temperature and evaporation rates of the year and has periodic thunder showers receiving about 381–508 mm of the total annual rainfall (Hussain, 2006). The cyclonic storms originating in the high seas during April-May and

October-November associated with tidal wave severally affect the tidal area, when crops, livestock, property and human lives are lost.

### **3.4.1 Temperature**

The Sundarbans mangrove region's temperature fluctuates from January to December but January is the coldest time and March is summer. Temperature rises from daily minimums of 2-4°C in the winter to over 32°C during the monsoon and a maximum around 43°C in March. The mean annual maximum temperature recorded is 34°C and the average minimum temperature is 20°C. However, recently weather forecast reports indicate that the air temperature in this region (The Sundarbans and adjacent parts of the Bay of Bengal) is gradually increasing (Figure 8).

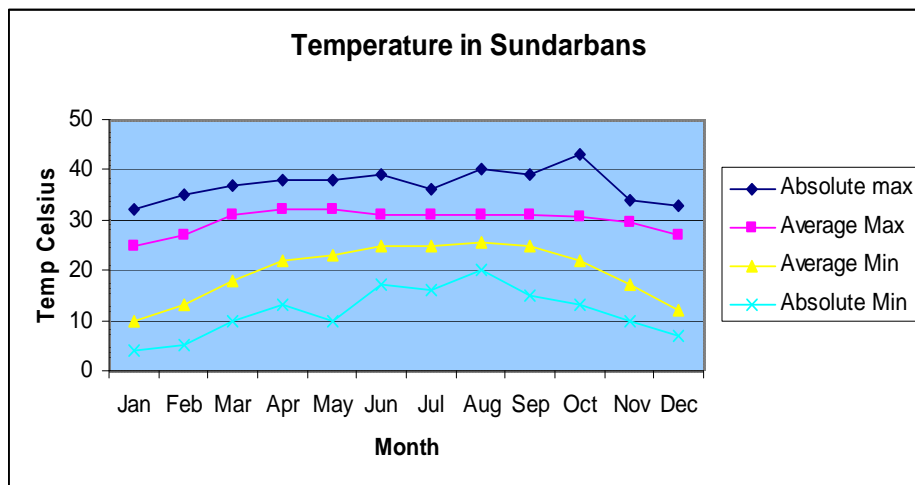


Figure 8. The average minimum and maximum temperature in Sundarbans

### **3.4.2 Rainfall**

The rainfall over the Ganga-Brahmaputra deltaic region decreases from east to west and from south to the north (Gopal et al, 2006). The majority of rainfall (80 % of the yearly rainfall) occurs during the monsoon (wet season). The annual rainfall ranges from about 1,800 mm in Khulna near the north of the Sundarbans to 2,790 mm on the coast. A little precipitation is received in the latter half of the hot season and in October. According to the previous record there was little variation in the rainfall over the 20<sup>th</sup> century. More specifically, during the first half of the 20th century, the highest and lowest annual rainfalls were only 142 % (in 1933) and 62 % (in 1935) of the normal

respectively (Gopal et al., 2006). Sundarbans received on an average 80 rainy days in a year (Figure 9).

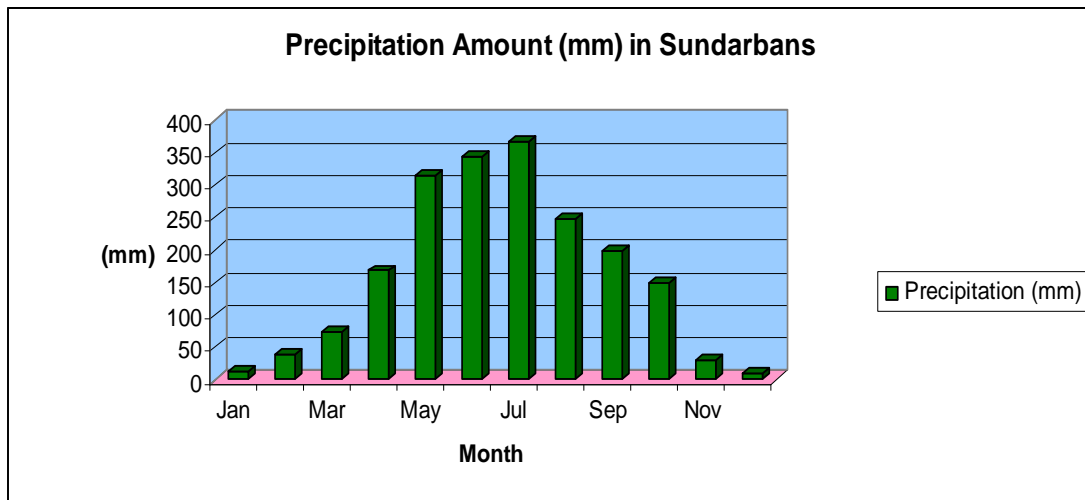


Figure 9. Monthly average precipitation amounts in Sundarbans

### **3.4.3 Wind**

The wind is rather strong during the monsoon and summer (Figure 10). otherwise it is generally light to moderate over the year although the southern part of Sundarbans which is on the coast of the Bay of Bengal has witnessed very strong winds especially in the summer and monsoon. The wind blows usually from south to east and south to west during May to September but from October the wind changes its direction. In winter the wind blows mainly from the north to west but from March to April it usually blows from the south and south-west. During the summer, thunderstorms are very common and these may be in association with severe squalls and occasional hail which is known as Kalbaishakhi in Bangladesh. Sometimes these storms develop into cyclones and suddenly the temperature drops down and it continues to rain up to 7 days constantly. During the cyclone, tidal waves can be as high as 7.5 m and these floods the costal region in Sundarbans forest and damage huge property, human and animals lives as in 1970 and 1991. For example, recently monsoon floods and cyclone Sidr in November 2007 were disastrous on a huge scale in Bangladesh. It was affected to 5000 lives and twelve million people in these area, and damaged or destroyed some one million homes, livestock, paddy fields, forests and the fishing industry.

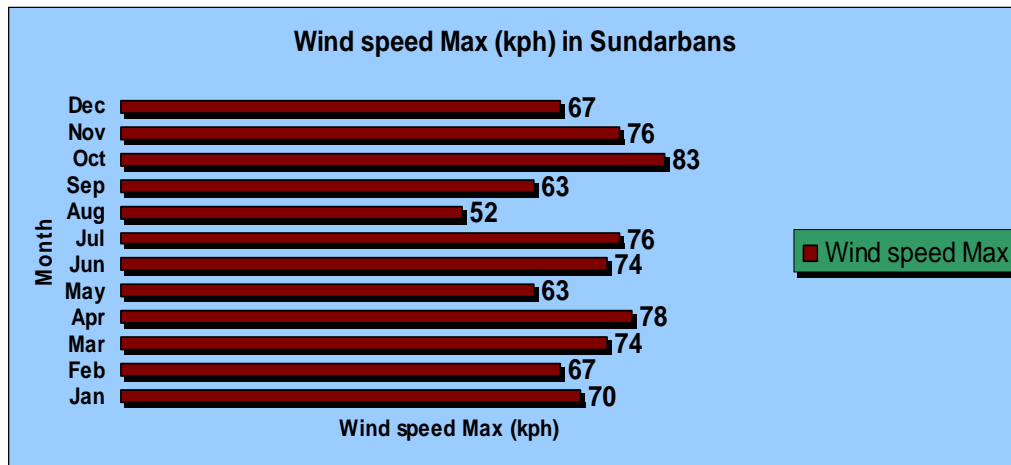


Figure 10. Monthly average maximum wind speeds (kph) in Sundarbans

### 3.4.4 Hydrology and Salinity

The hydrology of the Sundarban is dominated by the freshwater flows from three great rivers including Ganga, Brahmaputra and Meghna which exhibit very high seasonal variation in their discharge, and the tides which range in height from 2 to 5.94 m. Tidal influence extends to more than 50 km inland from the shoreline and surges increase considerably during the cyclonic storms (Gopal et al, 2006). The salinity is affected by tidal action and the fresh water flows from the rivers. Basically, fresh water flows from the rivers and the tidal ingress result in a gradient of salinity (Figure 11) that varies both spatially and temporally. However, the coastal region is more affected by salinity problems than the inland region because of upstream flows.

### 3.5 Biodiversity

The biodiversity of Sundarbans is based on a complex mangrove ecosystem and the name of this forest comes from the Sundari trees (*Heritiera fomes*). The dominant species are sundari (*Heritiera fomes*), gewa (*Excoecaria agallocha*), goran (*Ceriops decandra*) and keora (*Sonneratia apetala*). These Sundari trees dominate where the soil water is comparatively fresh, more specifically, in the northeast part and on higher ground in this forest. The Sundari trees are very useful for the purposes of commercial timber production.

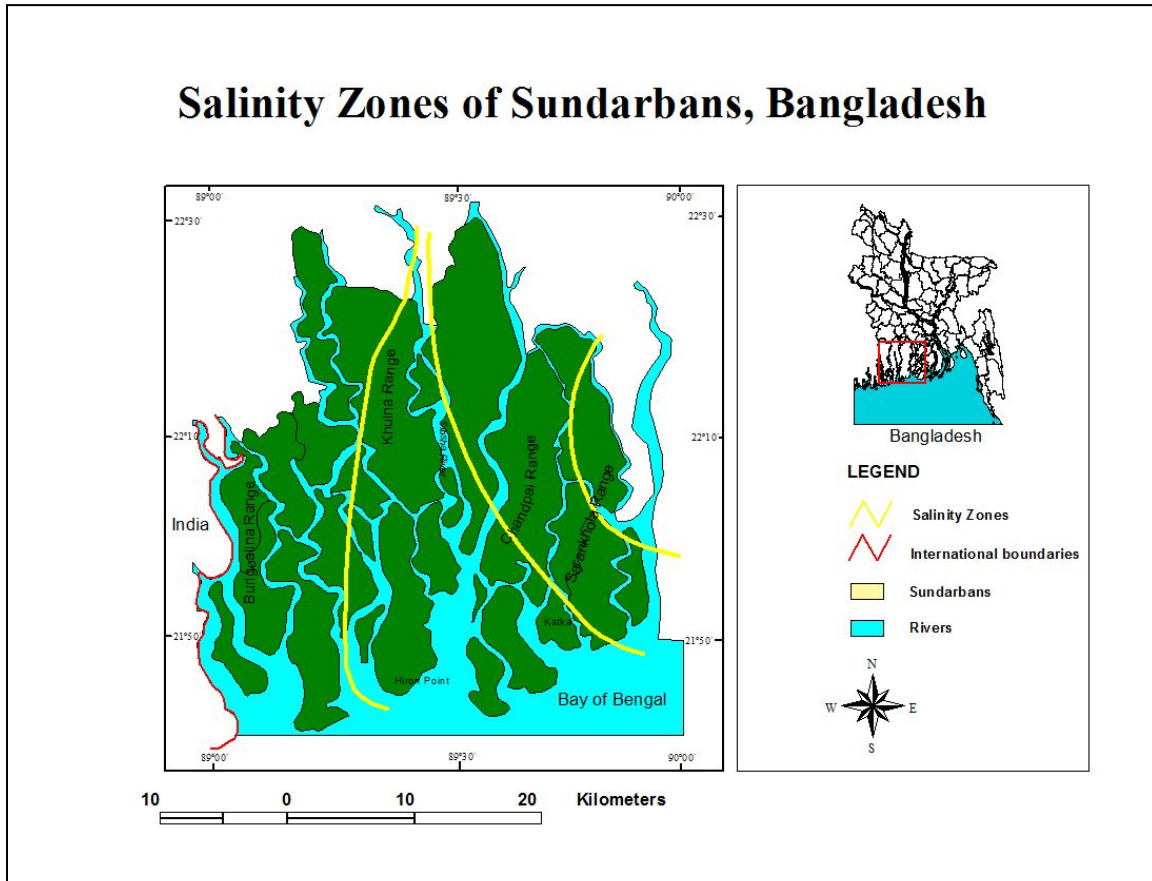


Figure 11. Salinity zones map of Sundarbans, Bangladesh

The mangroves of the Sundarbans are unique compared with the non-deltaic coastal mangrove forests and they are the home of Royal Bengal tigers. Today, we can find the name of the Bengal tiger in the endangered animal list mainly because of the animal's shrinking habitat and illegal hunting. This forest has a great population biodiversity such as 50 species of reptiles, including the Indian python, and 30000 spotted deer, saltwater crocodiles, Gangetic river dolphins, 120 species of fish, 260 of birds and so on. Biodiversity in both the Bangladeshi and Indian part of this forest displays little variation. Total biodiversity recorded to date from the Indian Sundarban mangroves is as follows (Table 6):

Table 6. Total biodiversity recorded to date from in Sundarban mangroves

Group of Organisms	No. of Species	Group of Organisms	No. of Species
Flowering Plants	105	Turbellaria	1
Pteridophytes (Ferns & Fern allies)		Monogenera	21
Algae	150	Trematoda	13
Lichens	32	Cestoda	6
Vertebrates	445	Nemathelminthes	68
Chondrichthyes	22	Acanthocephala	3
Osteichthyes (Fishes)	154	Nemertinea	2
Amphibians	8	Rotifera	4
Reptiles	58	Mollusca	143
Birds	163	Sipuncula	2
Mammals	40	Echiura	3
		Annelida	78
		Polychaeta	69
Phylum-		Oligochaeta	6
Sarcomastigophora	45	Hirudinea	3
Aplicom plexa	24	Arthropoda	476
Myxozoa	4	Crustacea	240
Ciliophora	31	Insecta	201
		Arachnida	33
Invertebrates		Merostomata	2
Porifera	1	Entoprocta	1
Cnidaria	33	Bryozoa	3
Ctenophora	2	Brachiopoda	1
Platyhelminthes	41	Chaetognatha	4
		Echinodermata	20
		Hemichordata	1

Source: Gopal & Chauhan, 2006, p. 343.

### **3.6 Local human population**

According to the 1981 census, approximately 2.5 million people lived in small villages surrounding the Sundarbans which by 1991 had increased to 3 million. Total 35,330 people worked in the forest, 4,580 of whom collected timber and firewood, 1,350 collected honeys and beeswax and 4,500 harvested the natural resources and hunted mainly deer, and 24,900 were fisherman and shrimp farmers (UNEP, 2008). The Sundarbans provides a livelihood at certain periods of the year for an estimated 300,000 people who work in various economic activities like, wood-cutting, fishing, and gathering

of honey, golpatta leaves (*Nipa fruticans*) and grass. In the Bangladeshi part every year around 4500 people are employed as contactors in the commercial logging of sundari and other timber, which is 45% of all that produced in state-owned forests. This timber is prepared to supply local newspaper mills, as well as match and board mills.

The local populations who depend on the forest and waterway for their livelihood are, extremely poor. Every year more than 10000 people come from far away during the fishing, and honey collection season and they stay for only three month in winter before returning home at the start of the monsoon season in April. The Sundarbans has a notorious background; approximately 300 people per year are killed by tigers and crocodiles within this region.

### **3.7 Cultural heritage**

The culture of the local people in the Sundarbans region developed by their own beliefs and this culture built based on the relationship between communities and the forest. The local culture also influences by the two major religions such as Islam and Hinduism. Most of the peoples are illiterate and they completely depend on nature for their livelihoods. They still use a variety of religious and other spiritual approaches increase their safety in the jungle. Before entering the forest, usually local people arrange a special religious program to pray for their safe journey into the forest and safe return. Also, blessings are sought from local spiritual/religious leaders and offerings are made to forest deities such as *Banbibi*, *Dakshin Rai*, and *Badi Ghazi Khan* (Barlaw, 2009). The local spiritual leaders are supply blessed pieces of red cloth and other charms to keep villagers safe during their trip to the forest.

