Chapter- IX

CHANNEL MIGRATION AND ITS IMPACT ON WILDLIFE HABITAT

9.1. Introduction

Rivers are dynamic systems that change their courses with time. The natural disturbance regime of a river consists of channel migration, erosion, sedimentation and water table fluctuation (Midha, 2010). The gradient or slope, water volume, water velocity and nature of river are responsible perimeter for changing the rivers shape and size. Generally river bank erosion is breaking down or carrying away the bank of the river by itself . Riverbank erosion is a common geomorphological process of alluvial floodplain rivers which corresponds to bank adjustment, bank trampling, changes in bed elevation and topography in reaction to modified flow condition (Nath *et al.*, 2013). The destruction of flood plain land, land loss and land use changes is associated with serious bank erosion. (Lovric and Tosic, 2016)

Meandering found to be a natural geomorphic characteristic in rivers which results in erosion of the bank and gradual migration of the river's course (Ahmed and Fawzi, 2000) which is mainly due to the presence of loose bank material and lateral erosion. Erosion and deposition of river banks by water flow and flood are natural phenomena which cause channel movement. The denudation processes on the earth surface like weathering and erosion also responsible for changes in landform. Variety of natural and anthropological agent's activities are causing continuous changes upon earth

surface. These agents cut, carry, away and deposit the materials from land surface. Erosion may be caused either by undercutting of the upper bank materials by channels during the high floods producing an overhanging cantilevered block that eventually fails or by over steepening of bank materials due to migration of the river channel (Gogoi and Goswami, 2013). Running water has higher capacity of erosion than the other geomorphologic agents (Aher *et al.*, 2012).

Channel migration is a natural process which is mostly associated with river system. Streams may migrate across valleys due to a various reasons including channel and bank erosion, meander chute cutoff, avulsion, aggradation and incision. The channel migration zone represents the area within which a stream may migrate over time and cause hazard. Channel migration is an important stream ecosystem process supporting habitat forming processes and ecological functions. The channel migration process is also an important risk factor for humans and infrastructure in that migration can result in property damage and change flooding dynamics. The dynamics of river channels are required to maintain the health of riparian ecosystems, but without proper land-use planning, river meandering and migration can threaten floodplain areas and nearby agriculture land (Micelle *et al.*, 2004). River bank erosion plays an important role in control of channel stability and bank erosion has significant contribution to the sediment load.

Water erosion is a worldwide threat which is potentially diminishing ecological functionality and food production capability and cause repetitive damage to built up infrastructure (Boardman, 1998; Valentin *et al.*, 2005). The complete knowledge and understanding of these mechanisms are very important for conservation implication. Running water has higher capacity of erosion than the other geomorphologic agents. In

monsoon, floods and flows of river water erode the bank of the river and during the winter, the water level of the river goes down and sandbanks are deposited alongside the riverbanks (Ahar *et al.,* 2012). River bank erosion effect the vegetation growth and causes degradation of fertile soil.

Remote sensing and geographic information systems provide tools for quantitative and qualitative land cover change and river channel monitoring studies. Remote sensing and GIS techniques are important tools for detecting the type of changes, location of the changes and quantifying the changes taking places in an environment (Joshi and Nagare, 2009). Use of RS and GIS techniques to detect changes in the land use-land cover is an emerging trend in the recent researches carrying out in different parts of India and abroad. Remote Sensing (RS), Geographical Information Systems (GIS) and Global Positioning Systems (GPS) facilitate environmental change detection, analysis, and monitoring. Remote sensing and Geographical Information Systems (GIS) are powerful tools to derive accurate and timely information on the spatial distribution of land use/land cover changes over large areas (Sarma *et al.,* 2007). Remote sensing satellite data having ability to provide comprehensive, synoptic view of fairly large area at regular interval with quick turnaround time integrated with GIS techniques makes it appropriate and ideal for studying and monitoring river erosion and its bank line shifting. Change detection and estimation of erosion and deposition of riverbanks are facilitated by application of RS, GIS and GPS (Ahar *et al.,* 2012; Joshi and Nagare, 2009). GIS is a very efficient tool in the process of identification and mapping of river changes and bank erosion. Digital change detection helps in identifying change between two (or more) dates that is uncharacterized of normal variation and Change detection is useful in many applications such as land use changes,

habitat fragmentation, rate of deforestation and other cumulative changes through spatial and temporal analysis techniques such as GIS and Remote Sensing (Wijitkosum, 2012).

Forest and land cover change detection is one of the major applications of satellite-based remote sensing. The present study has been carried out to assess the forest loss by using remote sensing and GIS technologies in Sonai-Rupai wild life sanctuary. The sanctuary is under great threat of forest loss and degradation which is ultimately affecting its rich biodiversity. The rivers within the sanctuary are very meandering and show channel migration which results in erosion and deposition of river banks. The aim of this investigation is to estimate the eroded and deposited riverbank areas from 1960 to 2005 and to identify the forest loss due to river migration through remote sensing and GIS technologies.

9.2. Materials and Method

9.2.1. Data Used

The study is carried out with the help of Remote Sensing data, topographic sheet and the ground truthing data collected from the field survey. Data from Survey of India (SOI) topographic maps (83 B/5 and 83 B/9) scale of 1:50,000 survey on 1959-1960 and 1960-61 and LANDSAT data acquired on monsoon and post monsoon were used for land use classification. The spatial resolution of Landsat imagery is sufficient to identify and monitor the dynamics of river systems such as migration of the confluence point of rivers, movement of river channels and eroded and deposited riverbanks. Monsoon and post monsoon data were used to check the hydrological variability. The spatial resolution of Landsat imagery is sufficient to identify and monitor the dynamics

of river systems such as migration of rivers, movement of river channels and eroded and deposited riverbanks. The Landsat images used in this study have been downloaded from GLCF, ESDI and Landsat.org. Landsat TM (30 January 1988 & 24 December 2001) and ETM+ (30 Jan 2005) images of path 136 and row 41 were used in this study. Landsat TM and ETM+ have 30 m spatial resolution. These images are projected and corrected geometrically by GLCF using the UTM projection method. These images are ortho rectified. For this reason, geometrical corrections of landsat images are not needed (Mundia and Murayama, 2009; Sarkar *et al.,* 2012). Layer stacking of the landsat images have been done in Erdas 9.1 software.

