Chapter I
INTRODUCTION

1.1 General Introduction

A forest is a natural ecosystem which has multi-species and multi-aged trees as dominant community where the diversity and sizes vary in different parts of the world (Todkari and Patil, 2010). Forests constitute one of our principal natural resources and are essential in maintaining environmental stability. It is one of the most important ecosystems on the earth surface, which consist of different biotic and abiotic components that vary according to topographic conditions. The abiotic component of the forest includes climate and soil type, whereas the biotic component includes plants, animals and other life forms. However, a forest ecosystem is primarily determined by the plant component than any other living component which supports the whole elements and functions of the ecosystem. The interrelationships among these components are such a way that one form of life is dependent upon others for its existence and species of plants and animals keep a check on their numbers through food chains. The destruction of any kind of link in the chain or in the web may lead to imbalances which may threaten the existence of man himself on this planet.

Forests cover is about one third of the earth's land surface. The total forest cover in India is 789,164 km^2, which is 24.01% of the geographical area of the country (FSI, 2013). In India, there are 75 National Parks and 421 Sanctuaries covering 1,40,675 km^2

area (42% of the total geographical area) and in Assam there are five (05) National Parks and eighteen (18) Wildlife Sanctuary.

The importance of forest is directly linked with sustenance of human life on the earth. Forests provide various goods and services which are vital to the socioeconomic development of human population and their survival (Ramachandra *et al.,* 2016). According to World Health Organization (WHO), in 2000 about 80% of the population inhabiting in the developing countries utilized wild products to meet their health and nutritional needs (Muzayen, 2009) and help in reduction of poor people's vulnerability by satisfying their basics needs (World Bank, 2001 and Shackleton and Shackleton, 2004).

1.1.1. Ecological benefits of Forests

Apart from various goods and services to human, forests provide additional ecosystem services such as – ground water recharge and flood moderation, reduction of erosion and top soil conservation, reduction of sediment yield of a basin, climate regulation through carbon sequestration, conservation of biodiversity, etc. (Chan and Sasaki, 2014).

The major functions of forest ecosystem are identified as energy flow, maintenance of food chain, nutrient cycling, etc. Some of the important services and benefits provided by the forest are –

➢ Forests are natural habitats for many species of plants and animals (Hassan *et al.,* 2005) and they also protect and sustain the diversity of nature.

- Forest are known to be biodiversity repositories, and helps to restrain soil erosion, prevent landslides by binding of soil with the help of tree roots, regulate humidity and temperature of ambient air, and mitigate global warming by absorbing 30 % of fossil fuel CO_2 emissions (Ramachandra *et al.,* 2016).

- Plant leaves that falls on the ground and dead plants decompose to form humus and organic matter that holds the water and provides nutrients to the soil. Thus, forests increase soil fertility and moisture holding capacity of soil.

- The layer of leaves that falls on the ground prevents runoff and allows the water to percolate into the soil which is helping in ground water recharge. Thus, forests act as hydrologic flow modulators.

- Through the process of photosynthesis forests absorb atmospheric CO_2 and help in mitigating fossil fuel CO_2 emissions and balancing carbon dioxide and oxygen of the atmosphere. They also help in reducing pollution by absorbing suspended particles in air.

- Forests help in maintaining microclimate of the area which plays an important role for the survival of many species.

- Forest cover has a vital role in maintaining healthy watershed. Rivers originating in a forest area carry the organic matter from forest to the downstream supporting a variety of fishes and aquatic animals. The richness of forest in upstream decides the biological value of the river ecosystem supported by it.

In addition to all the above services provided by the forests, they are also popular areas for relaxation and recreation (Kindstrand *et al.,* 2008 and Todkari and Patil, 2010). Forests add to the aesthetic value of the area and helps in developing ecotourism (Evans, 2009). Forests also provide food and medicinal products mainly to the local people, fodder for cattle and other grazing animals. They also provide valuable items like timber, paper, fuel wood, bamboo, cane, food, fibres, essential oils which are important for economic growth.