### **3.8 Conservation value**

The biodiversity of the mangrove forest (Figure 12) of Sundarbans is one of the richest and most extensive in the world. The Sundarbans covers 6% of the total land area in Bangladesh. Moreover, this forest represents over half of the country's remaining natural forest. This forest has significance as a source of timber, fishing, shrimps and natural resources. Its green belt besides the cost makes a natural barrier to protect the land

from frequent storms which is generally comes from Bay of Bengal and destroyed huge life.

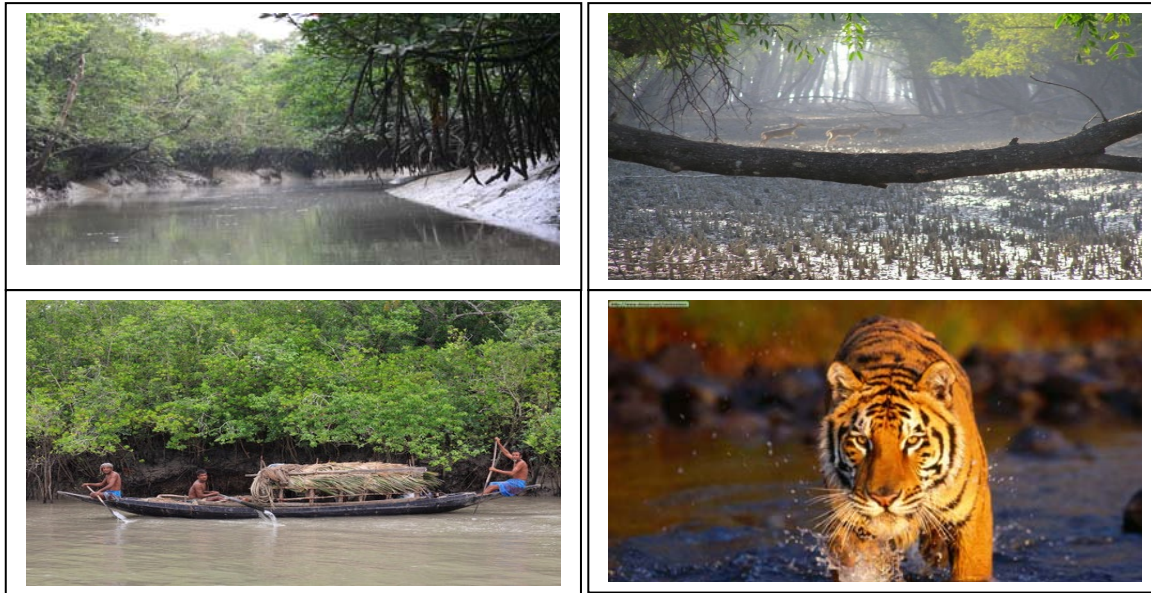


Figure 12. The biodiversity of Sundarbans

### **3.9 Management**

The Sundarbans is the only large mangrove forest in the world managed for commercial timber production and has had a long historical background since between 321-226 BC when the Muryan Empire created a Department of Forest Products headed by an official called a “*kupyadhyaksta*” (Barlaw, 2009). However, this forest has had a history of scientific management since 1879. At the same time, this mangrove was declared a reserve forest during the British Empire. An Integrated Sundarbans Management Plan is under preparation by the Sundarbans Biodiversity Conservation Project funded by the Asian Development Bank.

After liberation in 1971, Bangladesh is now managed by the Sundarbans West Forest Division and Sundarbans East Forest Division of the Forest Department, divided into 20 sections each harvested in turn on a 20-year cycle, with the three peripheral wildlife sanctuaries on the coast. A wildlife conservation plan prepared under the joint sponsorship of the World Wildlife Fund and the U.S. National Zoological Park emphasized management of the tiger and other wildlife as an integral part of sustainable forest and coastal management for both timber and the needs of the local population (Seidensticker & Hai, 1983). Now, it is completely controlled by the Forest Department

of Bangladesh and there are no options to enter in the forest to collect forest resources without permission from Forest Department. The responsible Department also issues hunting licenses under the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974. The Sundarbans is now effectively closed to legal hunting. Under the provision of this Act, activities prohibited within the wildlife sanctuaries, include residence, cultivation of land, damage to vegetation, hunting, introduction of domestic animals and setting of fires.

### **3.10 Present situation of tourism in Sundarbans:**

The total number of domestic and international visitors increased 100,000 in recent times (Forest Department, 2009). The international visitors make up around 2% of this total. Maximum international visitors come from India, USA, UK, Germany and France. The activities of tourists in Sundarbans mainly related to watching wildlife in forest, interaction with local people's and their activities as well as fishing, honey collection, timber production and enjoying various local cultural festivals. The visitors' flows have shown some variations over the last 5 years (Figure 13). The highest number of visitor receipts Sundarbans in 2008/2009 (Appendix-B).

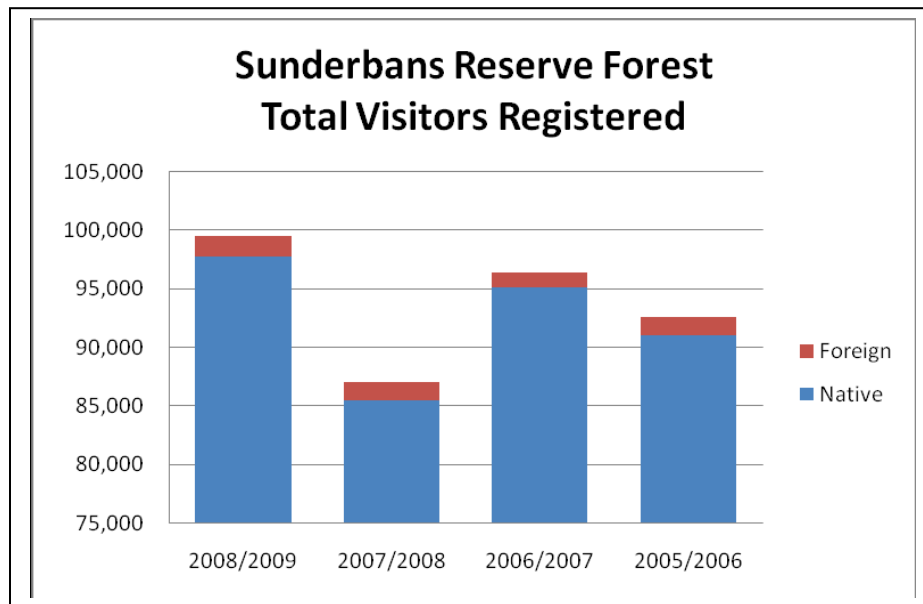


Figure 13. The number of visitors in Sundarbans, Bangladesh (USAID, 2009. p-6)

The global experience of tourism reflects that in recent years approximately 2% of the international tourism economy has decreased (UNWTO, 2009). However, it is

important to recognize that the tourism economy of Bangladesh has not contracted during that time (USAID, 2009). Moreover, the number of visitors in Sundarbans increased by 14% between 2007/8 and 2008/9 due to increasing domestic travelers. Therefore, it is important for Sundarbans to make a guideline for ecotourism planning and visitor management. This is an imperative issue to promote sustainable tourism development in this region.

### **3.11 Existing tourism facilities and lacking of facilities in Sundarbans:**

The most visited site in the Sundarbans is Karamjal, which is in the Eastern Sundarbans. Approximately 81% of total visitors to the reserve visit this one area (USAID, 2009). Katka, Nilkamal (Hiron point), Kochikhali, Mandabaria, and Dublarchar are also popular sites in Sundarbans for both local and international visitors (Figure 13).

In the Bangladesh part of Sundarbans, seasonality (Figure 14) and transportation problems are the main barriers for tourism development. The only way to enter this forest is through water transport. Visitors are not allowed to visit this national park without permission from the Forest Department. The peak season is in March, with 30% of the visitors coming in this one month. The high season is February-April, and the shoulder season is October-February. However, due to heavy rain and occasional cyclones constitute serious barriers to visiting Sundarbans in between July-September.

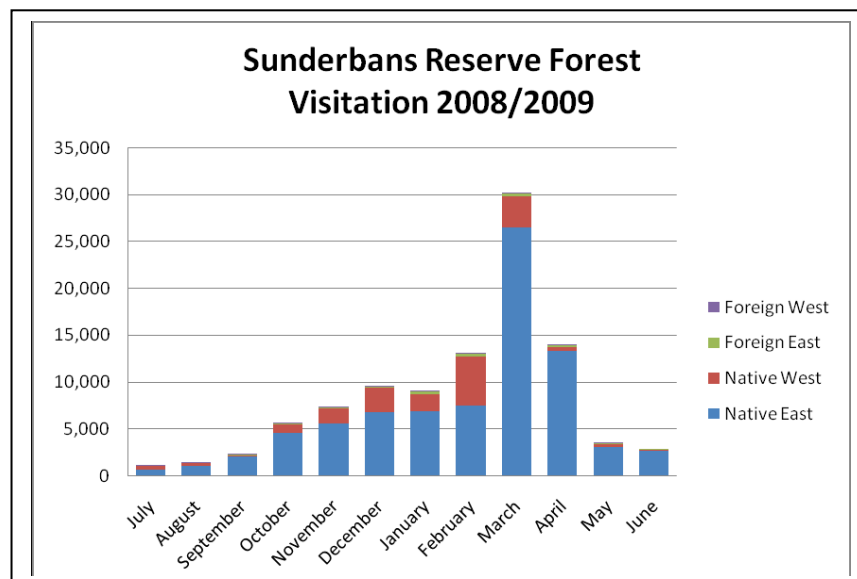


Figure 14. Visitor and seasonality in Sundarbans (USAID, 2009. p. 7)

Due to the difficulty and cost of arranging transport and to the lack of suitable accommodation, shortage of drinking water, lack of power and telecommunication facilities very few foreign tourists visit this forest every year (Appendix-B). Only a handful of tour operators work in this region and they have there won transport (Boat) and others tourism facilities like accommodations. Royal Tour and Bengal Tour are among them. Royal Tour has been operating here since 1992; they also operate the international Royal Hotel in Khulna city that serves as both a starting point for any tour and the base of operations (Salam et al, 2000). Moreover, in Sundarbans there is another large well-equipped rest house with observation towers belonging to the Forest Department at Katka in the East and Hiron Point in the South Sanctuaries. Tourism attractions of Sundarbans can be described as follows (Table 7):

Table 7. Tourism attractions of Sundarbans, Bangladesh (Rahman, 2000. Moss, 1993)

<b>Description</b>	<b>Comments</b>
Location	On the Bay of Bengal and largest mangrove formation in one of the world's largest river deltas
Tropical climate	Cool and dry during the tourist season
Waterways	Large and small waterways providing opportunities for cruising and jungle boating
Forests	Unspoiled mangroves; forest ecology
Wildlife	The largest single population of the Bengal tiger and exceptional populations of spotted deer and wild boar; adequate bird watching, migratory species and raptors in particular
Beaches	Unspoiled, wild, unpolluted and totally undeveloped beaches throughout along the Bay of Bengal and around some islands.
History/archaeology	Rare sites set in the forest
Sociology	Fishermen in particular, otter fishermen, also other traditional collectors of forest produce.
Cuisine	Many different species of edible fish, prawns and crabs
Culture	Annual festivals at Dubla and diverse culture.

Considering all the above information an ecotourism plan for Sundarbans has been prepared and GIS tools have been used as a decision support system in this research. The next chapter will discuss the method which is used in this research for ecotourism planning.

## CHAPTER 4

### 4. RESEARCH METHODS

The main theme of this chapter is to identify land use change over the last 33 years using satellite data and use these data for ecotourism planning in Sundarbans Bangladesh. The research is designed to investigate causes and the extent of ecological and physical changes pertaining to changes of land use patterns due to human activities, tourism development, and natural hazards over time. This chapter also describes different methods used for data collection, satellite image processing methods, accuracy assessments and ecotourism planning.

#### 4.1 Data collection

Raw satellite images of Sundarbans have been downloaded from the United States Geological Survey (USGS) website (<http://glovis.usgs.gov/>). Landsat TM, ETM and Multispectral Scanner (MSS) satellite images from 1977 to 2010 have been used for land use classification and change detection. Local Government Engineering and Development (LGED) vector maps have been used as a reference map for digital image classification. Ground observation information has been used to classify the image. Moreover, images have been calibrated using sun elevation and sun azimuth. Census data and other secondary data of ecotourism in Sundarbans have been collected from available literature in the form of books, journal and magazine articles, and annual reports.

#### 4.2 Digital Image classification

To identify changes in vegetation, first Normalized Differential Vegetation Index (NDVI) (Rouse *et al.*, 1973) images have been generated using images from different years. Subsequently, the maximum likelihood technique (Foody *et al.*, 1992) has been used to classify the image. Finally, both interclass and within same class change have been detected through area calculation. The whole classification and change detection process can be separated into the following major steps:

- Preprocessing
  - Image Enhancement

- Image Classification and Analysis

#### **4.2.1 Preprocessing of raw satellite images**

Before final analysis of satellite data, preprocessing is done to reduce any unwanted noises and geometric errors so that, we can have the desired outputs from the image. These enhance the quality of the image data by reducing or eliminating various radiometric and geometric errors caused by internal and external conditions (Bruce et al, 2006). Radiometric corrections include both errors system detector and environmental attenuation error. Geometric corrections include correcting for geometric distortions due to sensor Earth geometry variations and conversion of the data to real world coordinates (e.g. latitude and longitude) on the Earth's surface.

#### **4.2.2 Image Enhancement**

Remotely sensed data is influenced by the number of atmospheric factors including atmospheric particles. The processes that are caused due to the atmosphere include absorptions, scattering, emissions, etc. Enhancement operations have been performed on each image to improve the interpretability of the image by increasing apparent contrast among various features in the scene. These operations improve the appearance of the image to assist in visual interpretation and analysis which is also important for signature making process when finally the image should be classified. Contrast stretching and spatial filtering are some good examples of image enhancement where contrast stretching increases the tonal distinction among various features in a scene and spatial filtering enhances specific spatial patterns in an image.

#### **4.2.3 Image Classification and Analysis**

Digital image classification methods can be divided into two major categories including supervised classification and unsupervised classification. In a supervised classification, it is important to identify in the imagery homogeneous representative samples of the different surface cover types of interest. This is called signature. Thus, the researcher is supervising the categorization of a set of specific classes. It means, supervised classifiers require the user to decide which classes exist in the image, and then to delineate samples of these classes. These samples (known as training areas) are then

inputted into a classification program, and this program produces a classified image. Unsupervised classification does not require training areas, but merely the number of classes the researcher wishes to end up with. In this study I have used supervised classification. The current study discusses the two major image classification methods which have been used. The NDVI and Maximum likelihood classification are used for identifying land use change over the period spanning from 1979 to 2010. The image classification steps are followed according to the flowchart (Figure 15).

**4.2.3.1 The Normalized Differential Vegetation Index (NDVI):** The NDVI has been used for many years to measure and monitor plant growth (vigor), vegetation cover, and biomass production from multispectral satellite data (USGS, 2010). The mechanism of this technique depends on the reflection of both wavelengths, visible and near-infrared from the plants leaves.

