GEOSPATIAL WORLD FORUM
18 - 21 January 2011, Hyderabad, India
Theme
Dimensions and Directions of Geospatial Industry

Paper Reference Number: PN-366

Land Cover Change Dynamics and Future Implication Analysis in Rajiv Gandhi Orang National Park of Assam, Using Multi-Temporal Satellite Data

Pranjit Kumar Sarma[1]
Email: prangis@gmail.com

Prof. B.S.Mipun[2], Ajit Kumar Basumatary[1], Bibhab Kumar Talukdar[1], Rajiv Kumar[3], Sankar Prasad[3]

Author (s) affiliations and mailing address:

[1] Aaranyak, 50, Samanwoy Path (Survey) Beltola, Guwhati – 781 028, India.

[2] Department of Geography, North Eastern Hill University, Shillong – 793022, India.

[3] National Remote Sensing Centre, Balanagar, Hyderabad – 500 026, India.

ABSTARCT:

The Rajiv Gandhi Orang National Park (RG Orang NP) is an important protected area in North East India. It is one of the potential habitats of one horned rhino in the world. Satellite imageries of 1987, 1999 and 2008 were used to evaluate the land cover change dynamics in RG Orang NP. Results indicate massive changes in the vegetation and overall habitat of the NP. Dry savannah grassland has a substantial increase from 8.73% in the year 1987 to 17.98% in the year 2008. Similarly Wet alluvial grassland has decrease from 38.87% in the year 1987 to 26.07% in the year 2008. In case of woodland there is an increasing trend from 18.26% in the year 1987 to 25.85% in the year 2008. It has also been observed that degraded grassland in the park has increased from 8.71% in the year 1987 to 15.22% in the year 2008. This land cover changes in the RG Orang NP were the result of non-implementation of habitat management/manipulation activities on time that are a prerequisite for supporting viable populations of threatend animal species like the greater one horned rhino. Similarly the rapid spread of invasive species like Mimosa invesa is also responsible for this land cover change in RG Orang NP. In this communication, we recommend a set of habitat management activities for restoration of key habitats in RG Orang NP.

Key words: Habitat change, land cover, remote sensing, satellite imagery, national park

Introduction:

Information on land use / land cover in the form of maps and statistical data is very vital for spatial planning, management and utilization of land for agriculture, forestry, pasture, urban-industrial, environmental studies, economic production, etc .(Chopra *et al*. 1997). Currently, with the growing population pressure, changing human population-land ratio and increasing land degradation, the need for optimum utilization of land assumes much greater relevance. Anthropogenic changes in land use and land cover are being increasingly recognized as critical factor influencing global change (Nagendra, et. al, 2004). While land cover and land use are often assumed to be identical, they are rather quite different. Land cover may be defined as the biophysical earth surface, while land use is often shaped by human, socio-economic and political influences on the land (Nagendra, et.al, 2003). Remote sensing, integrated with Geographic Information System (GIS), provides an effective tool for analysis of land-use and land cover changes at a macro, meso and micro level which could potentially enhance management of critical habitats for wildlife. The geospatial technology that combines the technology of remote sensing and GIS holds the potential for timely and cost effective assessment of natural resources. The techniques have been used extensively in the tropics for generating valuable information on forest cover, vegetation type and land use changes (Forman, 1995). In this current study remote sensing and GIS techniques have been used to study the land cover change and erosion and depositional changes in RG Orang NP of Assam taking a time scale of thirty years.

Study Area:

The RG Orang NP of Assam located in flood plain region of the river Brahmaputra. The park has been often regarded as the man made forest that lies within the geographical limits of 26˚ 29' N to 26˚ 40' N latitude to 92˚ 16' E to 92˚ 27' E longitude. Orang was earlier an abandoned village which later on transformed into a forest with sizable areas of grassland and wetland. The total area of the national park is 78.8 sq. km. Orang was declared as wildlife sanctuary in the year 1985 keeping in view the potential habitat of one horned rhino. In 1999, Orang was upgraded to a National Park. Figure 1 shows the location of RG Orang National Park. The average annual rainfall is between 2,000 to 3,000 mm, and average temperature in the winter season is 8^0 C which rises to 37^0 C in summer. Relative humidity varies from 60% in March to

95% in July. RG Orang National Park is the prime habitat of many threatened species like Greater Indian One-horned Rhino, Royal Bengal Tiger, Elephant, Water Buffalo, etc.