9.2.2. Methodology

Geographic Information systems (GIS) and Remote Sensing (RS) are used in data encoding and analyzing purposes. ArcGIS 10 and ERDAS Imagine 9.1 version software and human interpretation have been used in extracting the data from the high resolution remote sensing image. The interpretation results are processed under the above environment by applying multi-temporal approach. The data of river channel migration is extracted from the available satellite imagery in different time period, based on spatial overlays techniques.

The base map of the study area was prepared by using survey of India toposheets. The toposheets were geometrically corrected in the Arc GIS 10 software. For georeferencing, Kalianpur 1975 geographic coordinate system was used as survey of India toposheets have been prepared by using Kalianpur 1880 Datum. The geographic transformation of Kalianpur 1880 datum is not available in the software so we are using Kalianpur 1975 which is very close to it. Then the toposheets were

transformed to WGS84 Geographic Coordinate system which were than projected in Universal Transverse Mercator projection WGS 1984 UTM Zone 46 N. The preparation of base map of the study area is the first step in the analysis of land use and land cover. Various features like roads, track, location or any other land based features were transferred to the base map. For this Personal Geodatabase were created in Arc GIS 10 in which different feature classes were created. The Base Map of the study area has been shown in ***Fig.1***. Base map is prepared in 1:75,000 scales. Digital Elevation Model (DEM as TIN) was produced from the standard topographic maps with the scale of 1:50.000. DEM was created in ArcGIS10 by using contour line. Contours are polylines that connect points of equal value of elevation. The contour lines were digitised from Survey of India topo-sheets with an interval of 20 m. Contour map is a useful surface representation because they enable to simultaneously visualize flat and steep areas, ridges, valleys in the study area.

The land-use/vegetation map of 1988, 2001 and 2005 was derived from the visual interpretation of satellite data. Land-use/Land-cover categories such as Forest cover; river, oxbow lake, grassland, etc. have been identified and mapped from the SOI topographic sheets. The land-use of 1960 (1959-1960 & 1960-1961) was mapped, classified and calculated accurately from the topo-sheets and it was compared with those prepared from the satellite imageries. For land-use class also Personal Geo-database was created. Land-use/Land-cover is prepared in 1:75,000 scales. Eroded and deposited land-cover formed by the river channel migration was finally estimated in Arc GIS 10.

Results of interpretation and extracted layers from satellite images were transformed into GIS layers in vector format. Erosion and accretion of the river were

digitized considering three different decades with vector shape file. River channel migration and change was detected by superimposing data layers together by the order of raster-vector or vector-vector. Data of different periods i.e. 1960-2005 were considered for erosion and deposition area calculation.

Boundary of river areas in 1960, 1988, 2001 and 2005 are digitized through visual interpretation. The digitized layers were analysed and compared pair wise to identify eroded and deposited areas. Overlay analysis between the year 1960-1988, 1988-2001 and 2001-2005 has been carried out to find out the eroded and deposited area and eroded and depositional layer was created. In overlay analysis union was used to find out the eroded and deposited layers and land use/ land cover map of eroded and deposited area was prepared by clipping from the 1960, 1988, 2001 and 2005 land use/ land cover map with the eroded and deposited union layer.

9.3. Results and Discussion

River channel migration is found to be one of the important factors for land cover changes in the sanctuary. The rivers flowing through the sanctuary are generally braiding in nature and river erosion is a common problem identified in the study area. Changes in land-use/land-cover were evaluated from the differences between 1960, 1988, 2001 and 2005 status. The land use pattern of an area depicts an idea of overall areal utilisation of resources - natural or cultural. The analysis of Landsat images revealed that the migration of river course with time and space. The most striking change in land-use/land-cover has been the sharp increase in degraded area or bare land. It shows that there is a tremendous decrease in forest cover since 1988 to 2005. River channel migration within the sanctuary was investigated and the changes in channel

characteristics during the period 1960 to 2005 have been studied. The base map (***Fig. 9.1)*** shows river channel migration for different time scale within the sanctuary.

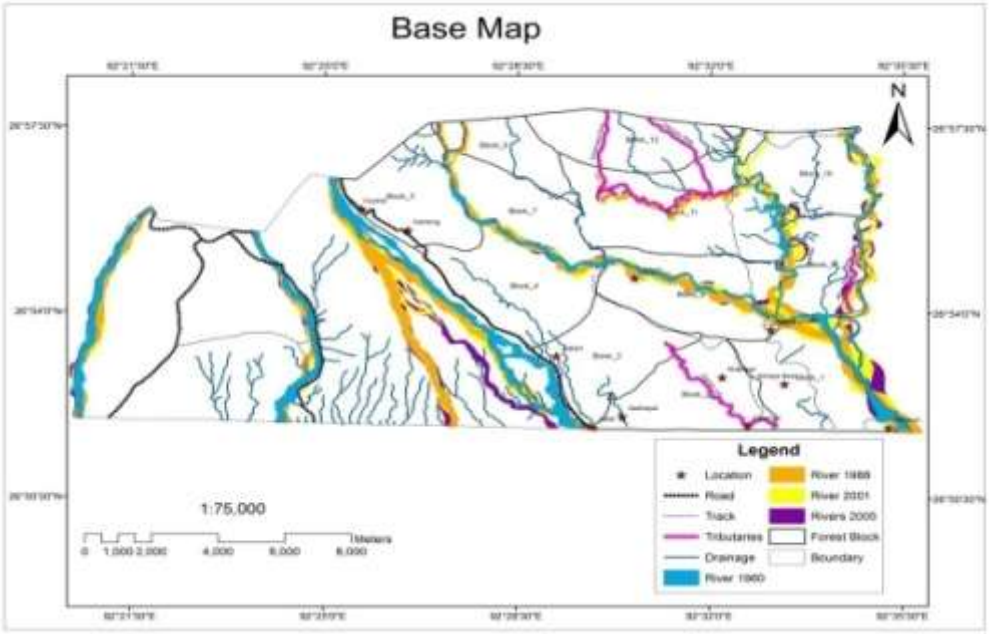

Fig.9.1: Base Map of the study area with River Migration

Digital elevation model (DEM) is a GIS based model which is prepared to show the relief and height of the landscape. The prime requirement to prepare this model is the altitude information or the contour lines. Here in this study a DEM of Sonai-Rupai wild life sanctuary is prepared to show the different altitude zones and also the represent the relief of the sanctuary. Contour lines were digitized from survey of India topo-sheets at 20 meter. It has been observed from the analysis of Digital Elevation Model (as Triangular Irregular Network, TIN) shown in ***Fig.9.2*** that the channel migration is closely related to slope of the study area.