The color of plant leaf and its chlorophyll strongly absorbs visible wavelength (light) respectively from 0.4  $\mu\text{m}$  to 0.7  $\mu\text{m}$  (more specifically, red band) for use in photosynthesis. The structure of leaves also highly reflect near-infrared wavelength from 0.7  $\mu\text{m}$  to 1.1  $\mu\text{m}$  respectively. How much wavelength should be affected depends on the number of leaves the plants have. Researchers can measure the intensity of light coming off the Earth in visible and near-infrared wavelengths and quantify the photosynthetic capacity of the vegetation in a given pixel of land surface.

If visible wavelength is poorly reflected then near-infrared wavelengths mean the vegetation in that pixel is likely to be dense and may contain some type of forest. However, if the variations of intensity of both wavelengths reflected are not sufficient then the vegetation is probably sparse and may consist of grassland, tundra, or desert.

Maximum satellite vegetation indices employ this difference formula to measure the density of plant growth on the Earth, near-infrared radiation minus visible radiation divided by near-infrared radiation plus visible radiation (red band). The result of this formula is called the NDVI. Written mathematically, the formula is:

$$\text{NDVI} = (\text{NIR} - \text{VIS}) / (\text{NIR} + \text{VIS})$$

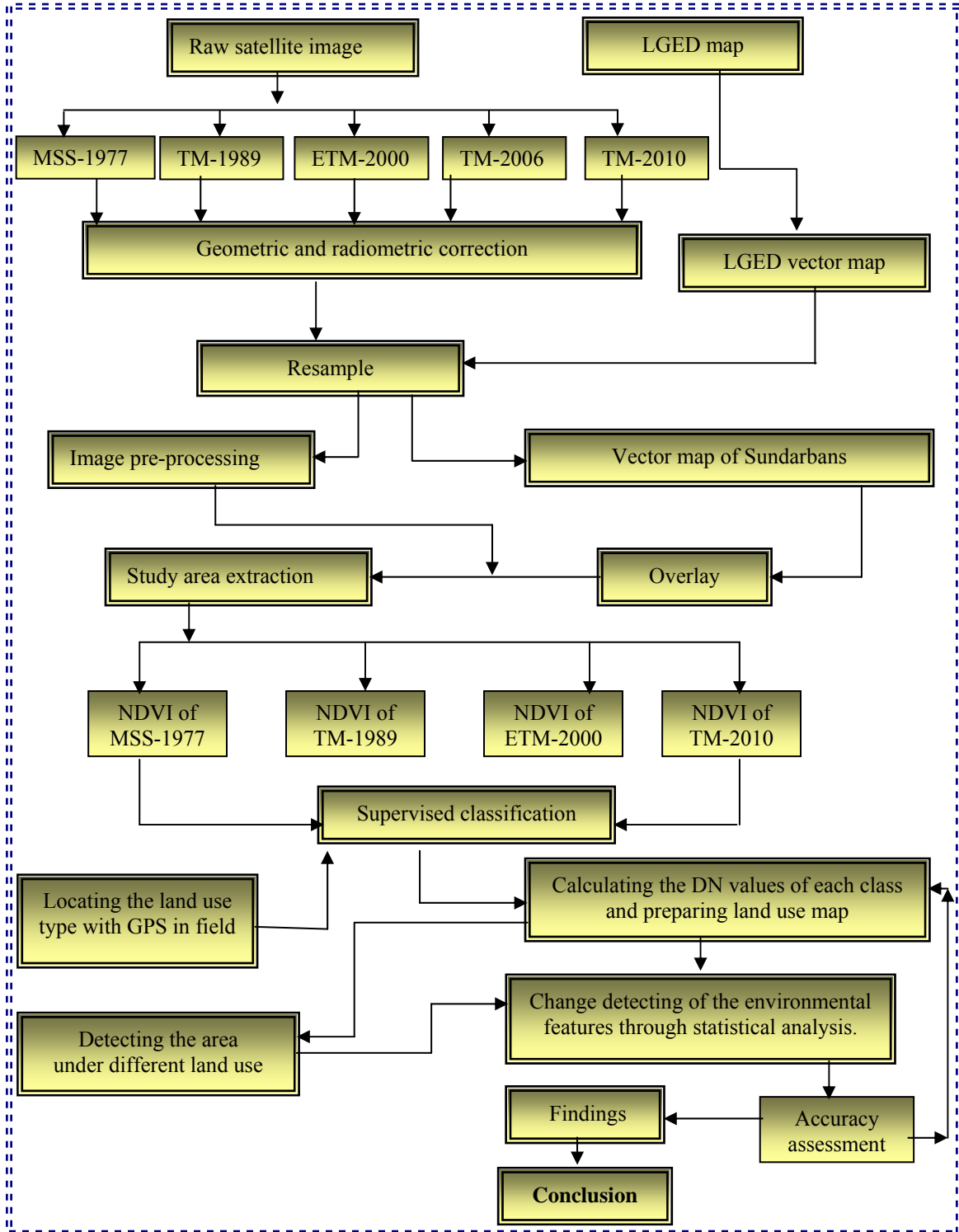


Figure 15. Schematic diagram of the image classification

Calculations of NDVI for a given pixel always result in a number that ranges from minus one (-1) to plus one (+1); however, no green leaves gives a value close to zero (Figure 16). A zero means no vegetation and close to +1 (0.8 - 0.9) indicates the highest possible density of green leaves (NASA, 2010).

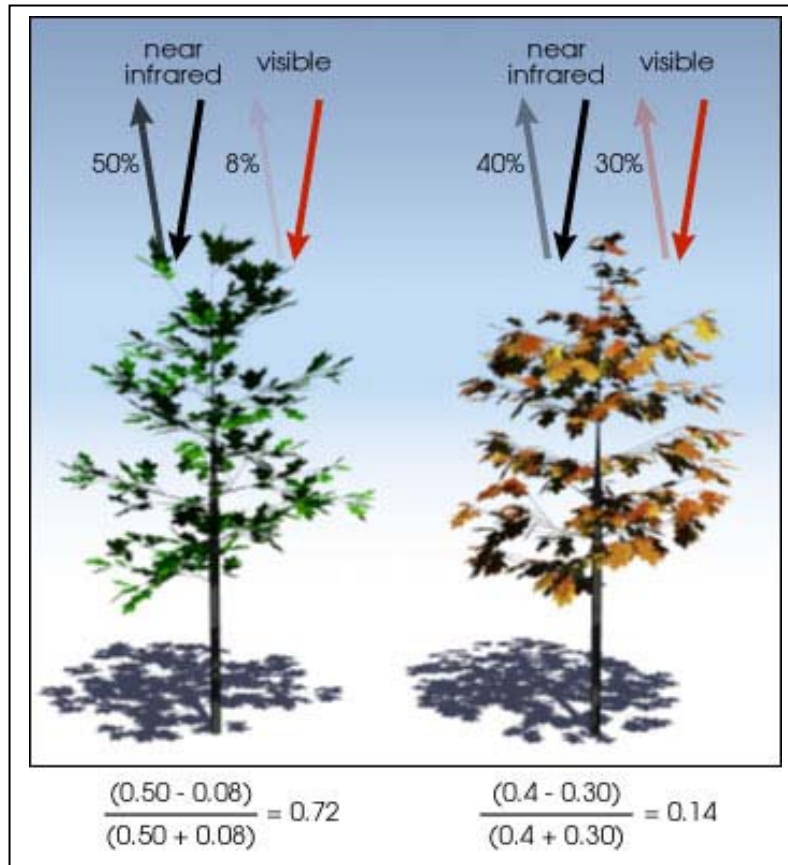


Figure 16. NDVI is calculated from the visible and near-infrared light reflected by vegetation

**4.2.3.2 Maximum likelihood classification:** The maximum likelihood classification is the most common and powerful classifier in the supervised classification method which is used for remote sensing image data. This classifier is based on Bayesian probability theory. The procedure of this technique is related to statistical analysis (mean; variance/covariance), where (Bayesian) probabilities function is calculated from the inputs for classes established from training sites. Each pixel is then judged as to the class to which it most probably belongs. In this study, I have used maximum likelihood

classification technique because this method provides much better result than others common supervised classification methods (PIPED and MINDIST).

The key theme in this mechanism depends on a set of signature files and the probability density function work associated with a particular training area. In this process of classification pixels are represented by the most likely classes based on the comparison of the priority and probability that it belongs to each of the signatures and this signature being considered as a data file. It can be precise as a single value and this value can count homogenous to all pixels within an image.

### **4.3 Accuracy assessment**

The accuracy assessment in digital image classification is the way to support classifications validity. Before using the classification result from satellite images current research needs to support the forest classification process. Accuracy assessment can be considered a matrix or table that displays statistics for assessing image classification accuracy by showing the degree of misclassification among classes. The error matrix is also known as a confusion matrix, a contingency table or a classified error matrix. The mechanism of error matrix permits the calculation of a range of measures that describes the accuracy of the classified map with respect to the reference map. In this process error matrix measured accuracy compares two thematic maps. These two thematic maps are often known respectively as a ground truth map (the reference map) and an automated image classification (the classified map) map. To generate the error matrix, thematic information is recorded from sample pixels that display the same ground area on the two maps. Calibration data are recorded from the reference map and validation data from the classified map.

This thesis adapted confusion matrix and Kappa statistic accuracy methods. Accuracy assessment was done using independent sample points (Appendix D). The ground truth sample points were collected by field investigations in January 2010 (one of my friend collect it on be half of me). Accuracy assessments have been performed by comparing two sources of information respectively, that is digital image classification data and ground truth reference data. The estimate of a measure of overall agreement between image data and the reference (ground truth) data is called Kappa or  $k^{\wedge}$  (The error

matrix tables have been included within the Appendix part in this report). To measure the kappa coefficient the following formula is applicable as below.

$$\hat{k} = \frac{N \sum_{i=1}^r X_{ii} - \sum_{i=1}^r X_{i+} X_{+i}}{N^2 - \sum_{i=1}^r X_{i+} X_{+i}} = \frac{\theta_1 - \theta_2}{1 - \theta_2}$$

where  $\theta_1 = \sum_{i=1}^r \frac{X_{ii}}{N}$  and  $\theta_2 = \sum_{i=1}^r \frac{X_{i+} X_{+i}}{N^2}$

Where,  $i+$   $X$  is the sum of the its row,  $i X +$  is the sum of the its column, and  $ii X$  is the count of observations at row  $i$  and column  $i$ . However  $r$  is the number of rows and columns in the error matrix, while the total number of observations is  $N$ . If the raters are in complete agreement then  $\kappa = 1$  but, if there is no agreement among the raters (other than what would be expected by chance) then  $\kappa \leq 0$

#### **4.4 Ecotourism planning**

‘Ecotourism planning requires exploring diverse types of natural and cultural attractions along with demographic characteristics, to provide the base for designing the travel industry different from the mass tourism standard’ (Banerjee et al, 2002, p. 2). To plan ecotourism in Sundarbans a GIS and Remote Sensing approach has been used. By using this technique Banerjee et al. (2002) have done their research for ecotourism planning and investigated a case study in western Midnapore, West Bengal, India.

In this study, I have followed their method partially. The current case study is based on Sundarbans and this mangrove is a forest reservation meaning that it is largely a protected area with a limited scope of developing infrastructure or any other tourism based facilities as well as roads network, hotels and recreation center. Moreover, in the Bangladesh part of Sundarbans water transport is the only way to enter this forest. This study considered the vegetation density map, land use/land cover map and accessibility map of Sundarbans for planning ecotourism in this region. Major river channels were considered main accessible point in this study. Existing tourism facilities were also considered as part of this planning process. The methodology is given in the figure 17.

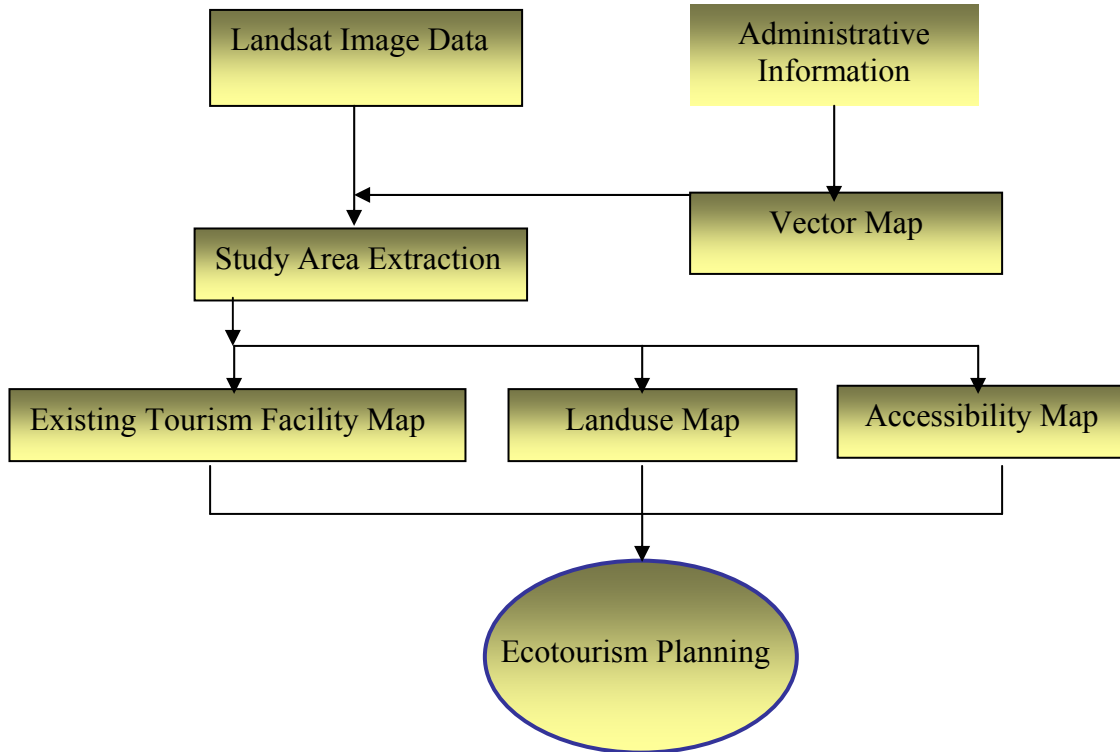


Figure 17. Methodology of Ecotourism planning in Sundarbans

In the planning process digital Image classification maps, administrative information (included international boundary, range office, existing rest house and its facilities) existing tourism facilities maps and major water bodies (river channel) are overlay into the same map for preparing a ecotourism map and takes decision for sustainable planning in Sundarbans, Bangladesh.

The next chapter will discuss satellite data analysis result, based on land cover change in Sundarbans and various planning issues related to ecotourism planning in this region.

## **CHAPTER 5**

### **5. DATA ANALYSIS AND ECOTOURISM PLANNING**

This chapter describes the results obtained through data processing following the methods of this research. Moreover, the chapter illustrates various ecotourism planning issues, causes of land use change, and proposes an ecotourism plan for Sundarbans.

#### **5.1 Land use changes in Sundarbans**

Landsat TM, Landsat ETM and Landsat MSS data have been classified for the study area and analyzed to evaluate forest cover changes between the years 1977 and 2010. Two different methods were used in this research to quantify mangrove forest change in the Sundarbans. The maximum likelihood classifier has been used to identify forest cover change and NDVI used for forest density measurements. Both techniques revealed different information about the spatial distribution of forest cover change in the Sundarbans. The first section describes the results of maximum likelihood classification change detection then NDVI differencing results will sketch for forest density change.