1.1.2. Human Pressure on Forests

The forest cover is continuously shrinking and the main reason attributed to this is the growing pressure of the ever increasing population. It has been found that large areas of forests in many places are being overexploited or are being cleared for resettlement and agricultural expansion (Chan and Sasaki, 2014). Deforestation, changing pattern of agriculture, urbanization, mining and industrialization has created threat on availability and abundance of forests on earth. According to FSI (2013) only 13% of the recorded forest area has no biotic influence and about 11% and 20 % of the recorded forest area have high and moderate biotic influence respectively. Some of the related to human pressures on forests are –

> ➢ Extraction of timber and Non-timber forest Products: Timbers form forests are extracted mainly for construction of houses and furniture. Rural people are highly dependent on forest for fuel wood. It has been reported that about 216 million tonnes of fuel wood is consumed in India, of which about 27% is sourced from forests (FSI, 2013).

➢ Livestock Grazing: Grazing has been found to cause extreme influence on forest vegetation (Afreen *et al.,* 2011). Although, FSI (2013) have reported that light controlled grazing is beneficial but heavy uncontrolled grazing is harmful to forests. The harmful impacts of uncontrolled grazing include death of seedlings, reduction of porosity of soil because of soil impaction, increased run off and loss of palatable grasses for the wildlife. The incidence of moderate to high grazing process has been found to be reported for more than 30% of the recorded forest area.

➢ Forest Fire: Forest fire is also one of the identified threats to forest loss and degradation. About 54% of the forest area is experiencing forest fire of which heavy fires is estimated to affect about 1.3 % and moderate and mild fires are estimated to affects about 6.5% and 46% respectively (FSI, 2013).

➢ Mining: Mining activities has significant impacts on forest and biodiversity in various part of India. Mining, particularly open cast mining has resulted in change of landscape and drainage, degradation of soil and water quality and destruction of forests causing loss of biodiversity.

➢ Forest fragmentation: Fragmentation decreases habitat simply through loss of forest area. According to Midha (2008), research shows that loss of habitat and breakings apart of habitats due to fragmentation are the major causes for species decline and biodiversity loss.

➢ Invasive alien species: Invasive alien species are one of the major threats to biodiversity through the word.

➢ Illegal logging: Illegal logging is also identified as a threat to forest loss and degradation. Illegal logging can result in the loss of habitats and biodiversity.

1.1.3. Issues Related with Human Pressure on Forests

Forests play an important role in the livelihood of rural people living in and around forest areas by providing various tangible and intangible benefits to them mainly in the form of wood and non-wood products. Various human related activities and processes such as human population growth, economic growth, poverty, lack of education, etc. have made tremendous pressure on nearby forests. It has also altered the composition of the land cover, with a significant change from natural habitats (e.g. forests, grasslands, wetlands) to agricultural, pastoral, urban, and other man-made land uses (Tscharntke *et al.,* 2005).

Tyub *et al., (*2013) revealed that people with low socio-economic status shift to forest areas and encroached forest land for settlement and agricultural fields. Encroachment of forestland is a serious threat to forests which causes degradation of both forests as well as the habitats of wildlife. The situation is very alarming and needs strong approach to address the problem. Unauthorized villages started to grow inside the reserved forests which are described as '***encroached villages'***. People residing in theses villages cleared up the forest in order to have land for cultivation. Some of these people also get engaged themselves in the illegal trade of timber and other forest resources. Thus, a combine effect of agriculture, illicit cutting of forest trees and hunting practices

of the encroached villagers is the greatest perceived threat to mammals, birds, and amphibians.

There has been observed some 'encroached villages' in the study area, the Sonai-Rupai Wildlife Sanctuary of Assam. Poaching and hunting of the wild animals is still continuing in the Sanctuary. Deforestation, encroachment, agricultural and other economic as well as associated activities in the forest area has changed the land cover of the Sanctuary. This type of change not only caused loss of forest area but also created a tool for perpetual degradation of forest resources.

1.1.4. Effects of Human Pressure on Forests

The major apparent or direct effects of human pressure on forests are – (a) deforestation, (b) forest fragmentation, (c) land-use/land-cover change and (d) loss of biodiversity. The significance of these effects depends on the amount or intensity of human pressure caused due to overexploitation of forest resources.