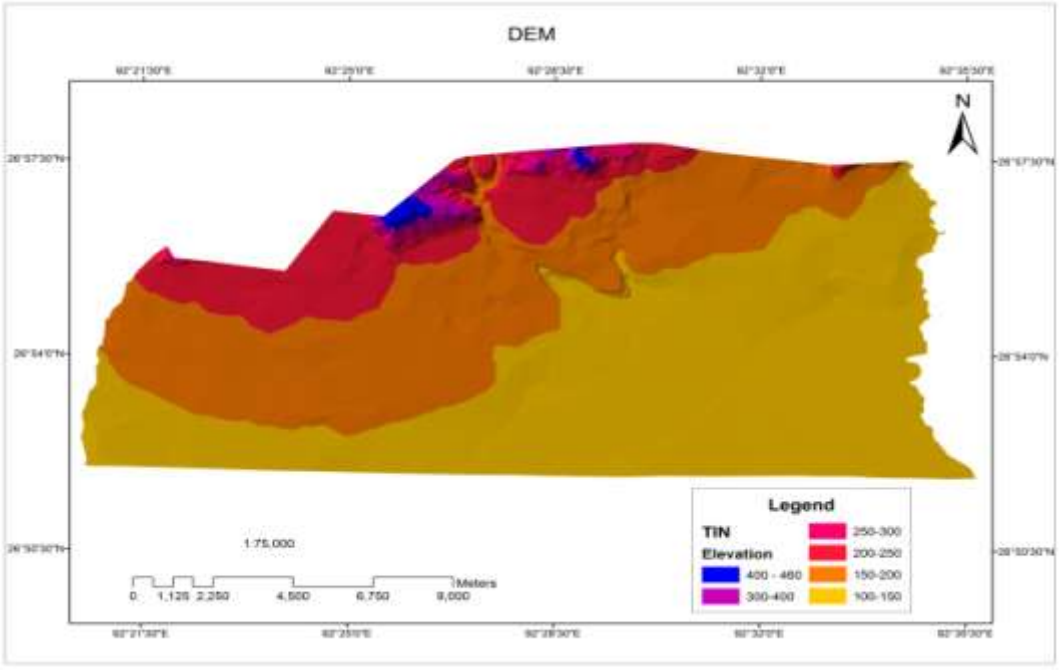

Fig. 9.2: DEM (as TIN)

Geological and topological settings are the important factors that control the behaviour of the river migration. As the river flows from north to south and also steepness decreases towards the south, it clearly indicates that channel shifting and migration is dependent on steepness of an area. Because of steepness of the area water flows with much higher velocity and increases the chance of erosion. The variation in slope aspect of the bed of the river is also not same.The calculated result and visual observation from the satellite imagery shows that the lower most part of the river system shows severe erosion.

The rivers are perennial in nature. It has been seen that during the period of monsoon because of flood and flow of the river water the banks are eroded and as the water level of rivers goes down in winter sandbanks alongside the riverbanks are formed. Due to this of continuous process of erosion, deposition and extension of sandbanks cause channel migration. According to Schumm and Litchy (1963), floods of very high magnitude may be a contributing factor to channel widening and river bank

erosion along with associated changes in the channel pattern. Heavy flooding causes abrupt changes in the flow pattern of the rivers (Gogoi and Goswami, 2013). Channel migration is affecting the land cover in the sanctuary. Total area covered by the rivers in 1960 was 11.67 km^2 which increased to 16.12 km^2 in 1988. During 2001 and 2005 river areas were 19.25 km^2 and 19.07 km^2 respectively. Various natural and man-made causes are responsible for the channel migration. During the period of monsoon, especially in the month of July, August, and September, the rivers are facing flood problems. Flood due to River Belseri and Gabru are causing loss of agricultural land. Because of loss of agricultural land, villagers are moving to forest areas for the agriculture opportunities. The some villagers are also involved in illicit cutting of forest in present in the bank of river. This clearing of forest cover near the river bank increased the activity of erosion.

9.3.1. Quantification of Erosion and Deposition

Erosion is also affected by many natural factors such as rainfall, vegetation cover, river bank soil stability, river sediment, bedrock characteristics, relief-slope characteristics, and hydraulic conditions (Aher *et al.*, 2012). Human activities such as clearing of vegetation along the river banks, construction in river bed, sand, gravel and fertile soil extraction, large scale deforestation and collection of sand and pebble are accelerating the rate of erosion and sedimentation. Removal of riparian forest vegetation appears to accelerate migration rates and increase bank erodibility by roughly 80 to 150 % (Micheli *et al.*, 2004). The river that flows into passage of plain region has high capabilities of erosion due to fertile and loam structures of soil (Aher *et al.*, 2012). It has been seen that the upstream part shows moderate erosion as compare to its lower part.

The erosion on the river banks led to a decrease in forest area and agricultural land. River channels are changing due to erosion and deposition of the river banks. From 1960-1988 estimated erosion was 9.81 km^2 and deposition was 5.27 km^2. During this period, rate of erosion was much higher than the rate of deposition. It was also estimated that forest loss due to erosion was 7.61 km^2 and deposition of forest cover was found to be 3.3 km^2. There was a net loss of 4.29 km^2 of forest cover due to river channel migration during the period 1960 to 1988. From 1988-2001 estimated erosion was 6.16 km^2 and deposition was 3.52 km^2. In this period also rate of erosion was higher than the rate of deposition. Forest loss due to erosion was 4.68 km^2 and deposition of forest cover 0.91 km^2. There was a net loss of 3.77 km^2 of forest cover due to river channel migration. During this period, there was more erosion than deposition which indicates that the rivers are getting wider. From 2001-2005 estimated erosion was 4.3 km^2 and deposition was 4.9 km^2. During this period rate of deposition was higher than the rate of erosion and it was found that forest loss due to erosion was 1.01 km^2 and deposition of forest cover was 1.09 km^2. Fig.9.3 shows the areal extent of rivers within the sanctuary from 1960 to 2005. Graphical representation of eroded and deposited land cover is shown in **Fig.9.4**, ***Fig.9.5*** and ***Fig.9.6.*** The areal statistic is calculated in km^2. The year wise data of the last three decades on erosion and deposition are calculated and are represented in Graph. The erosion and deposition bar diagram indicates increase in erosion in between 1960-1988 and 1988-2001 periods.