##### **5.1.1 Maximum likelihood classification result**

The change summaries describe the variation in areas occupied by each class between sensing periods and class-by-class reports illustrate changes by area. The classification result has been divided into three parts. The first part represents a digital image classification map. Then, the second part shows classification results graphically and finally the last part leads to comparisons and a discussion.

The results of maximum likelihoods classification are as follows (Figure 18-23).

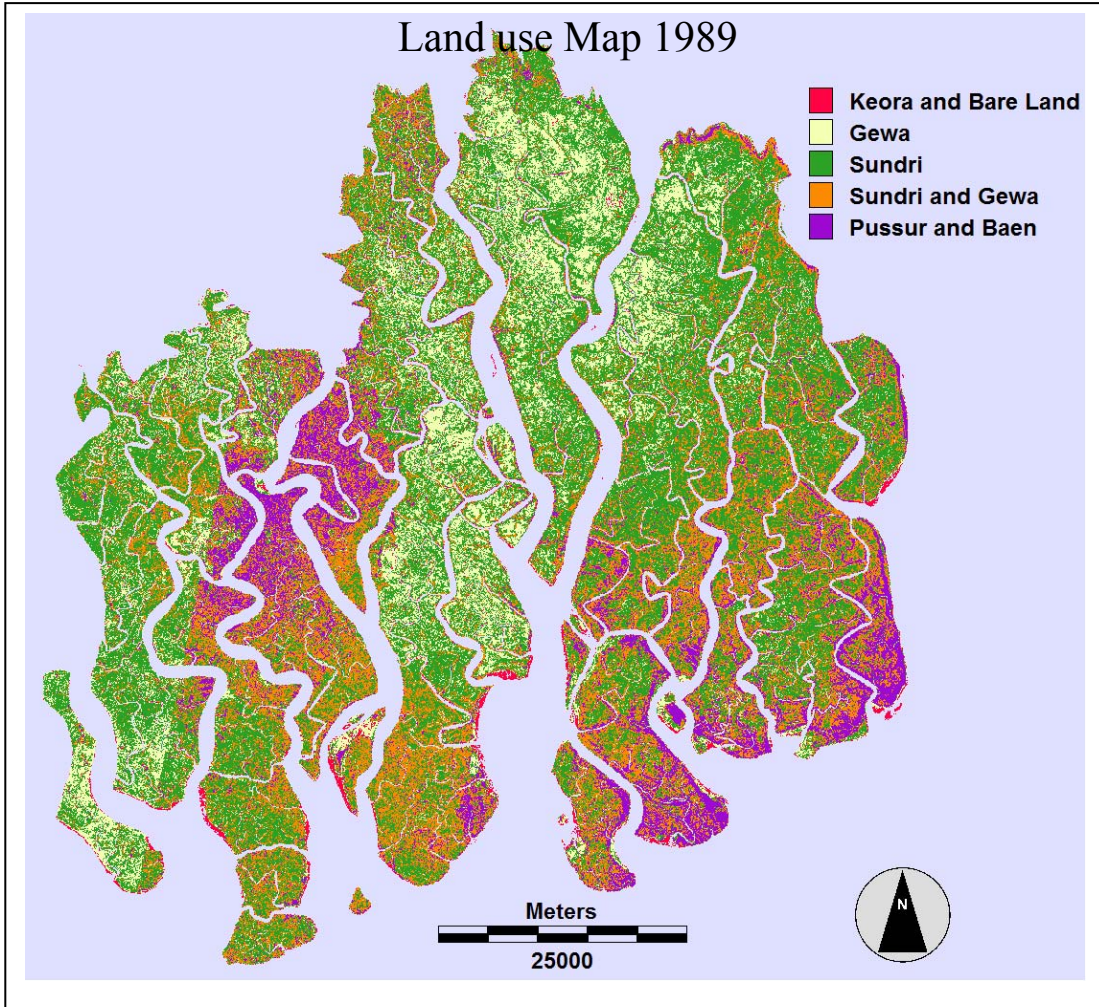


Figure 18. Land use map of Sundarbans, 1989

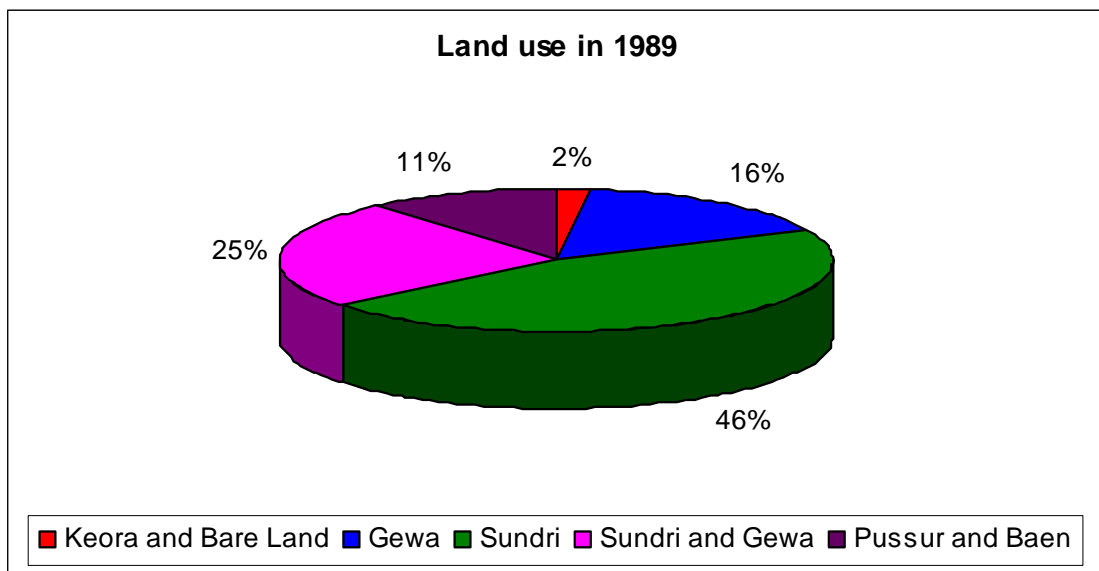


Figure 19. Land use of Sundarbans in 1989

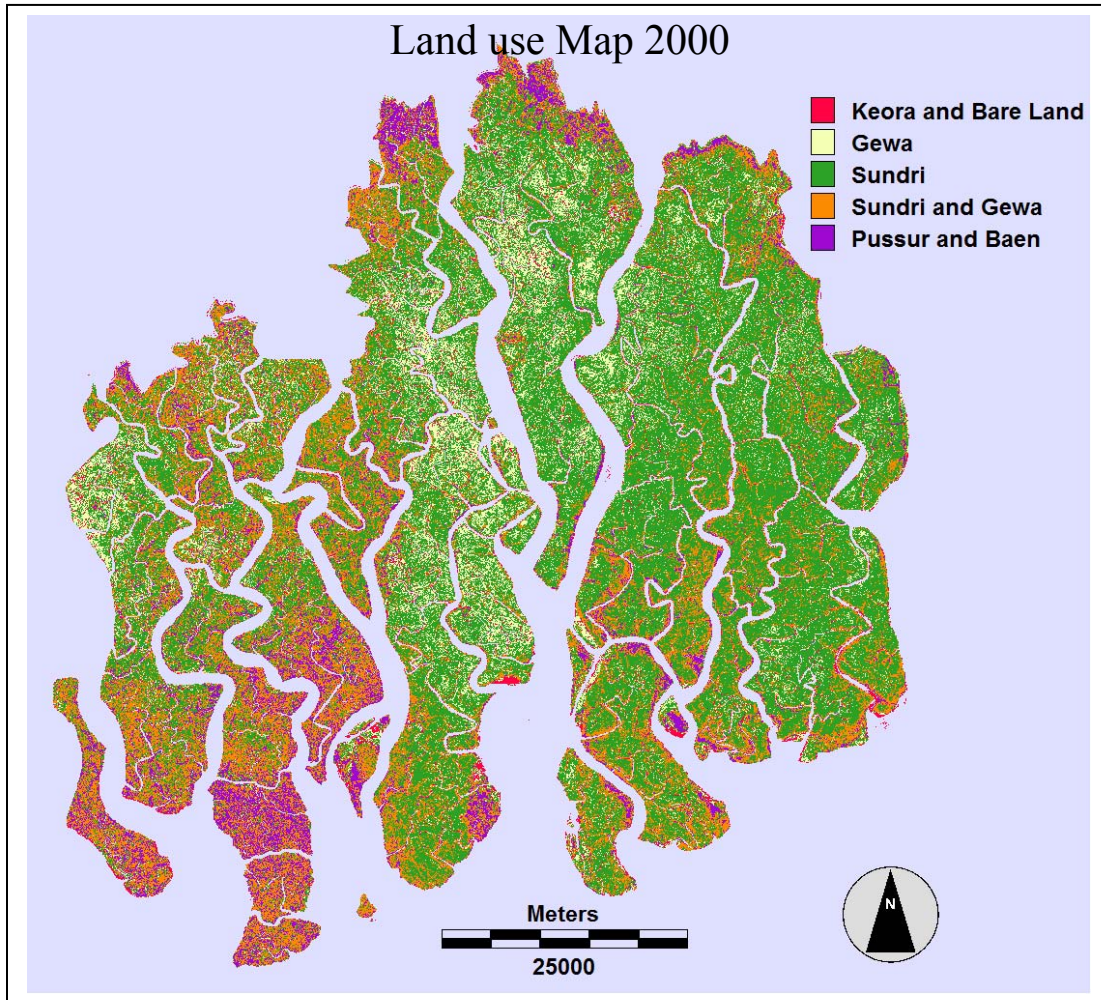


Figure 20. Land use map of Sundarbans, 2000

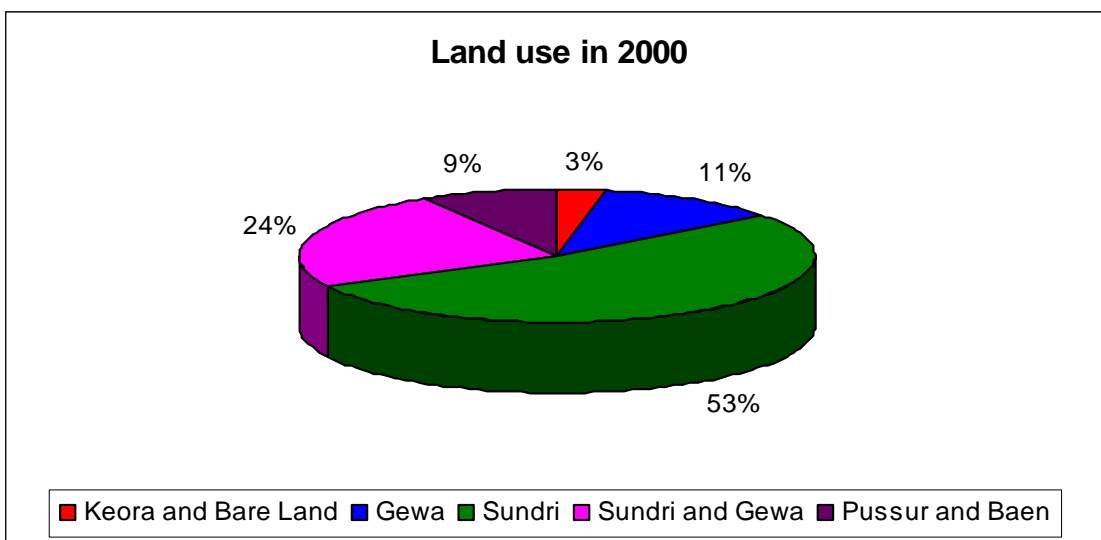


Figure 21. Land use of Sundarbans in 2000

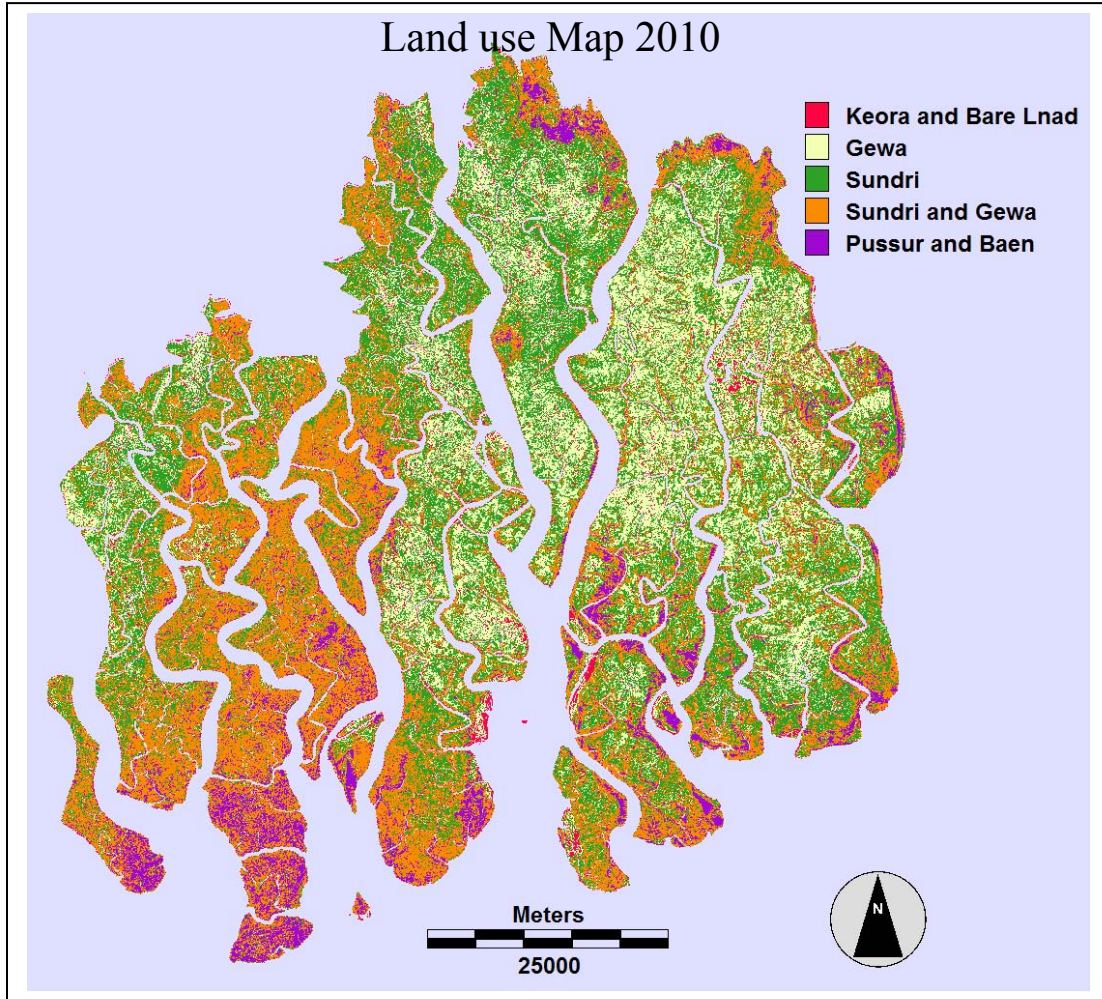


Figure 22. Land use map of Sundarbans, 2010

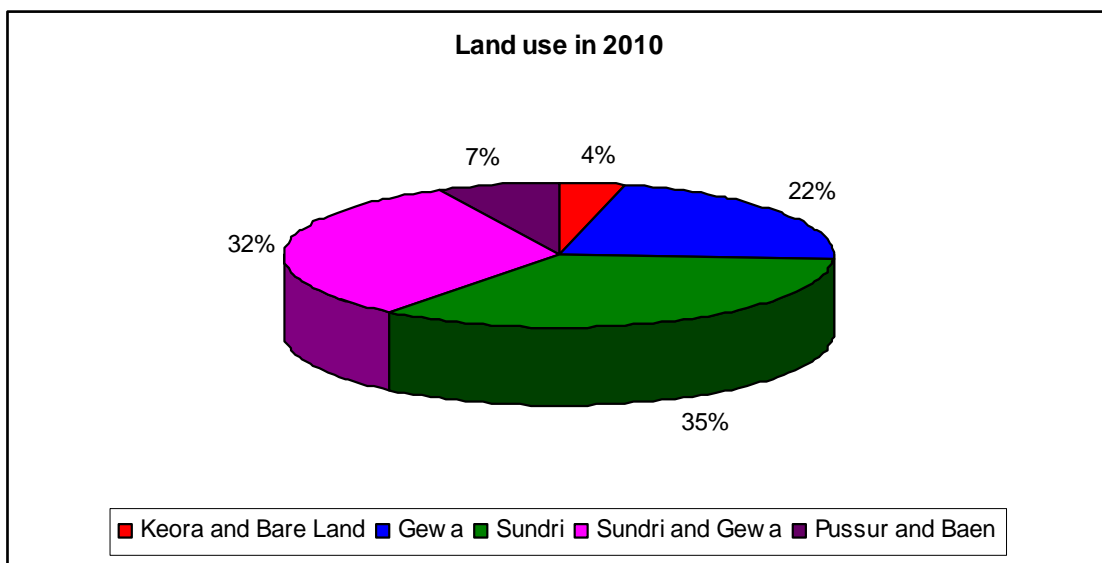


Figure 23. Land use of Sundarbans in 2010

### 5.1.2 Maximum likelihood classification result comparisons

The comparison of the land use in 1989 with that for 2010 shows the change that has taken place during the past 20 years. Bare land has been increased by 2% during this period. However, the major trees of this forest are Sundri which its numbers have seen decrease dramatically. Although, a major portion of Sundarbans is covered by Sundri, these trees have decreased from 45.66% to 34.82% during the 20 year period (Figure 18-23). Only Gewa trees have increased slightly (5%). Table 8 and Figure 24 shows the detail comparison of forest change for each class and area measured based on classified imagery of Landsat TM, ETM and MSS.

Table 8. Statistics of changes in areas (hectares) of forest cover classes between the years 1989-2010.

Land use Classes	1989		2000		2010	
	Areas (ha)	%	Areas (ha)	%	Areas (ha)	%
Keora and Bare Land	8204.212	1.96	14683.14	3.55	16472.43	4.01
Gewa	67728.25	16.23	46756.35	11.33	89243.55	21.75
Sundri	190599.8	45.66	218411.6	52.91	142942.3	34.82
Sundri and Gewa	103082.2	24.70	97624.62	23.66	132424	32.27
Pussur and Baen	47846.56	11.45	35267.490	8.55	29319.3	7.15

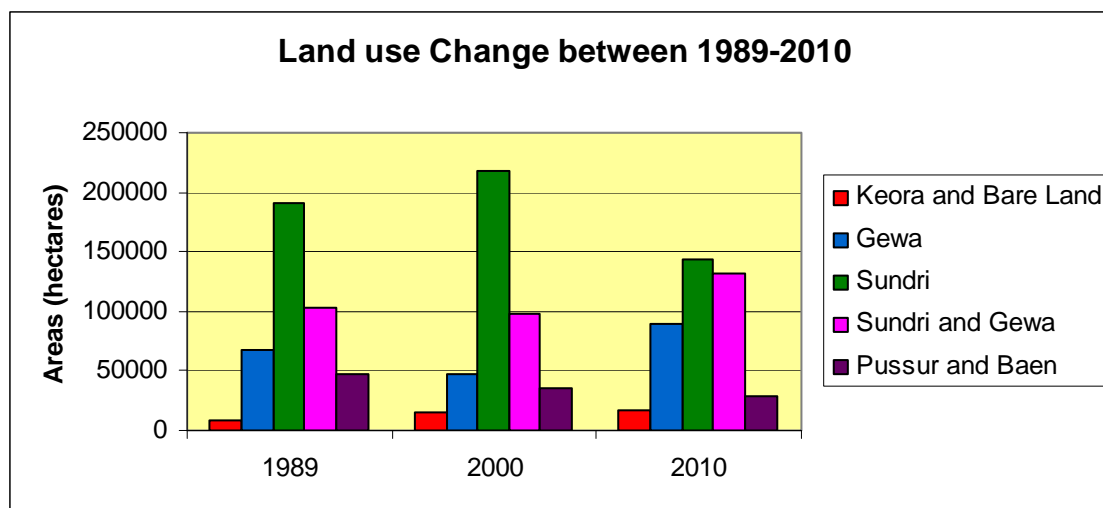


Figure 24. Land use changes of Sundarbans ‘between’ 1989-2010

### **5.1.3 Normalized Differential Vegetation Index (NDVI)**

This section describes the results of the NDVI differencing. The result of NDVI represents vegetation density and this data can be used to identify and declare potential sites for ecotourism (Bannerjee et al, 2002). Vegetation change is defined as an alteration in the surface components of the vegetation cover or as a spectral/spatial movement of a vegetation entity over time. NDVI differencing is interrelated with various vegetation parameters as well as green leaf and biomass. NDVI values range between minus one (-1) to plus one (+1) where no green leaves gives a value close to zero and close to +1 indicates the highest possible density of green leaves. However, researchers can expand this value scale (if required) to more visualized in a map. In this study, NDVI value scale has been expanded between 0-1.13. Landsat TM, ETM & MSS data have been classified for NDVI differencing between the year of 1977 and 2010 (Figure 25).