(a) Deforestation

Deforestation is the conversion of forest areas to non-forest land use such as arable land, urban use, logged area or wasteland for different reasons such as agricultural, industrial and urbanization. According to FAO (2006) deforestation is the conversion of forest to another land use or the long-term reduction of tree canopy cover below the 10% threshold. It is generally removal of forests to non-forest areas for urbanization, agriculture and for some other reasons without corresponding re-afforestation of the area. Aina and Salau (1992) have defined 'Deforestation' as a process where the trees are felled for several purposes, but without replanting new trees.

(b) Forest Fragmentation

Forest fragmentation occurs when a large region of forest is broken down, or fragmented into smaller patches of forest habitat (Fahrig, 2003). Simply, forest fragmentation refers to any process which results in the conversion of formerly continuous forest or habitat into patches of smaller forests or habitats separated by non-forested lands. Land cover changes due to various anthropogenic processes like agricultural intensification, logging and infrastructure development, construction of roads and power lines, illegal and indiscriminate felling of trees are also causing forest fragmentation (Karanth *et al.,* 2006). These changes have led not only to the loss of habitat and biodiversity, but also to the modification of natural landscapes and ecosystem functions such as disruption in biogeochemical cycling, nutrient and water cycling, ecological processes (Fahrig, 2003; Holway, 2005 and Batar *et al.,* 2017,). This type of alteration of forest structure and composition is causing detrimental effects on wildlife and further land use changes (Holway, 2005; Bennett and Saunders, 2010 and Ramachandra *et al.,* 2012a).

(c) Land Use/Land Cover Change

Land use/land cover (LULC) changes play a major role in the study of global change. The "Land Use" is defined as the way in which and the purpose for which human beings employ the land and its resources. In other words, land use refers to man's activities on land, whereas land cover denotes natural vegetation cover, water bodies etc. Land cover is altered primarily by direct human use through agriculture, pasture, forestry, developmental activities etc. Human as well as natural modifications

of LULC largely are causing deforestation, biodiversity loss, global warming and increase of natural disaster such as flooding (Wijitkosum, 2012).

Economic exploitation of natural resources (logging, mining, hydroelectric power, etc), population expansion (urbanization and colonization), and the expansion of agriculture (permanent agriculture and shifting cultivation) are known to be the three major proximate causes of land use change. Information on the rate and kind of changes in the use of land resources is essential for proper planning, management and to regularize the use of such resources (Phukan *et al.,* 2013). Growth of settlements in the forest areas and in the fringe areas for agricultural and settlement purpose have been identified as the major factor for the land cover change in the study area.

(d) Loss of Biodiversity

The loss of biological diversity include the habitat loss, expansion of exotic species, over-utilization of natural resources, and expansion of agriculture. The main cause of the biodiversity loss can be attributed to the influence of human beings. Anthropogenic activities have modified the territory, exploited the species directly and degraded the forest and have altered the natural environment by changing the biogeochemical cycles and transferring species from one area to another. Understanding and knowledge of the various aspects of human influences on biodiversity, and their underlying driving forces, is of crucial importance for setting priorities and conservation plans.

1.1.5. Forest Fragmentation due to Channel Migration

River is important part of human being which is continually changing from its evolutions because of natural and man-made activities. River can change their course

and experience erosion and deposition over time under natural condition. Channel migration is a natural process associated with river system. Erosion, deposition and extension of sandbanks cause the movement river channel. Through the process of channel expansion, bend migration and channel avulsion channels migrate through the floodplains. Channel migration is the process by which steam channels move and shape floodplains through time. Floods of very high magnitude are causing channel widening and river bank erosion along with associated changes in the channel pattern (Schumm and Litchy, 1963). River flowing through the forest causes bankside erosion and sedimentation of and sometimes forest fragmentation also occurs. Shifting of rives courses are also known to cause forest fragmentation.

1.1.6. Effect of Forest Fragmentation

Forest fragmentation can influence the entire suite of ecological processes, from individual behaviour through population dynamics to ecosystem fluxes. Generally, it causes habitat fragmentation for many species by reducing total habitat which may lead to increased competition among species due to limited resources. Thus, forest fragmentation is a threat to global biodiversity which may cause more impacts on a wide range of ecosystem functions and services (Wu *et al.,* 2003). It has been seen that fragmentation mostly impact the large-bodied or wide-ranging species because of their dependency on large areas of favourable habitat to survive by reducing landscape patch-size and increasing movement barriers. Degradation of forests can also results in the disruption of water supplies, leading to droughts in some places whereas floods in other places. It can cause deterioration of water quality, as the forest will no longer be able to filter and purify the water and can also increased soil erosion, leading to a higher frequency of landslides and the silting up of rivers. Habitat loss can have negative

impacts on species richness as well as population abundance (Laurance *et al.,* 2002) and genetic diversity (Aguilar *et al.,* 2008).