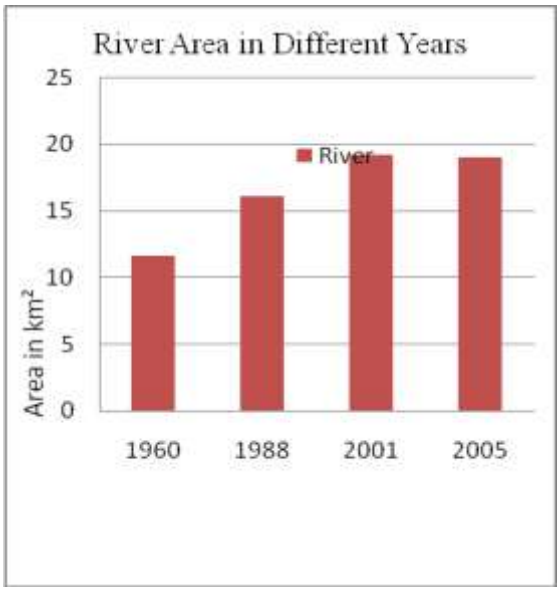

Fig.9.3: Area extent of river within the sanctuary

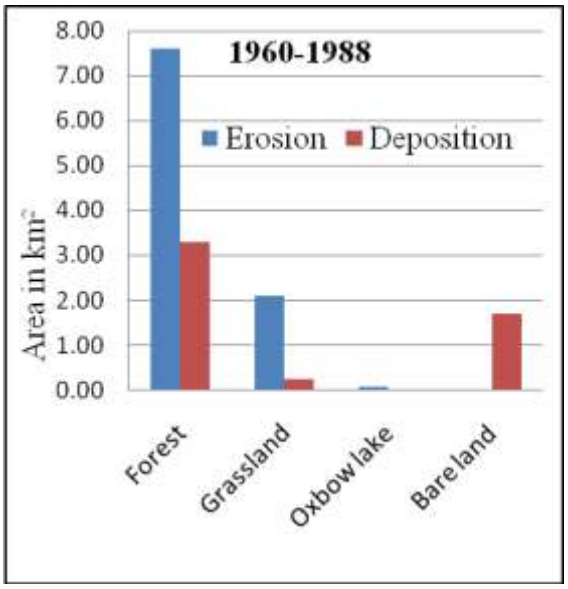

Fig.9.4: Eroded and deposited land cover during 1960-1988

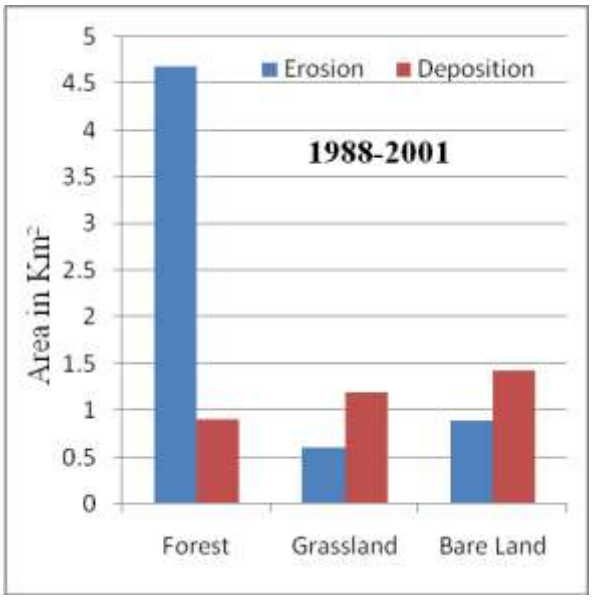

Fig.9.5: Eroded and deposited land cover during 1988-2001

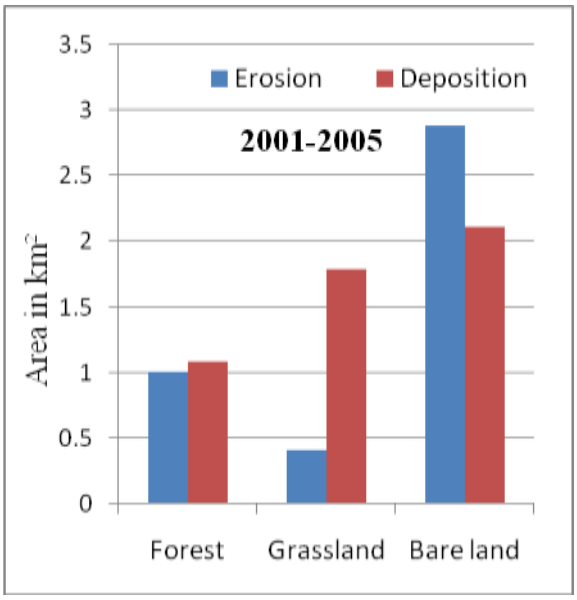

Fig.9.6: Eroded and deposited land cover during 2001-2005

The overall rate of change, erosion and deposition has and its location has been change over the years. Net change in land use/land cover due to river migration is shown in ***Table 9.1***.