### **5.1.4 Normalized Differential Vegetation Index (NDVI) comparisons**

The NDVI difference map reveals that, the density of the forest has decreased over the study period 'between' 1977-2010 (Figure 25). In 1977 the NDVI map represents the highest value of density which is 1.13 it means very dense forest but by 2010 it was only 0.90 because of deforestation over the time. Most of the deforestation occurred in the southeastern corner and western edge of the study area. However, NDVI values increased in the north-central part and southwestern part of the study areas. Density of forest decreased along the cost regular basis, because of tidal waves, floods, cyclones and human and tourism activities. The accessibility of this forest in only water channels, therefore, human disturbance influenced the change besides rivers and canals channels. Vegetation density decreased consequently over the study period.

In 1989, the south central and south eastern parts of the NDVI map looks dark due to cloud cover. The comparative result from NDVI 'between' 1977-2010 has been illustrated in figure 25.

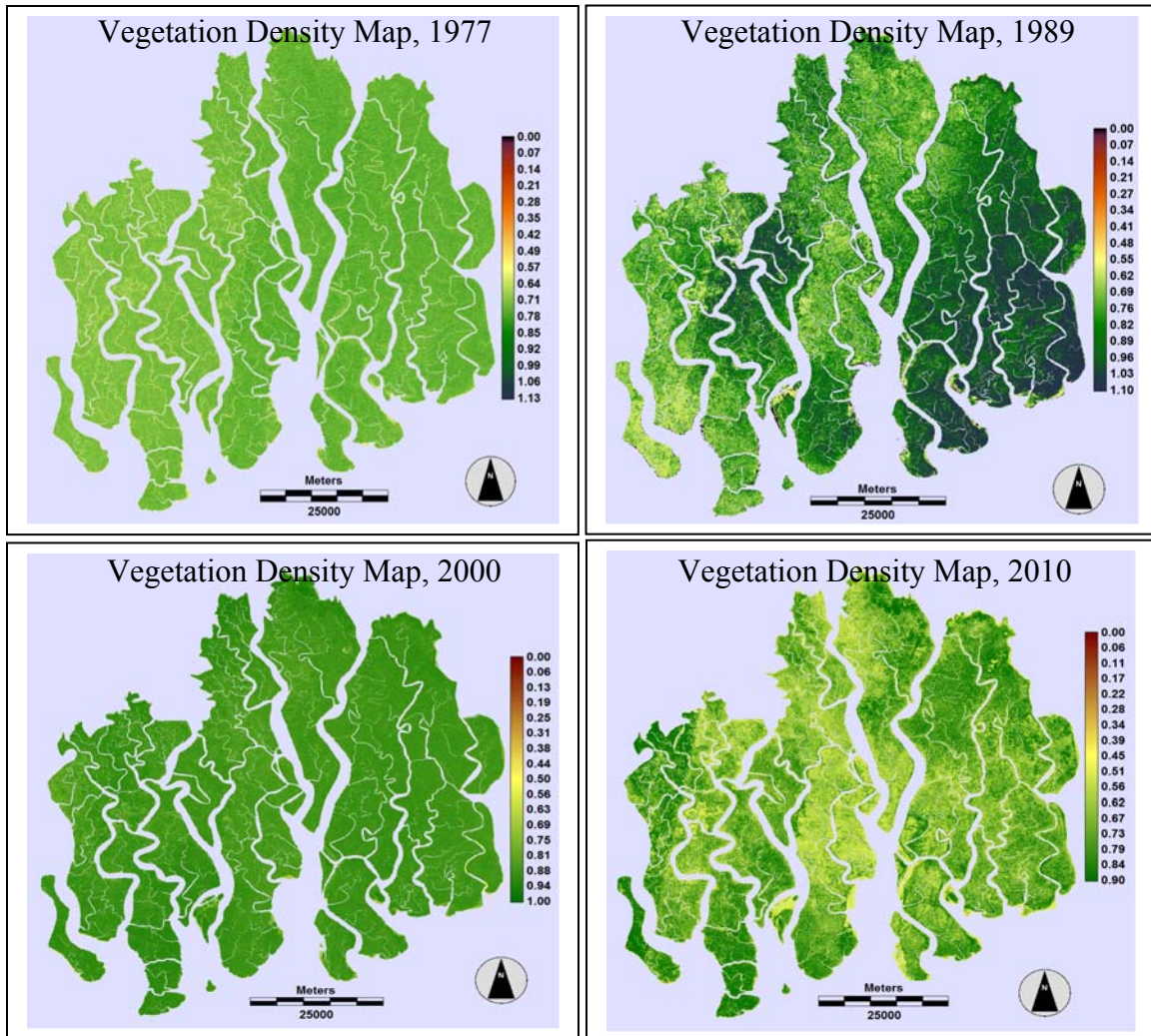


Figure 25. Vegetation density map of Sundarbans between 1977-2010

## 5.2 Causes of land use change in Sundarbans

Sundarbans land use has been changing for a long period due to various human activities, tourism and climate change effects. More than 2 million people live within the proximity of the boundary and this number is doubling every 34 years (FAO, 1998). The local people are completely dependent on this forest and the activities of local people are mainly fishing, honey collection, wood cutting and processing for timber production. However, some people are involved in cultivation or shrimp farming in this region. The climate change effects have heavily influenced this mangrove specially cyclones. The recent cyclone Sidir during 2007 destroyed almost 2.5% of forest completely and 22.2% forest was affected more or less on that occasion (Appendix-C). Flooding is another common climate change issue which causes erosion along the banks of the courses of the

river almost every year. However, the main trees of this mangrove are the Sundri and recently, a huge amount of these trees has been removed due to the die back disease in some regions of the study area. The major causes of land use change appear in Figure 29:

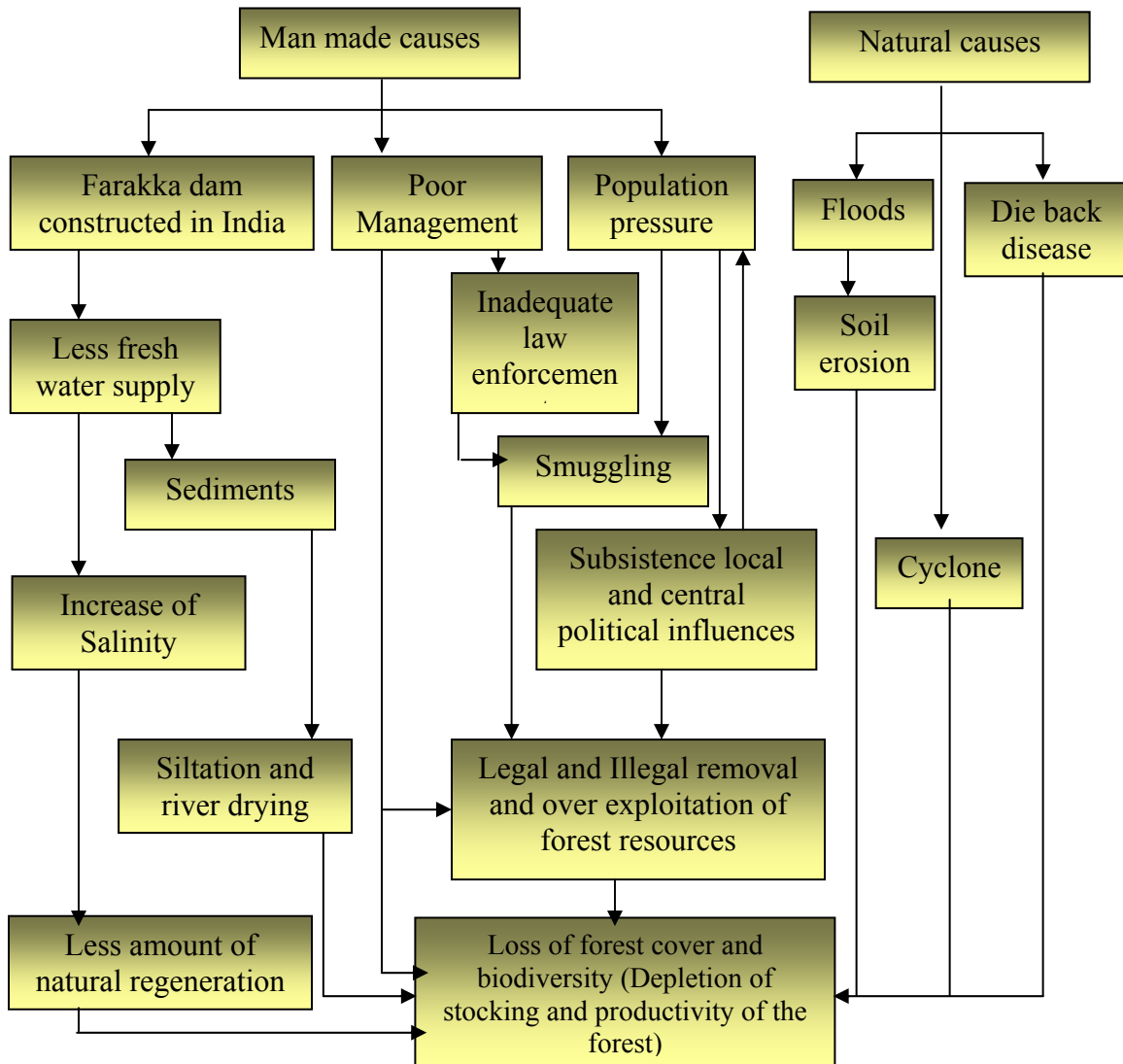


Figure 26. Causes of changes of Sundarbans mangrove forest (Akhter, 2006, p. 91)

Poor management is the cause for legal and illegal removal and over exploitation of forest resources in the Bangladesh part of Sundarbans. Another important issue for forest reduction is decreasing freshwater flows from the upstream catchments, especially from the Ganges-Gorai drainage due to the construction of the farakka dam in India (Akhter, 2006).