Different studies have shown that not only large body animals but butterflies, ants, beetles and termites have also been affected due to fragmentation and edge effects (Laurance *et al.,* 2000). The process of forest fragmentation result into loss of original habitat, reduction in remnant patch size, increasing isolation of remnant patches, and exposure of forest fragments to edge effects because of the abrupt transition between forest and matrix habitat (Midha, 2008). The forest loss or fragmentation of a habitat for a species can eventually lead to its extinction. Therefore, fragmentation has serious consequences for wildlife and the ecology of ancient forests.

1.1.7. Management and Conservation of Forests

Natural resources like forests are the basic sources of human survival and prosperity. However, it has been observed that the forests are rapidly degrading in recent few decades mainly due to over-exploitation and encroachment. Larger forest ecosystems are reducing in size and fragmented. Therefore, wild habitats are being threatening their biological integrity as well as the survival of some far ranging or critical wildlife species (Kumar *et al.,* 2002).

Encroachment in forests and over-exploitation of forest resources are mainly because of the growing demand for forest resources by the rapidly growing population, which has resulted in various problems such as land degradation, vegetation loss, habitat fragmentation, pollution, etc. Thus, wildlife habitats are being affected constantly by different anthropogenic activities. Therefore, proper management plan should be taken for the conservation of forests and wildlife habitats.

The Sonai-Rupai wildlife Sanctuary has been facing serious problem of habitat loss and fragmentation. Therefore, there is an urgent need of conservation and proper management of the wildlife Sanctuary. The effective and scientifically sound management of protected area (PA) is the need of the hour for sustainable conservation of remaining natural resources of the Sanctuary.

1.1.8. Scope of Eco-Tourism in the Study Area

Ecotourism is a nature-based travel to relatively undisturbed areas with an importance on education. The study area i.e. Sonai-Rupai Wildlife Sanctuary has a diverse types of habitat with wide varieties of flora and fauna. It is characterized by a range of habitats extending from seasonal wetlands and grasslands in the plain to sub-tropical broad-leaved forest in the foothill areas. The Sanctuary can also serve a great site for trekking. Hence the wildlife Sanctuary can be said to have the entire natural infrastructure to develop ecotourism. Even eco-tourism in the Sanctuary can provide employment opportunities to those people who are dependent on the forest products for their survivals. Therefore, attention should be given to the services and facilities towards the promotion of ecotourism in the Sanctuary.

1.2. Statement of the Problem

Forest loss and fragmentation may be caused by both anthropogenic and natural activities/events. The prime anthropogenic activities are felling of trees for timber and firewood, overgrazing, conversion of forest land to agricultural land, clearing of forests for residential and industrial purposes, construction of roads, etc. The natural causes of forest loss and fragmentation may be bankside erosion and sedimentation, channel migration, wildfire, landslides, etc. Bankside erosion may also cause large scale

deforestation causing loss of wildlife habitats. Migrations of river channels bifurcates wildlife habitats. Thus, whatever may be the reason, forest fragmentation alters natural habitat in many ways, including reduction of patch size, increment of distance between similar patches and increment of edges and predation. The forest fragmentation reduces the extent and connectivity of remaining habitats and some of the species are disturbed and may not be able to persist as a result of those changes. Thus, it affects the abundance, richness, and dispersal ability of forest dwelling species. Therefore, forest fragmentation is an issue of great concern worldwide and has already been recognized as one of major threats for the conservation of the biodiversity and ecological functions of forest ecosystem.