Table 9.1: Change in land use due to river channel migration during 1960s-2005

Class	1960-1988 (km^2)	1988-2001 (km^2)	2001-2005 (km^2)
Forest	-4.29	-3.77	0.08
Grassland	-1.86	0.59	1.38
Oxbow lake	-0.08	-	-
Bare Land	-	0.54	-0.77

From the visual interpretation with GIS and Remote Sensing investigation, it is clearly observed that the study area is facing erosion and deposition in different spot. The erosion and deposition rate also varied in different parts of the study area. River channels are moved by erosion and deposition following their direction. River channel are changing over time due to erosion and deposition. River channels are shifted by erosion and deposition following their direction. The eroded and deposited land cover map for the year 1960-1988, 1988-2001 and 2001-2005 is shown in ***Fig.9.7, Fig.9.8*** and ***Fig.9.9.***

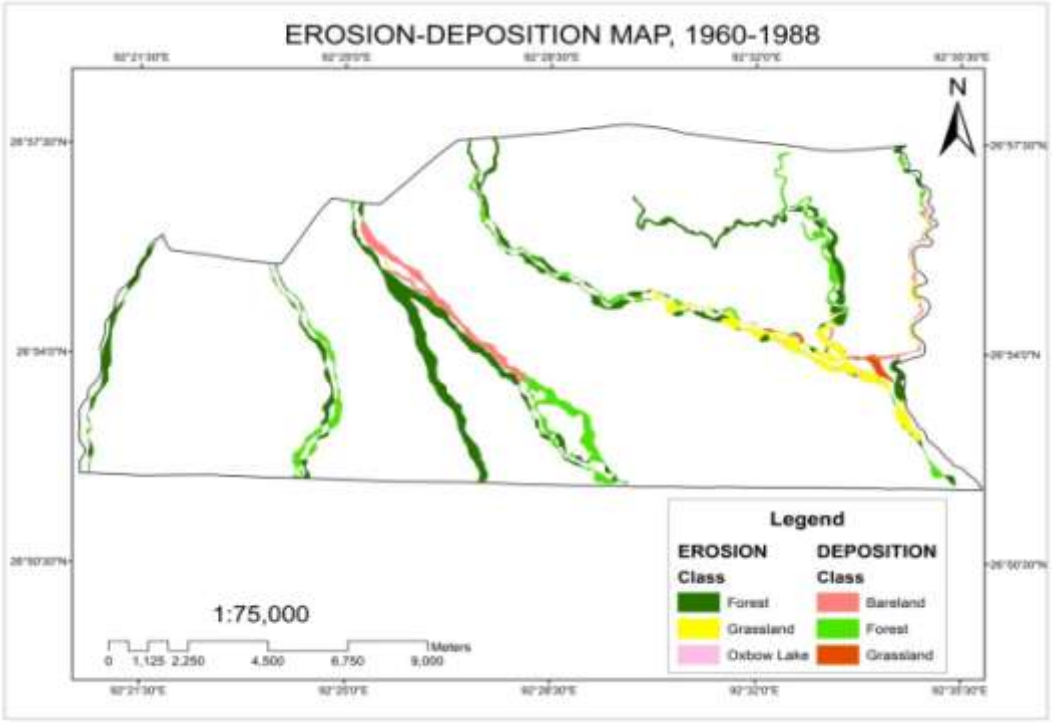

Fig.9.7 : Erosion –Deposition Map for 1960-1988

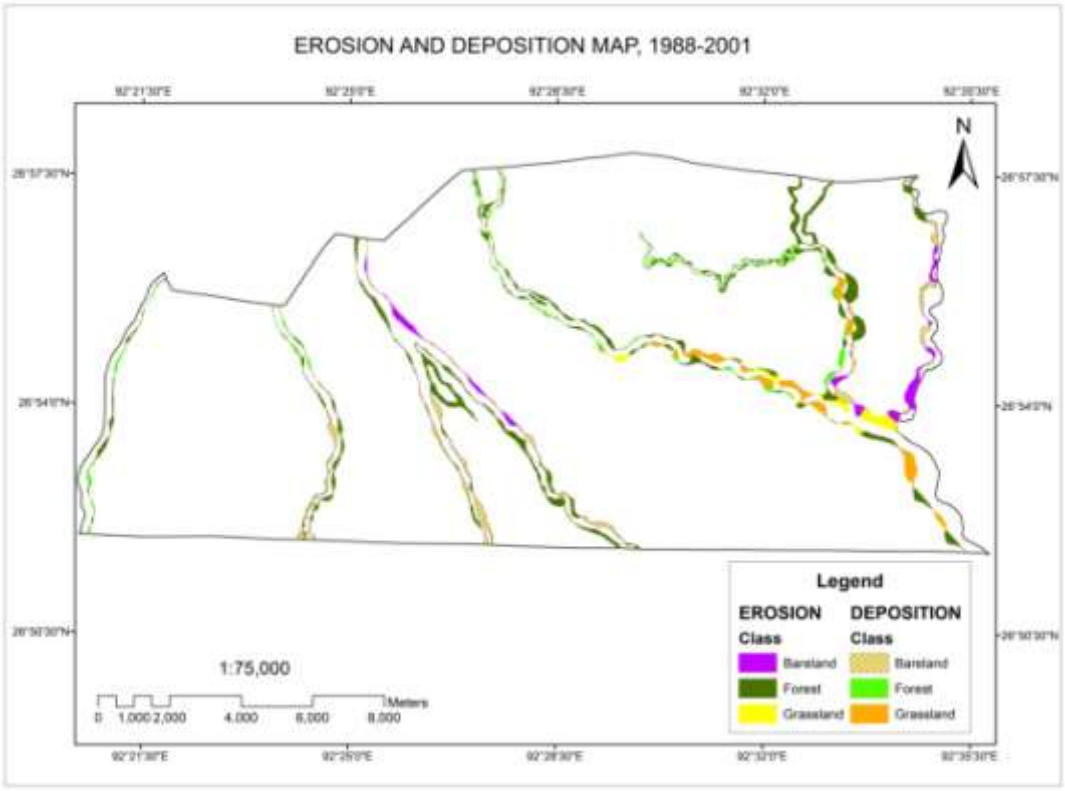

Fig.9.8 : Erosion-Deposition Map for 1988-2001

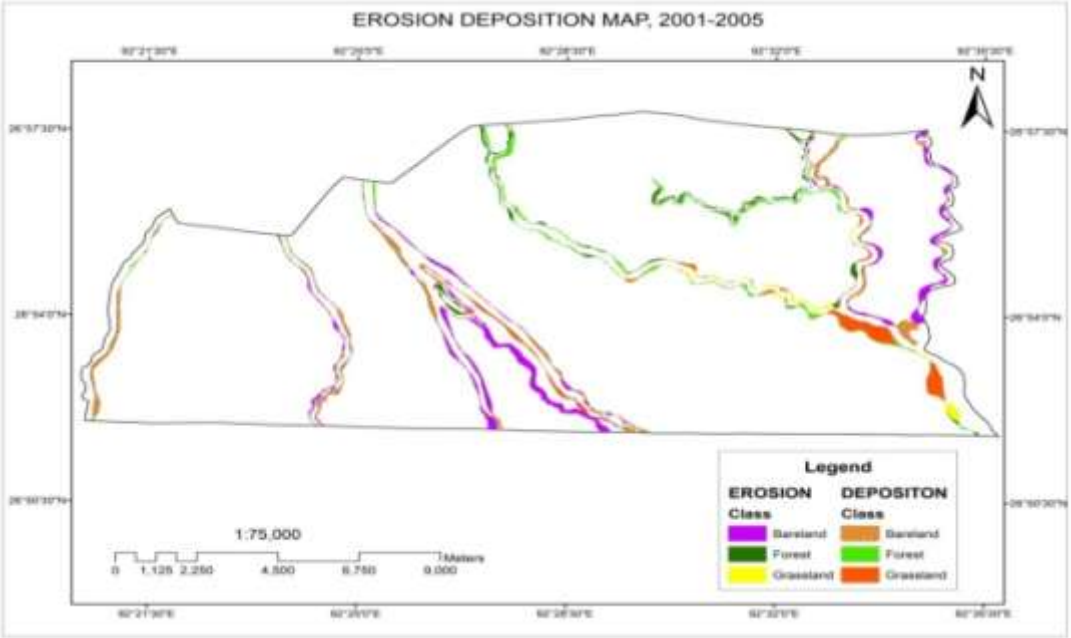

Fig.9.9 Erosion-Deposition Map for 2001-2005

The general trend of channel movement of the River Belseri is towards the west. Anthropogenic factors are also responsible for bifurcation of river Belseri. A large part of agricultural land as well as homestead plantation and rural settlements are affected by erosion every year. Various flood and erosion protection measures such as earthen embankments, spurs, porcupines etc. are used to protect the area. But they are not enough as a long term measure. Local villagers have made embankment in the bank of river to protect their agriculture field from flood which results floods, erosion and sedimentation on the other side of the river bank. It is evident that the problem of river flooding is getting more and more acute due to human intervention in the fragile highland areas.

In 1988, it was found that 10.01 km^2 of forest land was fragmented by river Belseri and in 2001 this 10.01 km^2 of forest land has been converted to deforested land. This has resulted in habitat loss which has affected the biodiversity of the sanctuary. In

2005 also, it has been seen that new channels are opening up and the river Belseri is shifting towards its west. It has also been found that erosion due to river Belseri is higher in lower part of the sanctuary which is a flat terrain. It also shows that river Chapnoi and Pachnoi are very stable rivers as compared to Belseri and Gabru. The study also shows that Belseri is the most meandering river which opens up new channel which is causing forest fragmentation and which ultimately lead forest degradation. There is no recognizable trend observed for the River