### **5.3 Ecotourism and land use change in Sundarbans**

In Bangladesh, the tourism industry is growing rapidly especially in two destinations which are internationally recognized (Appendix H). These are the Sundarbans mangrove forest and Cox's Bazar sea beach. The tourism industry is frequently referenced in Bangladesh as a highly important stakeholder/user group with the potential to provide extensive benefits to the Sundarbans Reserve Forest (USAID, 2009, p. 6). However, recently, even though Sundarbans received 100,000 visitors only 2% of these were foreign while the rest were domestic visitors (Forest Department, 2009). The domestic visitors increased consequently (Appendix B) and the impact of tourism increased rapidly due to environmental damages. Nevertheless, tourism is not as problematic compared to other factors of land use change in the study area. However, the rapid increase of visitors in Sundarbans can be considered a warning signal for tourism development in this region. Indeed, ecotourism planning is must needed for sustainable tourism development in this reserve mangrove forest.

### **5.4 Ecotourism planning**

Ecotourism has increased very quickly in recent years especially in developing countries. However, in western society, travel to experience wild nature is not a new phenomenon. Historically, it started in 1872 in the United States with Yellowstone Park, in 1879 in Australia with Royal Park and in 1885 in Canada with Banff Park and Niagara Falls, when governments set aside natural areas for protection and recreation in the form of national parks (Eagles, 1997).

Due to the rapid growth of ecotourism the industry has begun with a challenge for decision maker, how they manage tourism negative impact, therefore, planning is a must for future development in a sustainable way to protect the natural environment of ecotourism destinations. In recent years, policy makers have begun to advocate sustainable destination planning for tourism with a set of management approaches that can help ensure that tourism is not environmentally damaging, contributes to conservation and local community development, and provides opportunities for enhanced conservation and sustainable development.

#### **5.4.1 Various issues of ecotourism planning**

Ecotourism destinations are always environmentally sensitive because ecotourism activities directly involve various environmental phenomena including bird watching, trekking, mountaineering, horse riding and elephant riding within the forest wilderness trail, staying in natural caves, studying about flora and fauna, simple bush walking, fishing, animal behavior study, ecological studies. The United Nations World Tourism Organization (UNWTO) published an important guideline in 2004 to *Indicators of Sustainable Development for Tourism Destinations*. This guideline is the result of efforts from over 60 authors working in 20 countries, covering a wide variety of case circumstances for tourism development in both developed and developing countries. Its intent is to provide a process by which policy makers can use research based indicators to make decisions on guiding the development of sustainable tourism. According to UNWTO, sustainability issues and indicators in tourism destination development are the following:

- Wellbeing of Host Communities
- Community Participation in Tourism
- Tourist Satisfaction
- Health and Safety
- Capturing Economic Benefits from Tourism
- Sustaining Cultural and Natural Heritage
- Managing Scarce Natural Resources
- Limiting Impacts of Tourism Activity and Controlling
- Use Intensity
- Products Development and Marketing
- Sustainability of Tourism Operations and Services
- Baseline Issues and Baseline Indicators of Sustainable Tourism

The above mentioned tourism planning issues are overall applicable for any kinds of sustainable destinations management and planning. However, Eagles (1997) mentioned

some key points for planning and management of ecotourism destinations based on his study. These are the following:

- Tourist travel motives and marketing
- Management of environmental quality
- Limits of acceptable change
- Management of tourist use
- Allocation of access
- Market specialisation
- Management of recreation conflict
- Enforcement and monitoring
- Consumer assurance of quality
- Facility design
- Community development
- Financial Viability
- Public and Private Sector Co-operation

The current study considered some key issues for planning Sundarbans for ecotourism development according to UNWTO destinations guideline.

#### **5.4.2 Ecotourism planning in Sundarbans**

Tourism has been considered recently as an important component of the management and development of the Sundarbans. In recent years, Sundarbans received a lot of international and domestic visitors especially after 2007 when cyclone Sidr destroyed a large portion of this forest and international media concentrated on this story. Indeed, the impact of tourism increased rapidly due to environmental damage but there is no consistent analysis of tourism impacts on the ecosystem or neighboring communities. Moreover, in the Bangladesh part of Sundarbans there is no existing tourism plan in effect to help measure how tourism management is functioning at present, nor is there any management authority within the reserve that has tourism management as part of its mandate. Therefore, ecotourism planning is necessary for sustainable tourism development and forest management in this region.

The current study has considered various planning issues related to Sundarbans and a set of GIS databases has been prepared for ecotourism planning. The ultimate goal of the GIS database was fixed to produce an ecotourism map for Sundarbans. The GIS database which was prepared is based on some specific information as well as administrative information, present land use, accessibility, and existing tourism facilities in Sundarbans. In the process of mapping, initially land use change has been identified from Landsat satellite TM, ETM and MSS data over last 33 years (1977-2010) then present land use specified from Landsat TM 2010. In the second stage, a vector map prepared based on LGED map included accessibility map, existing tourism facilities map and administrative information map. Finally, all individual maps were overlapped to produce an ecotourism map of Sundarbans (Figure 34). All vector maps are as follows (Figure 30-34):