Sonai-Rupai Wildlife Sanctuary of Assam is located in the northern part of Sonitpur district of the state and lies along the foothills of Eastern Himalayas of Arunachal Pradesh. The Sanctuary is spread out over an area of 220 square kilometres and was declared as a Game Reserve in 1934, because of its rich biodiversity. During the last few decades, the geo-environmental condition of the Sanctuary was destabilized due to both natural and man-made causes. Seasonal flooding, bankside erosion, sedimentation and migration of the rivers flowing through the Sanctuary, etc. are the important natural causes. Bankside erosion and channel migration in the Sanctuary are causing considerable amount of deforestation as well as forest fragmentation. The manmade causes of deforestation and forest fragmentation in the Sanctuary include encroachment of forest areas for residential and agricultural purposes, overgrazing, logging for timber and fuel wood, hunting and poaching, etc. The adjacent forest cover in Balipara and Charduar Reserve forests and a part of the Sanctuary have been already. So, the Sanctuary is under threat of deforestation, forest fragmentation and habitat loss.

Mammals like rhino, tiger and wild buffaloes have already extinct locally from the Sanctuary. Therefore, there is an urgent need to make a detail study on the changes in LULC, causes of deforestation and forest fragmentation in the Sanctuary as well as their root effects and remedial measures for the conservation and sustainable maintenance of the Sanctuary.

1.3. Aims and Objectives

As discussed already, loss of forests and forest fragmentation are the prime causes of the loss of habitats and biodiversity in the Sanctuary. Therefore, the study has been made with the following objectives –

(a) To study the environmental status of Sonai-Rupai wildlife Sanctuary in terms of soil quality, water quality, diversity of tree species.

(b) To study the socioeconomic status and forest dependency of the nearby villagers of the Sanctuary.

(c) To study the changes in land-use/land-cover in the Sanctuary during the last few decades.

(d) To study the river channel migration causing forest destruction and forest fragmentation.

(e) To study the effects of forest degradation/loss and forest fragmentation on wildlife habitat.

1.4. Working Hypothesis

Sonai-Rupai wildlife Sanctuary has already lost its half of the forest cover due to encroachment, bankside erosion and sedimentation, and channel migration. The forest

loss and fragmentation have caused loss of biodiversity in the Sanctuary. Thus, the study is based on the following working hypothesis –

- ➢ Encroachment and channel migration are the root causes of deforestation and forest fragmentation in the Sanctuary.

- ➢ Socioeconomic conditions of the nearby villagers are responsible for overexploitation of forest resources and encroachment in the Sanctuary.

- ➢ The rich biodiversity of the Sanctuary is on serious threat due to deforestation and forest fragmentation.

1.5. Methodology

The study is based on both primary and secondary data. It primarily involves intensive literature survey including study of related books and articles in details to build up a clear idea about the topic and the research problem. At the beginning, existing information in the form of secondary data were collected from literature and indigenous knowledge survey. This involved intensive literature search from universities, institutions, Forest Department and other Government Offices. Secondly, mapping of land cover/forest and other related parameters was performed and then on the basis of it, rapid and intensive field survey with group specific methods was applied to collect information on biodiversity and habitat use. Further related information was collected through discussions with individual experts and resource persons.

Satellite images are being increasingly used as the primary source of information for the analysis of forest fragmentation. Remote sensing and GIS was used to examine the forest cover change at landscape level and the migration of the river channels. A base map was prepared by using Survey of India toposheets and the forest boundary

map available with the forest department. The different thematic layers comprising both satellite based and conventional data were intergraded using GIS platform. Overlay analysis was done in Arc GIS software to study channel migration and quantification of erosion and deposition was done.

To assess the soil quality of the Sanctuary, soil samples were collected from different sites of the Sanctuary covering different categories of land use and forest cover for three seasons namely- pre-monsoon, monsoon and post-monsoon seasons. The physicochemical properties of the soil sample were determined following standard procedure of soil analysis as described in Trivedi and Goel (1986) and Gupta (2004).

Surface water quality was assesses on the basis of the quality of river water of the rivers flowing through the Sanctuary. River water samples were collected in polypropylene bottles (5 litre) and analysed for different parameters following the methods mentioned in APHA (1998), Trivedi and Goel (1986) and CPCB manual. Water quality parameters were determined for three seasons namely – pre-monsoon, monsoon and post-monsoon seasons.