Chapnoi and Pachnoi. River Gabru is also meandering river which doesn't show any trend of channel shifting but it erodes the side of the bank. It is estimated that 3.7 million hectares of agricultural lands have been rendered wastelands in India due to intense rill and gully erosion (Joshi and Nagare, 2009). Flood and erosion has lead to channel migration of the Subansiri River in Assam where Erosion is more pronounced in both banks than the sedimentation (Gogoi and Goswami, 2013). Activities such as land clearing for agriculture may increase the magnitude of flood which increases the damage to the property and life.

9.3.2. Causes of Channel Migration

Besides the geomorphological causes, different human activities have also influences the erosion of the river banks in the sanctuary. Earlier river bank were covered with dense vegetation which protect them from heavy flood and erosion. During the last few decades encroachment and deforestation due to illegal logging has made the forest prone to erosion. In late 1980s and 1990's people from different part of the state came to the district (Sonitpur) for livelihood opportunities. They start clearing the forest for their settlement and agriculture.

9.3.3. Effects of Channel migration on Wildlife Habitat

Channel migration is a natural characteristic in river which results in erosion, deposition and sedimentation. Consequently the river erodes, deposits and migrates for a long distance causing severe damage to the surround landscape. The natural character of the river is that it erodes one side of the bank and the eroded particles are deposited in the opposite sides. The fertile soil and plants species near the river bank are removed by these activities. This causes the degradation of the fertile soil which has higher capacity of productivity and efficiency. Sediment deposits make the soil unsuitable for agriculture. Because of the decrease of the fertility of agricultural land, people shift to other place in search of agriculture land and thereby causing forest clearance in the sanctuary. The deposition of sand and gravels creates difficulties for the inhabitants of the vegetation also. Because of the sedimentation on the river bed, floods in the rivers increase.

River Channel Migration for different years is shown in ***Fig.9.10, Fig.9.11*** and ***Fig.9.12.*** Channel migration is also responsible for creating abandoned channels which were used to serve as a wildlife habitat. This has resulted in habitat loss in the study area. Plate 9.1 shows abandoned channel of River Gelgeli. The abandoned channel has only sand and gravels which affects the vegetation growth. The growth of vegetation on theses abandoned channel is not occurring.