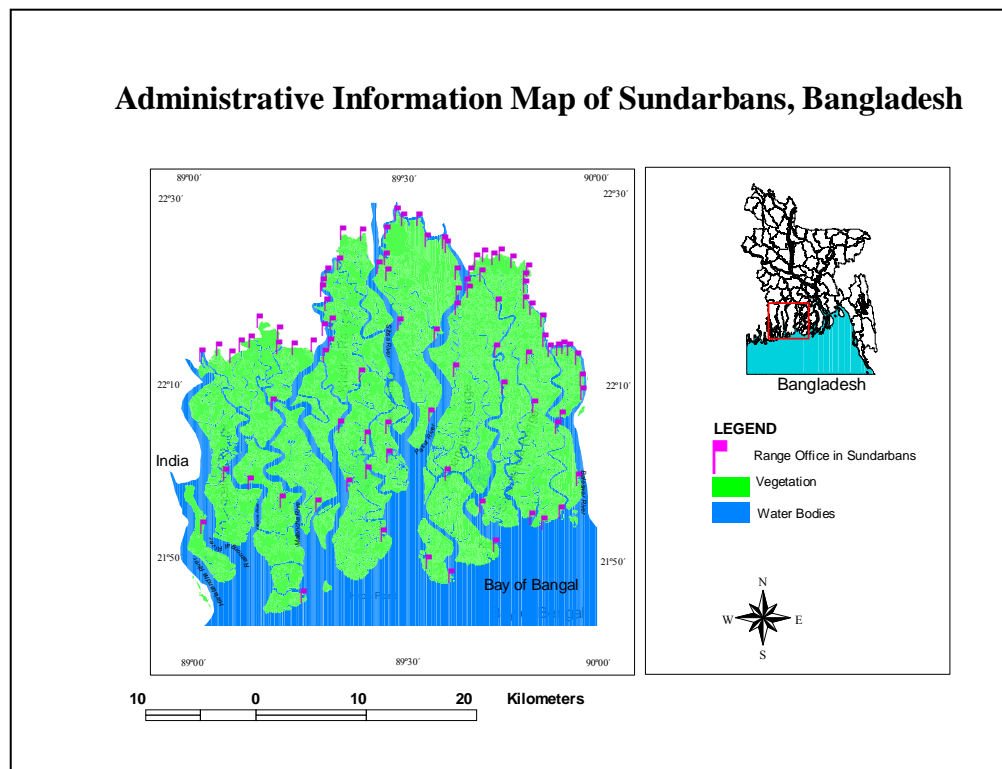


Figure 27. Administrative information map of Sundarbans

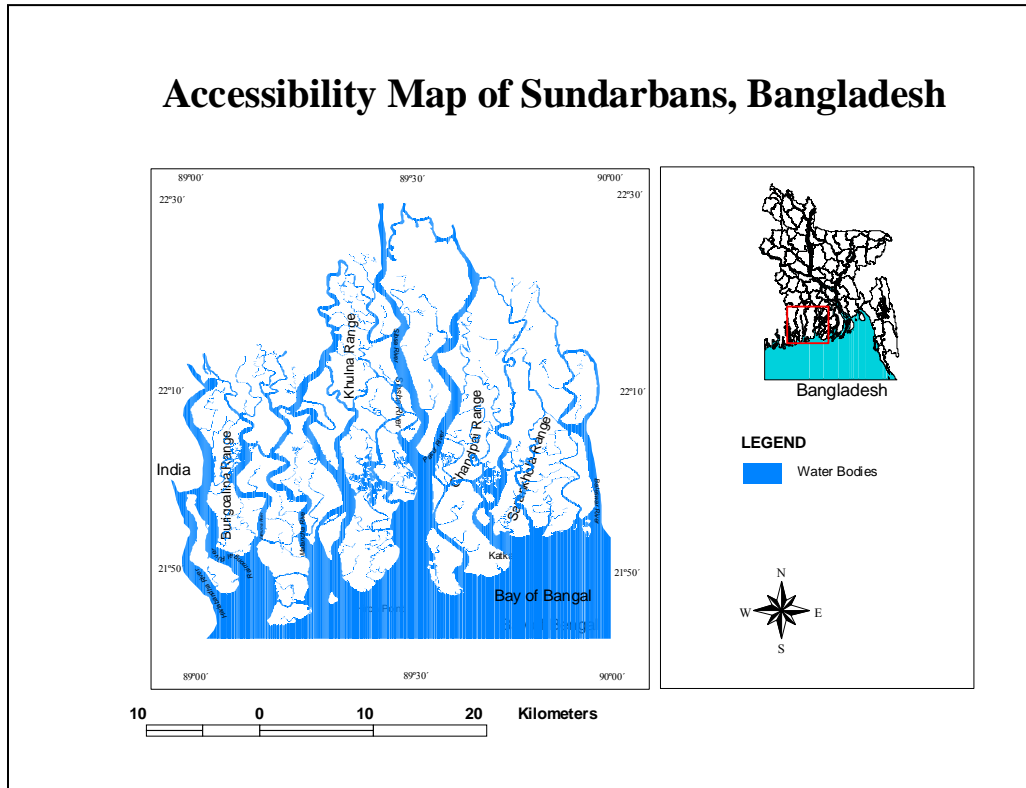


Figure 28. Accessibility map of Sundarbans

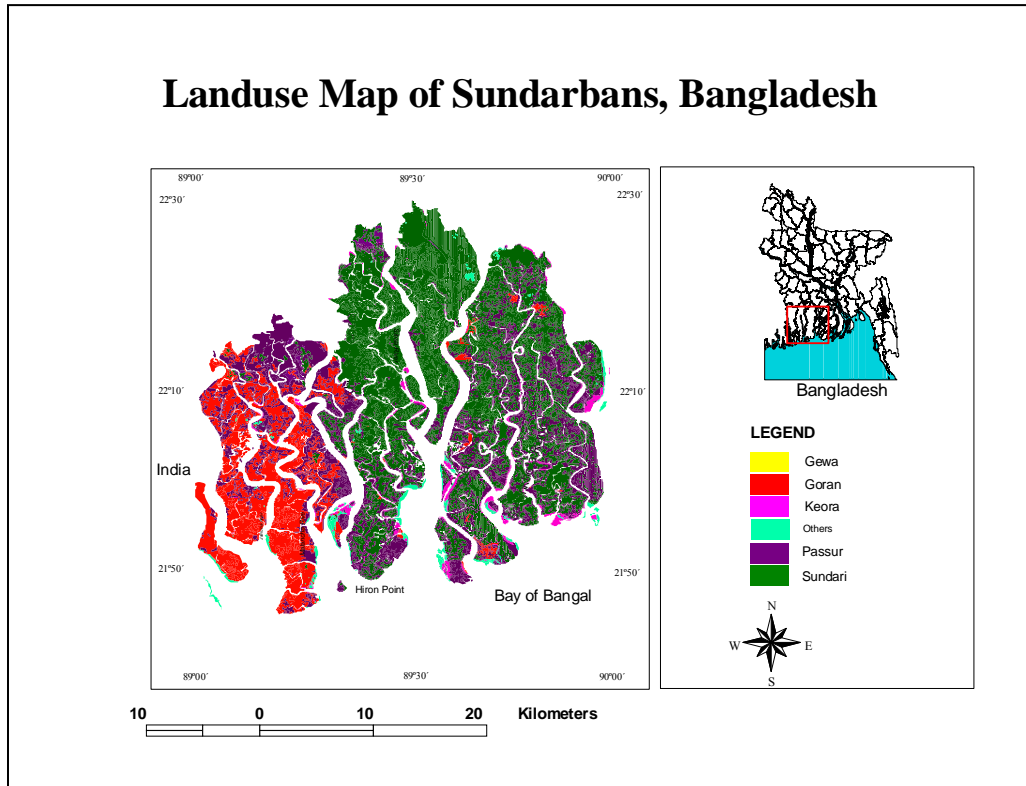


Figure 29. Land use map of Sundarbans

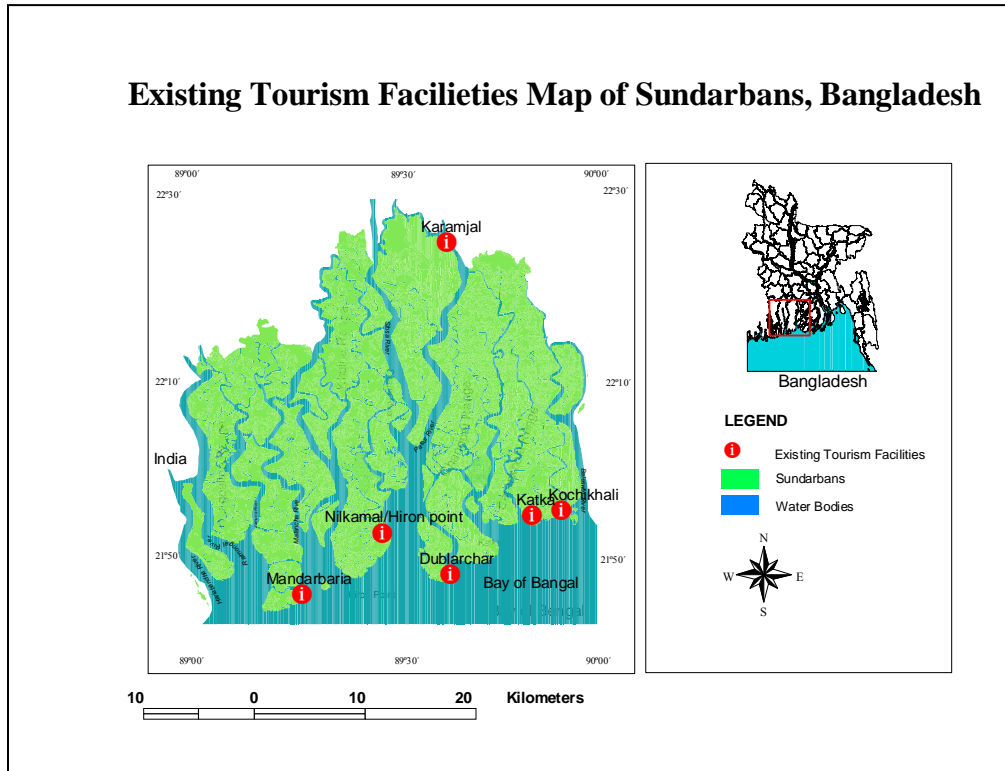


Figure 30. Existing tourism facilities map of Sundarbans

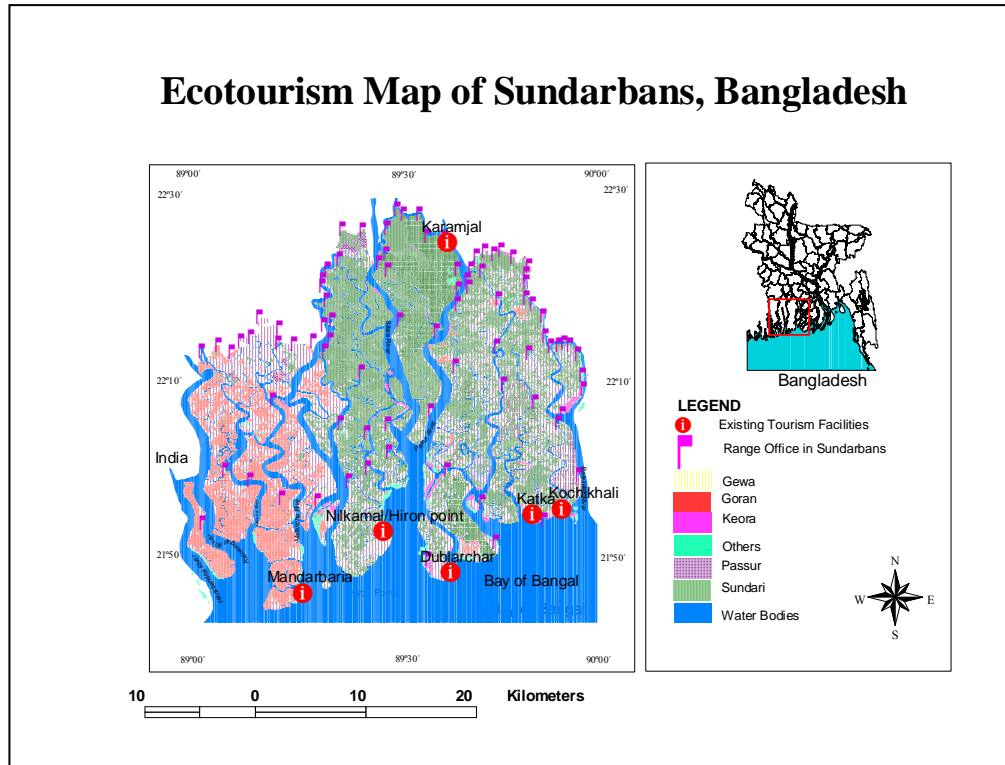


Figure 31. Ecotourism map of Sundarbans

In the planning process the present situation of tourism and existing tourism facilities and the lack of tourism facilities in Sundarbans are considered prime factors for a proposed plan for ecotourism development in this region.

### **5.4.3 Proposed plan for ecotourism development in Sundarbans**

‘The Sundarbans should be considered a site for low volume high-cost ecotourism rather than for a wider, less affluent mass market’ (Rahman, 2000. p-147) due to difficult terrain of mangrove area. In order to plan for ecotourism development in Sundarbans ecosystem protection is the first issue, because tourism development in an environmental sensitive area generally creates problems for natural ecosystem. The current study found that this mangrove has been reduced since long because of various human activities and natural causes. In recent years ecotourist flows into this region have increased radically therefore, ecotourism planning has become an important issue for reduced future environmental damages.

For sustainable tourism planning in Sundarbans 6 major components are proposed in this study to developing ecotourism in this region (Figure 35).

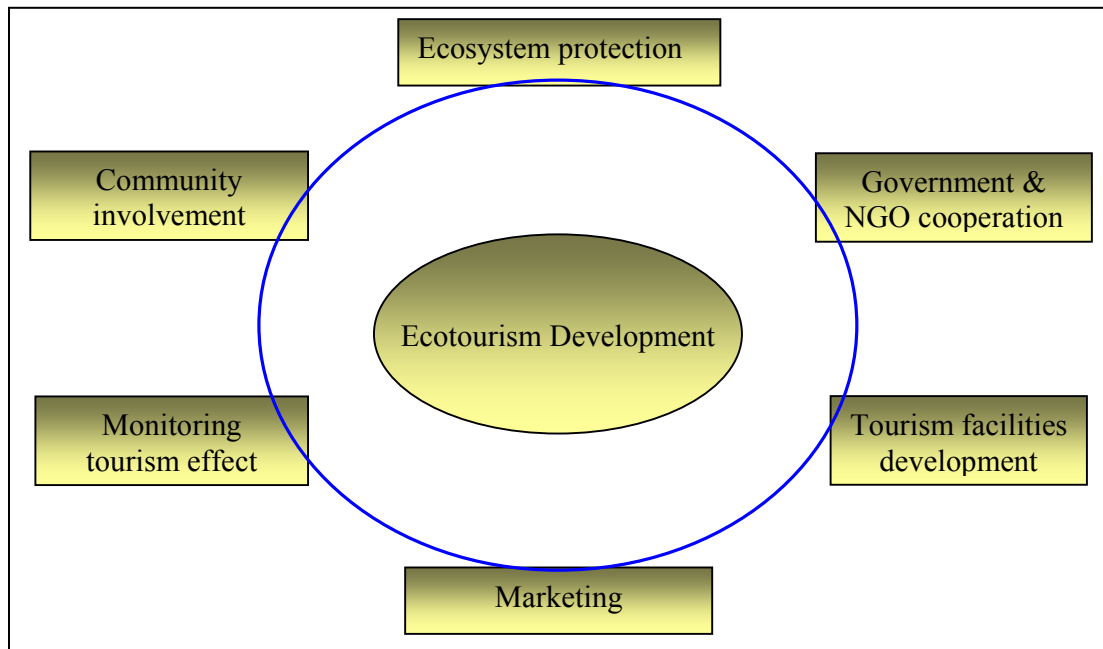


Figure 32. Major components of tourism planning in Sundarbans, Bangladesh

All components are interrelated with each others. This plan is based on existing tourism facilities, present situation and future possibilities of ecotourism in this region.

**5.4.3.1 Ecosystem protection:** The physical environment and the mangrove biota of the Sundarbans are changing in interrelated ways. Especially, human activities and natural hazards can consider as prime factors for this change. However, this forest and its wildlife are protected by the law but due to huge pressure of human population, deforestation is increasing day by day. Natural hazards and, recently, tourism flows have created new problems within this protected area. Therefore, to reduce these problems *this study proposed a minimum 300m buffer zone around sanctuaries* in this natural mangrove. This buffer can be created by the satellite images and by using the distance operation function of GIS software. Tourists are not allowed in this buffer zone but they can visit the southern part of this forest because on this side huge free space and grass land are available.

**5.4.3.2 Monitoring tourism effect:** Monitoring comprises a periodical process of planning, implementation, communication and follow-up activities. Tourism development in the natural forest area generally creates some problems. Therefore, monitoring of tourism effect is a very important consideration for ecotourism planning. Sundarbans is the largest forest in Bangladesh and this forest is completely controlled by the Forest Department. However, for tourism development in Sundarbans the Forest Department needs to collaborate with the Civil Aviation and Tourism Department to facilities development and monitor visitor impact in this mangrove. *The current study proposed a joint management for Sundarbans* due to ecotourism development in this region.

**5.4.3.3 Tourism facilities Development:** In the Bangladesh part of Sundarbans limited tourism facilities exist. More specifically, for management purposes, the forest has four range offices, Chadpai, Shorankhola, Nolian and Burigoalini and each range office is subdivided into 16 forest stations, 39 petrol teams and 55 compartments. All range offices and most of the forest stations have rest-houses with 4-16 beds, which can be

hired in advance at rates of US\$ 5-10 per night (FAO/UNDP 1994). However, it is not enough to develop ecotourism in Sundarbans. Moreover, there is no scope to develop any commercial hotel or tourism infrastructure (road, resort center, Children parks) inside the forest. Therefore, ***this research proposed development tourism facilities in Khulna city*** (Appendix-F) which is considered the gateway city to the Sundarbans, where all tourism modern facilities can be developed. Moreover, Mongla is a small port city in this region and from this city it is simply possible to go Karamjal and Katka tourist sport in Sundarbans by boat. Mongla city can be considered another option for tourism infrastructure development in this region.

**5.4.3.4 Government and nongovernmental cooperation:** For tourism development to occur government and nongovernmental organization cooperation is a must. Government should be a policy maker and all other stockholders should be involved in tour operating and visitor hospitality management. In Sundarbans, a few tour operators are involved in these activities but the government urgently needs support them for training, proper guideline, financing for skill development. ***This study proposed to collaboration for both government and non government organizations.*** The Governments can start special scheme to provide low interest loan for tourism inventors.

**5.4.3.5 Community involvement:** Local people's interest is a big issue when a tourism destination is developed according to a plan. Local cultures, traditions and costumes can also attract tourists to visit a tourist site. These provide an opportunity to share experience and culture for both host communities and travelers. There are no permanent residents inside the Sundarbans but almost 2 million peoples are living around this reserve forest. All people depend on this forest for earning their livelihood. For planning tourism in this region, the local people can be considered as a part of hospitality services, because they can assist tourists according to their experience as guides in the forest. Moreover, they can be employed in the service industries operating or accompanying jungle boat trips and wilderness trails and assisting in transport operation.

In addition, small handicrafts industries, including basket work, weaving, leather goods, brass ware, jute products and clay pots can be established in nearby villages. ***The***

*study recommended that local people should be involved in the planning process under participatory approaches*, meaning when decision makers prepare a plan then they must consider local people's opinions and their interest.

**5.4.3.6 Tourism marketing:** Tourism marketing is considered another important issue in tourism planning. Due to technological developments tourist are able to research for necessary information before visiting a place. Therefore, all necessary information needs to be included in a national portal and this information needs to be regularly updated. Moreover, a tourism destination should develop based on a target tourist's market. Indeed, marketing strategy should focus according to target groups and target traveler's motives. Generally, Bangladesh focused on international media as a country of natural hazards but most people around the world are not informed that this country has a major contribution of 'world largest mangrove forest of Sundarbans'. *The current research proposed to prepare a marketing strategy for both international and domestic tourists.*

The next and final chapter will discuss the conclusions and additional recommendations will be made considering ecotourism planning and development in the Bangladesh part of Sundarbans.

## **CHAPTER 6**

### **6. CONCLUSIONS AND RECOMMENDATIONS**

This chapter provides the conclusions and recommendations for ecotourism planning in the Bangladesh part of Sundarbans. Moreover, the study limitations and future research scope are included in this chapter.

#### **6.1 Conclusion**

Tourism is a highly complex activity and, thus, requires tools that aid in effective decision making and fulfill the competing economic, social, and environmental demands of sustainable development. Applications of GIS in tourism and recreation planning illustrate that GIS is a strong and effective tool that can aid in tourism planning and decision-making (Giles, 2003). This technology can play an important role in auditing environmental conditions, examining the suitability of locations for proposed developments sites, impact assessment for tourism activities, visitor flow management, and identifying conflicting.

This study evaluates the potentiality of GIS for ecotourism planning in Sundarbans and GIS has been used for ecotourism planning as a decision supporting tools. The study found that GIS technology is a set of effective tools for ecotourism planning in Sundarbans. Using these tools it is possible to identify land use change over time. Therefore, it can be recommended that GIS can be used for monitoring tourism effects over time in an environmentally sensitive region.

The current study investigated Sundarbans to prepare ecotourism planning for sustainable development in this region. In the planning process the study considered some important issues related to ecotourism planning including present land use of Sundarbans, land use change over the last 33 years (1977-2010), causes of land use change, existing tourism facilities, present status of tourism, and lack of tourism facilities, accessibility information and administrative information. All information was assembled to produce an ecotourism map of Sundarbans. GIS tools assisted in the mapping process.

The study found that, the land use of Sundarbans changed over the study period and the density of forest declined at the same time. However, the change occurred because of various human activities and climate change effects. Human activities include fishing, agriculture, shrimp farming, wood cutting, timber production and tourism. However, tourism has not yet been considered responsible enough for these effects as it is at a very early stage but the rapid increase of visitors in Sundarbans is considered a warning signal regarding tourism development and its possible negative effects in this region. The present land use of the Sundarbans has been classified from Landsat TM images (2010).

For ecosystem protection in Sundarbans this study proposed a 300 meters buffer zone around the sanctuaries. The Sundarbans of Bangladesh already protected by the law and any kinds of damages (flora and fauna) prohibited within this reserve forest. Therefore, the authority of this forest established 3 sanctuaries for wildlife protection but this study proposed 300 meters buffer zone around the existing sanctuaries (Appendix-G) for tourism planning. Because, tourism activities generally make some environmental problems due to various activities of tourist so, it is important to make a save distance from sanctuaries.

The involvement of local people can be considered as a part of hospitality services in ecotourism industries in this region, because they can assist tourists according to their experience as guides in the forest. Moreover, they can be employed in the service industries operating or accompanying jungle boat trips and wilderness trails and assisting in transport operation. This study recommended that the local people should be involved in the planning process under participatory approaches which is refers, when decision makers prepare a plan, they must consider local people's opinions and their interest.

The number of visitors in Sundarbans has been increasing regularly in recent years. Therefore, it is important for the Sundarbans authority to make an ecotourism plan for sustainable tourism management in this region.

## **6.2 Recommendations**

Based on the study some important planning issues are recommended as follows:

- Ecosystem protection will get first priority in the ecotourism planning in this region

- Local peoples interest must be involved in planning
- A joint management within all responsible departments (Forest, Tourism, Environment & Local govt.) required for monitoring, evolution and development.
- Close collaboration for both countries management (Bangladesh-India) is essential for sustainable development in this region.
- Various tourism facilities can be developed in Khulna city and Mongla area which are includes;
  - Information and education center for both international and domestic visitor
  - National information portal based on web pages
  - Hotel, motel, and parks
- Establishment of a Mangrove Interpretation and Visitor Centre in Karamjal, at the boundary of Sundarbans
- Government can help interested tour operators organization by
  - Provide easy license
  - Low interest loan
  - Training and guidelines
- Product promotions for national and international tourist
  - Published photography book of Sundarbans
  - Wildlife videos
  - Environmental awareness issues
- Identification and promotion of local craft products from micro-enterprises of the impact zone
- Developed environmental friendly boat for safety journey in Sundarbans
- Marketing strategy for both domestic and international tourists.

All above recommendations can be considered guidelines for ecotourism planning in the Bangladesh part of Sundarbans. The Sundarbans mangrove region is divided by an international boundary between Bangladesh and India; therefore, both countries must collaborate to promote sustainable development in the entire region.

Khulna city is the gateway city of Sundarbans forest (Appendix F). Moreover, this city is a divisional city in Bangladesh. It has all municipal facilities, airport and good transport system with the capital city of Dhaka including railway, road, water and air. Therefore, Khulna can be developed as the main tourism infrastructure area for ecotourism development in Sundarbans.