The Sanctuary is found to be a suitable habitat for large number of mammalian, birds and invertebrate species. It harbours an important species of primates 'Capped langur'. Therefore, the present study has been carried to record data on tree species so that it will be helpful to formulate conservation strategy for plant species in particular trees species and for the proper conservation of animal species inhabiting in the Sanctuary. The vegetation survey in the Sanctuary was carried out using quadrat method. For calculating the tree species composition, abundance and diversity indices, the following variables were used - basal area, relative dominance, and relative frequency. The sum of the relative dominance and relative frequency gave the

importance value indices (IVI) and (FIV) which has also been calculated. Species Richness and diversity Index was also calculated. Population structure and regeneration status of tree species were also studied.

The socioeconomic survey in and around the Sanctuary was carried out to assess the socioeconomic conditions of the nearby villagers and their impact on the Sanctuary. The data was collected with the help of questionnaire and personal interview. The survey employed a mixed-methods methodology for data collection from the various key informants using questionnaires and focus on group discussions (FGD). Two main sources of data collection (i.e. secondary and primary) were focused to ensure that reliable and authentic data and information are achieved. A socioeconomic profile of the surveyed areas was drawn from primary data through key informants at the household levels.

1.6. Significance of the study

The present study will generate a baseline database on the land-use/land-cover change in the Sanctuary during the last few decades. Land-cover map will give the present status of the Sanctuary. It will also provide data on forest loss and how much forest area has been degraded and what are the main causes of forest degradation, loss and fragmentation within the Sanctuary. Data generated from soil and water analysis will be helpful for planning of proper management and restoration of the Sanctuary. The vegetation study will generate data on present status, diversity and regeneration status of tree species in the Sanctuary. Channel migration study will help to know the impact of river channel migration on the forest loss and habitat fragmentation. The study will explain the relationship between forest fragmentation and its effects on the wildlife

habitat including its effect on water quality soil quality and Man-Animal conflicts. By Studying all the above aspects it will be very convenient to prepare a conservation and management plan for the Sanctuary.

1.7. Organization of the Study

The thesis is designed in eleven chapters. Chapter-1 introduces the topic and gives a brief introduction to the problem under study; this is followed by the objectives of the study and the hypotheses that guide the course of the research. A very brief description of the methodology approach for the study has also been discussed. The first chapter is concluded with the organization of the study. The organization gives details of the contents of each of the chapters of the thesis.

The second chapter deals the review of literatures relevant to the research theme. Research works undertaken by scholars in related fields in different parts of the world give guidance and clues to any investigation. These works have been critically studied and categorized under several sub-themes of the present study.

The third chapter describes the salient features of the location, climate, topography and drainage pattern, flora and fauna of the study area as well as Geo-environmental problem of the Sonai-Rupai Wildlife Sanctuary.

Chapter IV deals with Land use/Land cover Change within the Sanctuary. It starts with the meaning of land cover and shows how it differs from land use. Next, it introduces the land cover categories used in the study and the basis of categorization. Methodology adopted to study the land use/ land cover change is also discussed in detail in this chapter. At the end, the chapter gives an account of the latest land use / land cover pattern in the study area.

The physico-chemical assessment of soil quality of the Sanctuary in different season is assessed and discussed in chapter five. A detail methodology for the analysis of soil quality is discussed in this chapter and the statistical analyses of the data have been presented in a Tables and Figures. The sixth chapter study the seasonal variation of physico-chemical and bacteriological characteristic of the river water in the Sanctuary. Methodology adopted for water quality analysis is discussed in detailed in this chapter and results are presented in Tables and Figures. An assessment of status and diversity of tree species present in the Sanctuary is described in chapter seven. IVI and FVI are calculated and the results are presented in tables.

The eighth chapter deals with the socioeconomic study of the villages which are in and around the Sanctuary to know their dependency and impact on the wildlife habitat. The methodology for socioeconomic study are discussed which is followed by result and discussion. The ninth chapter documented the river channel migration within the Sanctuary and their impact on wildlife habitat. Quantification of erosion and deposition has been analysed by using GIS techniques and discussed in detail. The effects of channel migration, erosion and sedimentation on wildlife habitat, forest loss, soil and water quality are discussed in details which is followed by conclusion of this chapter.

Tenth Chapter deals with the causes and effect of forest fragmentation in the Sanctuary. The impact of habitat loss and fragmentation on wildlife habitat is discussed in this chapter. Impact of fragmentation on habitat loss and Human Elephant Conflict is also discussed in details in this chapter. In the last chapter general discussion of the study is described followed by conclusion and recommendation.

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