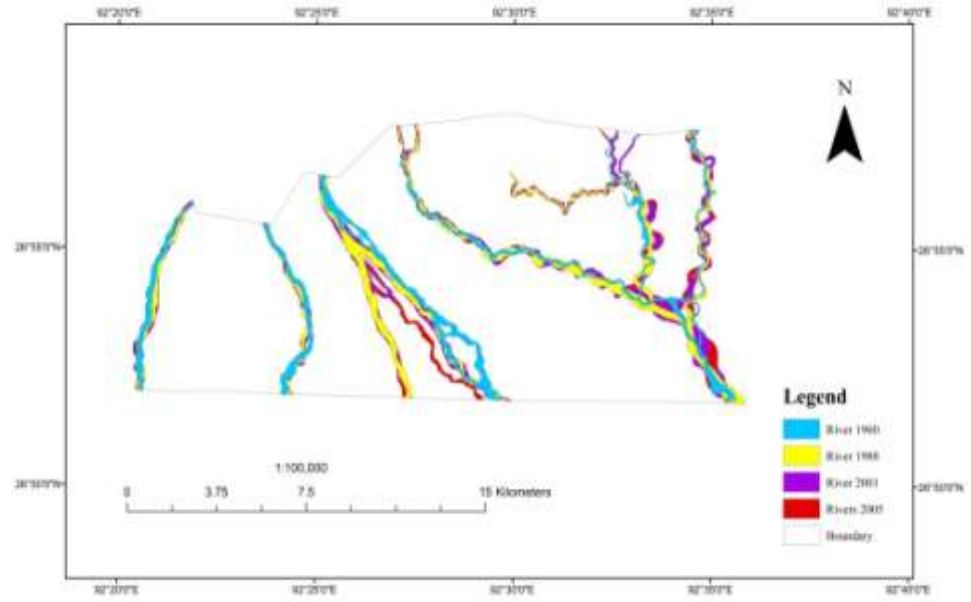

Fig 9.10: River Channel Migration for different Years

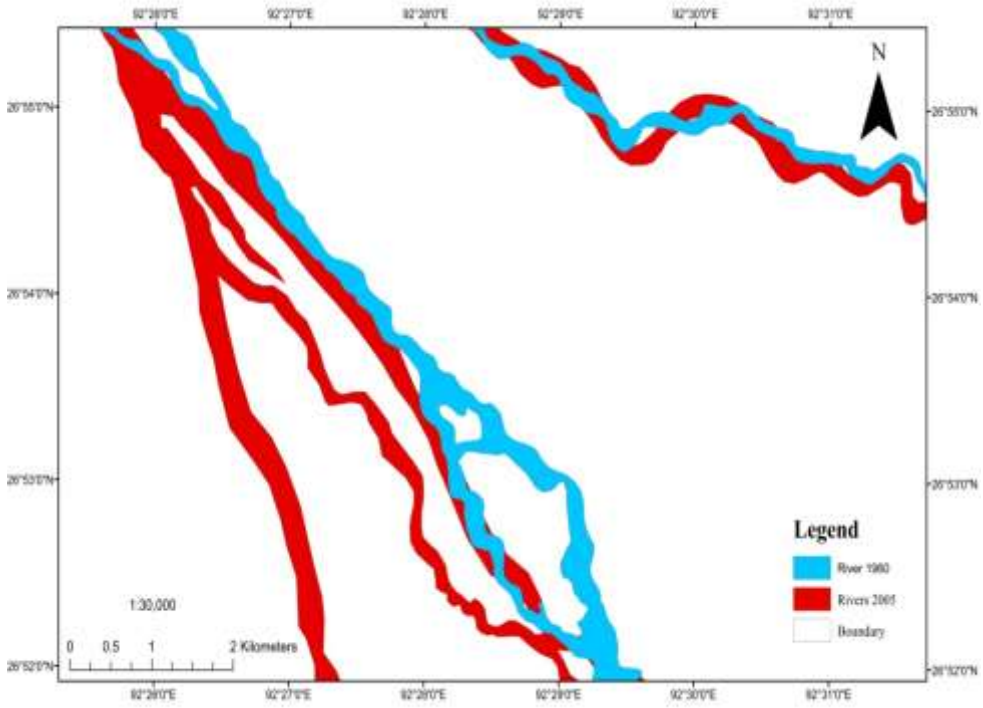

Fig. 9.11: Maps showing River Channel Migration for River Belseri

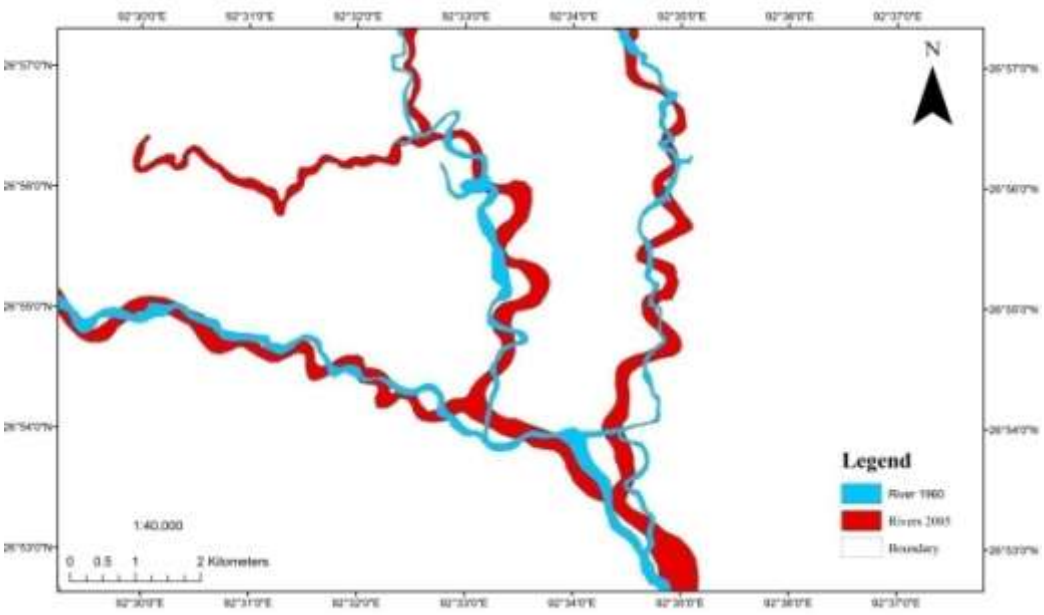

Fig. 9.12: Maps showing River Channel Migration for River Gabru

9.3.3.1 Deforestation and Forest Fragmentation due to Channel migration

River channel migration and flood is causing loss of forest land by causing deforestation and forest fragmentation. It has been seen that the rivers flowing through the Sanctuary are disastrous in nature especially during rainy season. When the river enters into the plain from the higher gradient of foothills of Arunachal Pradesh spreads its enormous discharge and takes meandering course in the downstream. The Rivers are characterized by its exceedingly high flow during rainy season which changes its channel morphology and bank line shifting. The lateral migration of the river bank line is causing loss of forest land every year. The frequency of bank erosion of the river is the maximum after monsoon when there is decrease in rainfall intensity but has high water flow. The recession of water level cause disequilibrium between the water level and river bank which results in the loss of soil cohesive strength which leads to bank erosion.