### **6.3 Study limitations and future research scope**

There are some specific limitations, which should be addressed as a means of improvement for further study. This study was prepared based on raw satellite data and field ground truth information used for image processing but it was not possible to carry out a questionnaire survey in the field because of time limits. Planning is never complete without local people's opinions included. Therefore, this study should not be considered a complete strategy for ecotourism planning in Sundarbans. Yet, this research will expose opportunities for further research and investigation, and help decision makers to review what options exist for improving tourism facilities in Sundarbans and how they can better ecotourism planning especially, from a point of reducing the negative impacts from tourism development in this region.

Another important research is necessary in this region for local population's development. Because, local peoples are completely depends on this forest for their living hoods. Therefore, occupations pattern change is must for sustainable forest management and ecotourism developments in Sundarbans.

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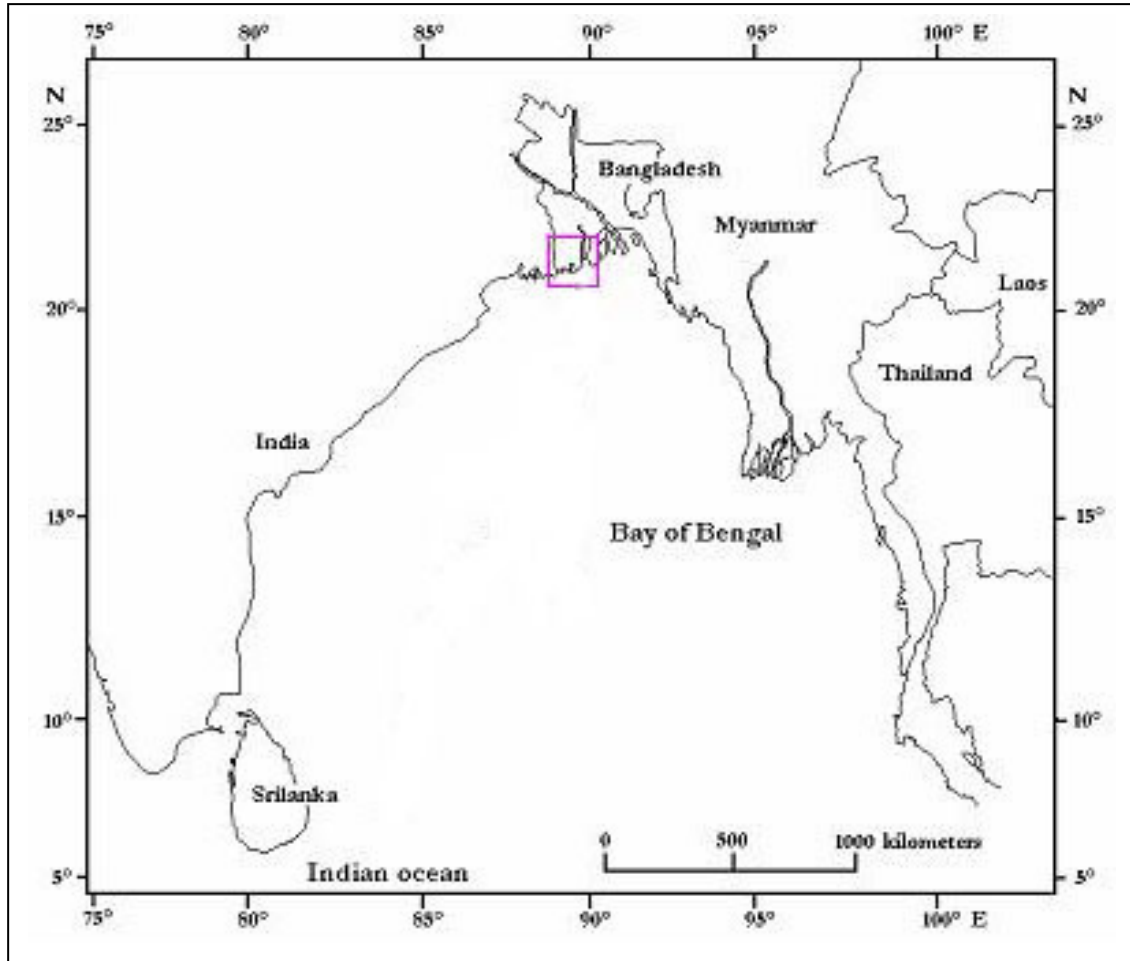
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## APPENDICES

### Appendix A. The location map of Bangladesh



### Appendix B. The total number of visitors in recent in years in Sundarbans, Bangladesh

Categories	2008/2009	2007/2008	2006/2007	2005/2006
Native	97,721	85,473	95,102	91,039
Foreign	1,745	1,540	1,257	1,581
Total	99,466	87,013	96,359	92,620

Source: (USAID, 2009. p-6)

**Appendix C.** Statistics of damaged forest areas caused by cyclone Sidr in 2007

Type of damage	Area(ha)	Damage by Category (%)	Damage by total area of the Sundarban (%)
Highly affected	14,840	11	2.5
Moderately affected	91,420	69	15.2
Slightly affected	26,700	20	4.5
Total	132,960	100	22.2

Source: (CEGIS, 2007)

**Appendix D.** Satellite image analysis error matrix

Error Matrix Analysis of CLASS-ISO (columns: truth) against CLASS (rows: mapped)

	1	2	3	4	5	
1	0	0	0	13451	75738	1.0000
2	0	0	0	693627	266555	1.0000
3	0	266744	747886	270359	288981	0.5291
4	0	931596	532387	0	0	1.0000
5	0	313997	9054	0	0	1.0000
Total	5470657	1512337	1289327	977437	631274	
ErrorO	1.0000	1.0000	0.4199	1.0000	1.0000	

	6	Total	ErrorC
1	93838	183027	1.0000
2	31413	991595	1.0000
3	14278	1588248	0.5291
4	7395	1471378	1.0000
5	2719	325770	1.0000
Total	149643	10030675	
ErrorO	1.0000		0.9254

ErrorO = Errors of Omission (expressed as proportions)  
 ErrorC = Errors of Commission (expressed as proportions)

90% Confidence Interval = +/- 0.0001 (0.9253 - 0.9256)  
95% Confidence Interval = +/- 0.0002 (0.9253 - 0.9256)  
99% Confidence Interval = +/- 0.0002 (0.9252 - 0.9257)

**KAPPA INDEX OF AGREEMENT (KIA)**  
-----

Using CLASS as the reference image...

Category	KIA
-----	-----
1	-1.1997
2	-0.1775
3	0.3928
4	-0.1080
5	-0.0672

**CLASS-ISO**

Category	KIA
-----	-----
1	-0.1097
2	0.5011
3	-0.1719
4	-0.0336
5	0.0000

Overall Kappa = 0.8163

**Note:** The Kappa coefficient lies typically on a scale between 0 and 1, where the latter indicates complete agreement, and is often multiplied by 100 to give a percentage measure of classification accuracy, Kappa values are also characterized into 3 groups: a value greater than 0.80(80%) represents strong agreement, a value between 0.40 and 0.80 (40 to 80%) represents moderate agreement, and a value below 0.40(40%) represents poor agreement.

According to the accuracy assessments (error matrix result) the present study image analysis represents a strong agreement which is 81%.

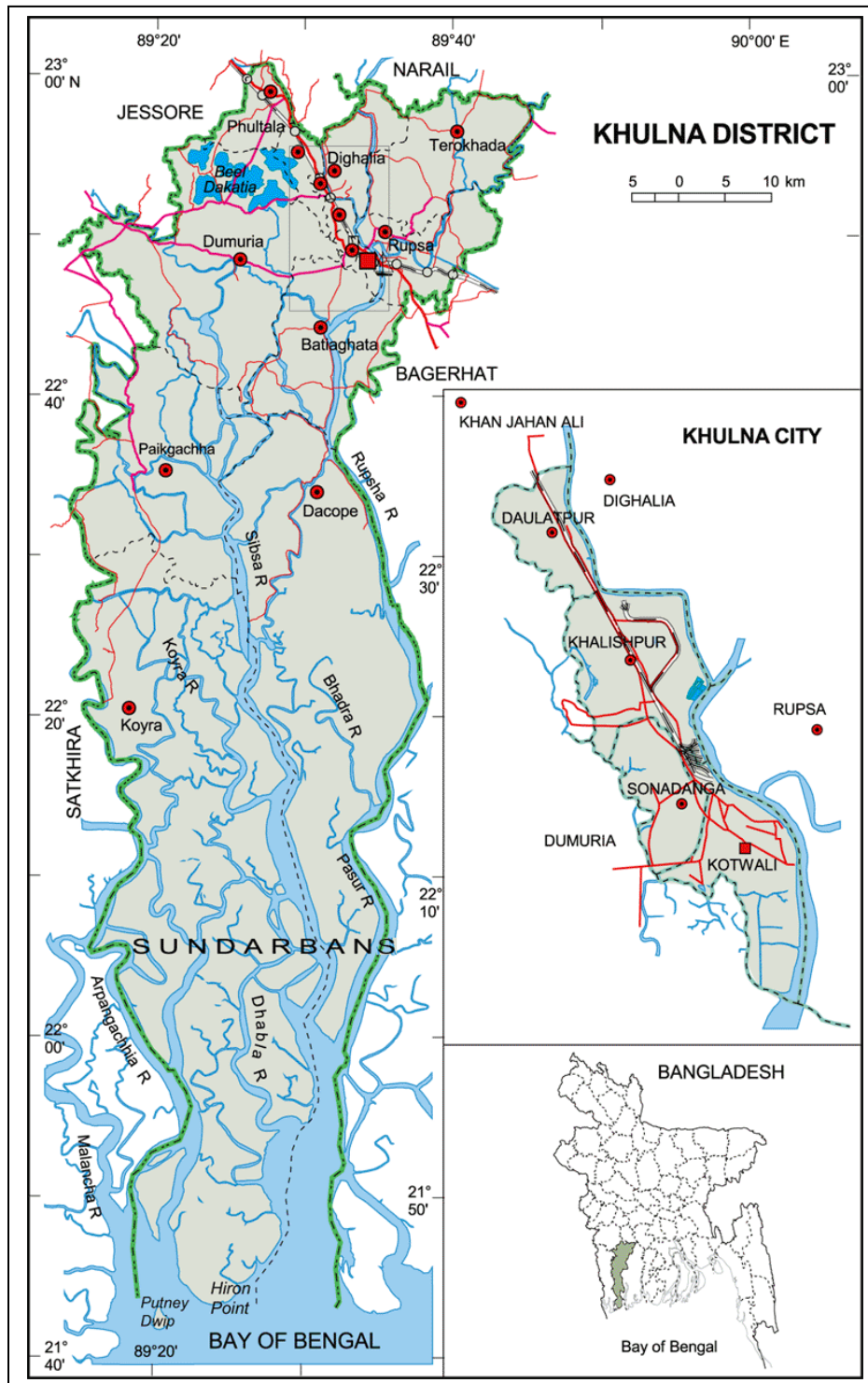
**Appendix E. Landsat TM & MSS bands characteristics**

<b>TM Bands</b>		
<b>Channel</b>	<b>Wavelength Range (µm)</b>	<b>Application</b>
TM 1	0.45 - 0.52 (blue)	soil/vegetation discrimination; bathymetry/coastal mapping; cultural/urban feature identification
TM 2	0.52 - 0.60 (green)	green vegetation mapping (measures reflectance peak); cultural/urban feature identification
TM 3	0.63 - 0.69 (red)	vegetated vs. non-vegetated and plant species discrimination (plant chlorophyll absorption); cultural/urban feature identification
TM 4	0.76 - 0.90 (near IR)	identification of plant/vegetation types, health, and biomass content; water body delineation; soil moisture
TM 5	1.55 - 1.75 (short wave IR)	sensitive to moisture in soil and vegetation; discriminating snow and cloud-covered areas
TM 6	10.4 - 12.5 (thermal IR)	vegetation stress and soil moisture discrimination related to thermal radiation; thermal mapping (urban, water)
TM 7	2.08 - 2.35 (short wave IR)	discrimination of mineral and rock types; sensitive to vegetation moisture content

<b>Landsat MSS Bands</b>		
<b>Band</b>	<b>Wavelength Region (µm)</b>	<b>Resolution (m)</b>
1	0.5-0.6 (green)	80
2	0.6-0.7 (red)	80
3	0.7-0.8 (red - near-IR)	80
4	0.8-1.0 (near-IR)	80

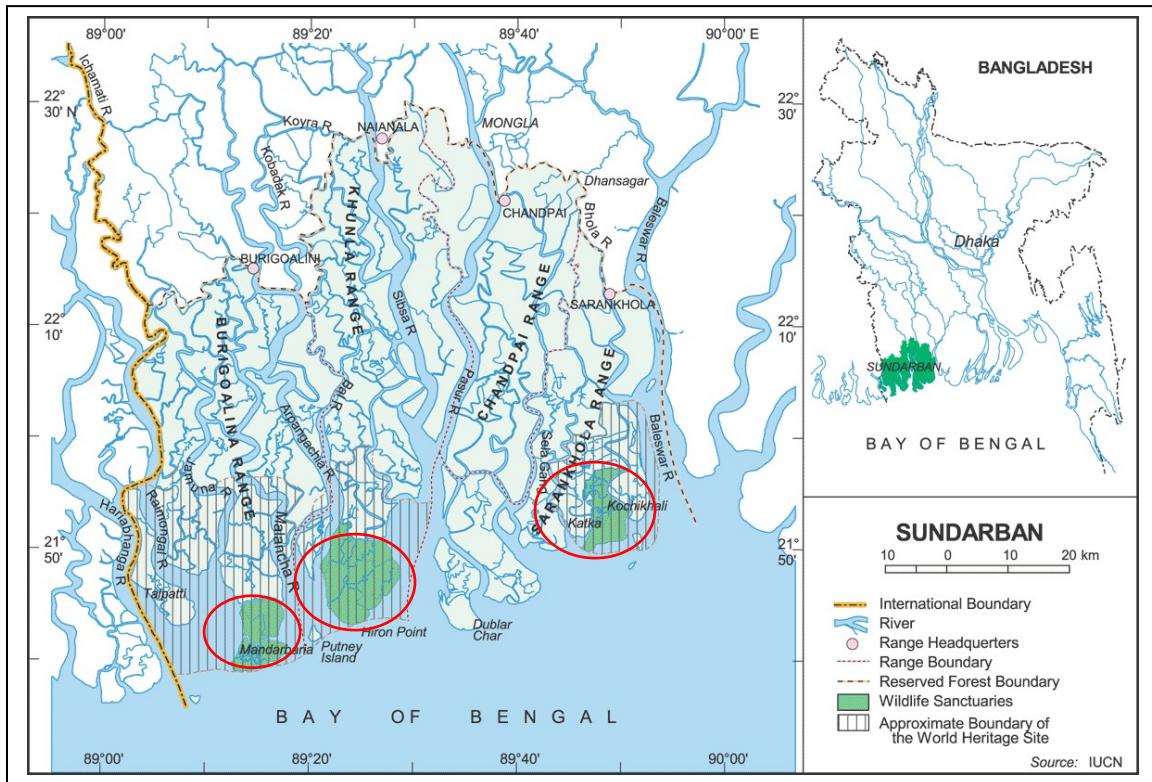
Source: (CCRS, 2010)

Appendix F. Proposed ecotourism infrastructure development area



The map of Khulna District, Bangladesh (Banglapedia, 2006)

**Appendix G. Sundarbans wildlife sanctuaries**



Source: (Banglopedia, 2006)

**Appendix H.** Tourist map of Bangladesh (Bangladesh Parjatan Corporation)