(a)

(b)

Plate: 9.1 (a & b): Showing Abandoned Channel of River Gelgeli

(a)

(b)

Plate 9.2 (a) & (b): Showing Sedimentation due to River Gelgeli

In the study area the river has mostly eroded the sanctuary land and agriculture land. River Gabru and Belseri is the most meandering river flowing through the sanctuary. These two rivers are causing erosion and deposition phenomenon and are causing forest degradation and fragmentation. The deposition of silt and sand has made the soil infertile and unfavourable for the growth of vegetation.

The socio-economic impact of this type of change is very much significant. Due to the erosion of the agriculture and resident areas the people had to migrate to another places and have to start a new life. They occupy forest land for their livelihood which is causing loss of forest land and fragmentation of the natural habitat. Sedimentation due to River Gelgeli is shown in ***Plate 9.2 (a) and (b)*** where it can be seen that sands and gravel has been deposited in a vast area. Forest loss due to erosion by River Gelgeli is shown in ***Plate 9.3 (a) & (b)*** and in River Belseri is shown in ***Plate 9.4 (a) & (b)***. Forest loss and bank erosion is shown in ***Plate 9.4 (a), (b), (c) & (d).*** It is observed that huge bank erosion is occurring in the bank of River Gabru. The construction of heavy embankment is also not sufficient to control the bank erosion as shown in ***Plate 9.5 (a) & (b).***

(a)

(b)

Plate 9.3 (a & b): Showing Forest loss and erosion near River Gelgeli

(a)

(b)

Plate 9.4 (a & b): Showing Forest loss near River Belseri

a) 2013

b) 2014

c) 2014

(d)2015

Plate 9.5 (a, b, c & d): Showing Erosion by River Gabru in different years

(a) 2017

(b) 2018

Plate 9.6 (a & b): Showing Bank Erosion by River Gabru

9.3.3.2. Effects on Soil Quality

Channel migration is causing loss of forest cover and fertile soil every year due to erosion and sedimentation. The deposition of sediment on the soil makes it infertile and unfavourable for the growth of green cover. The soil quality of different land use in the sanctuary was carried to study the nutrient status of the soil. The soil was analyzed from forest, grassland and bare land. Barren land was once dense forest but due to deforestation and illegal logging the green forest cover was removed. This barren land has created fragmentation between two forest landscape. The long term effect of deforestation on the soil resource can be severe. Forest floors with their leaf litter and porous soils easily accommodate intense rainfall where as barren land cannot hold the water thus causing surface runoff and soil erosion.

Litterfall and its decomposition is one of the major ecological aspects of forest which regulate nutrient cycle through plant-soil system. The physicochemical properties of soil are related to growth and metabolism of plant and soil fauna. Moreover, litterfall increases infiltration and aggregation capacity of soil along with increase in its fertility, which subsequently reduces surface runoff due to growth of vegetation. Forest litter protects soil particles by reducing impacts of raindrops. Forests in general have a greater influence on soil conditions than most other plant ecosystem types and maintaining moderate temperature, and humidity at the soil surface, input of litter with high lignin content, high total net primary production, and high water and nutrient demand. It was found high organic content in forest soil then the grassland and barren land. Barren land has lost it nutrient content due to erosion and compaction. Soil Erosion has washed out the nutrient which is mainly present in upper layer. Nneji (2013) have also reported that

deforestation is one of the major factors that take away about 14million tones of soil essential nutrients.

9.3.3.3. Effects on Water Quality

It has been found that Deforestation also disrupts the global water cycle. Urban water protection is potentially one of the most important services that forest provides (Chomitz *et al.,* 2007). Water resources affected by deforestation include aquatic habitats, flood/drought control, siltation, damage to crops and irrigation systems from erosion and turbidity (Anon., 1994a; Bruijnzeel *et al.,* 2005). Forests can reduce the costs of doing so either actively by filtering runoff or passively by substituting for housing or farms that generate runoff (Dudley and Stolton, 2003). Deforestation is known to results in soil compactions which make them unable to absorb rain which causes stream flow faster causing flash flooding (Chomitz *et al.,* 2007). With the removal of part forest, the area cannot hold as much water creating a drier climate. Deforestation is also known to result into watersheds that are no longer able to sustain and regulate water flows from rivers and streams. Deforestation and other land use changes have increased the proportion of the basin subject to erosion and so over the long run have contributed to siltation.

From the water quality study it was found that water near the deforested land was found to be highly turbid increasing the suspended particles. The deforestation in the river bank areas and agricultural boundary has resulted in erosion of the river bank which has resulted in high suspended solid in the water. In the study area, heavy siltation has raised the river bed which has also increased the risk of flooding. Similar results were found in Yangtze river basin in China (Yin and Li, 2001; Bruijnzeel *et al.*,

2005). The downstream flow causes soil erosion which also causes silting of water courses.

9.4. Conclusion

Forests are the natural resources which have been degraded during the last few decades continuously either by natural or through man-made activities in the study area. The study has been done to understand the changes and estimate the forest loss caused by river migration in the forest areas of the sanctuary using remote sensing and GIS. The rivers in the sanctuary are characterized by frequent bank erosion leading to channel pattern changes and shifting of bank line. Forest areas in the bank of river have been reduced considerably during the period of 1988 to 2005. It was found that river Belseri flowing across the sanctuary is the most meandering river which opens up new channel leading to bifurcation of the forest and which is resulting in fragmentation. River Gabru is the most devastating river, which is causing severe flood and bank erosion in the study area.

The resulted river migration has subsequently caused fragmentation, which has resulted in degradation and loss of forest cover. Channel migration is responsible for changing physical characteristic of river and its surrounded environment and is also affecting soil and water quality. The conservation and management of biodiversity along a river depends on the maintenance of essential ecological processes, such as periodic floods, water flows, and specific rates of sediment transport. So, proper management practices should be adopted for conservation of the river in the sanctuary.

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