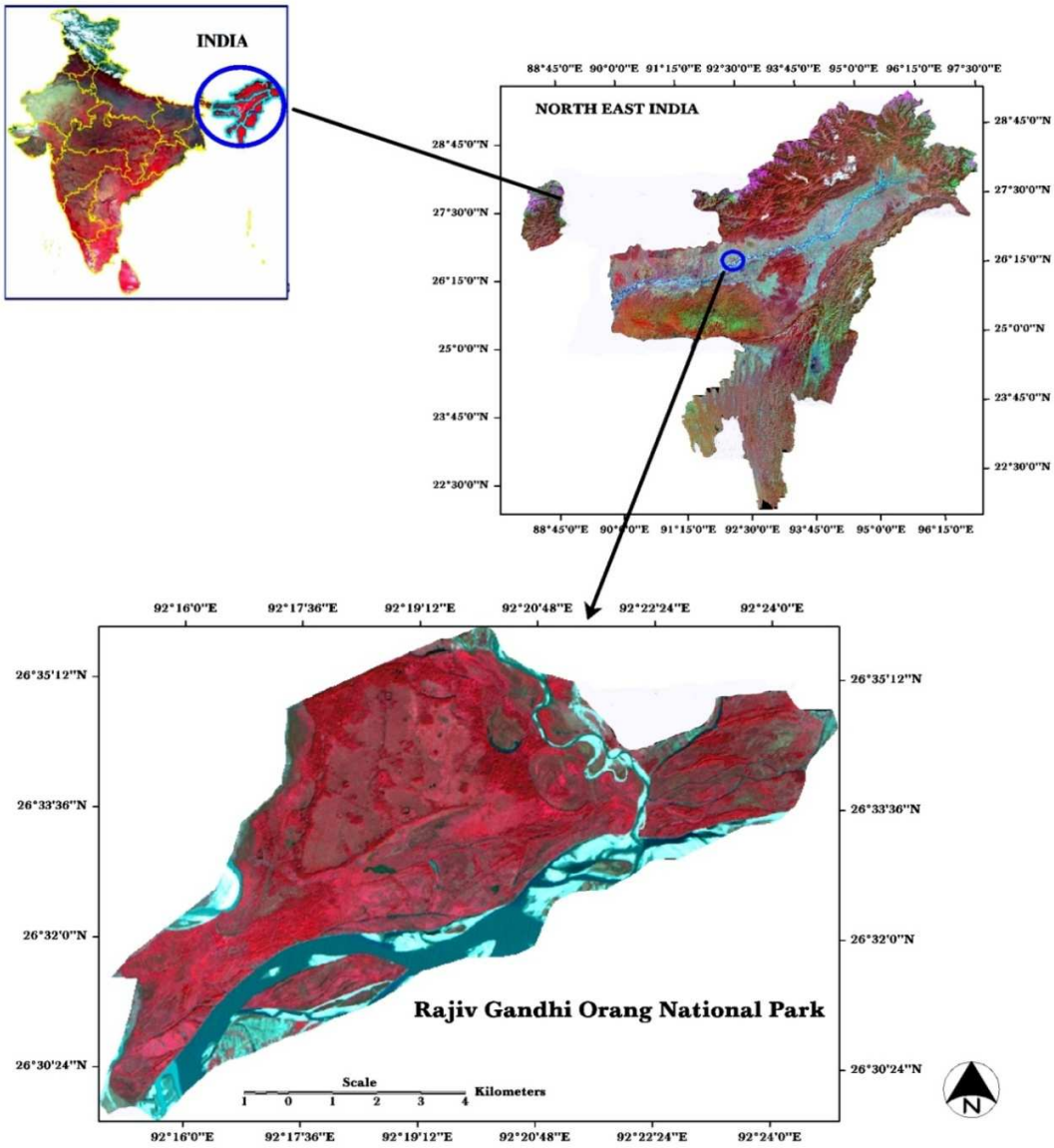


Fig. 1 – Location Map of Study Area

Materials and methods:

To analyze the land cover change dynamics in RG Orang NP multi date satellite imageries were used. Besides this the Survey of India topographical sheet no. 83 B/6 at 1:50,000 scale and also maps available with state forest department of Assam were used for delineation of forest boundary and to generate baseline information for the study area. The details of the datasets used in this study are given in table- 1.

Table-1 Datasets used

Data Type	Path/ Row	Date of acquisition
Landsat TM	136/42	26th December 1987
Landsat TM	136/42	19 December, 1999
IRS LISS III	110/52	08 November, 2008
Survey of India toposheets	No. 83 B/6 (1:50,000 sclae)	1974
Maps of State Forest Department	1:50,000 scale	1985

Satellite imagery of Landsat TM of 1987 and 1999 and IRS P6 LISS III of 2008 were used to analyze the land cover change dynamics in the RG Orang NP. The open source Landsat TM of 1987 and 1999 were downloaded from the NASA's Global Land Cover Facilitator's (GLCF) website (www.glcf/edu.org) and satellite imagery of 2008 was procured from NRSC, Hyderabad. The imageries were projected to UTM – WGS 84 projection system using Landsat ETM image as reference. Sub-pixel image to image registration accuracy was achieved through repeated attempt. Radiometric correction of all the images was done using dark pixel subtraction technique (Lillesand, et al 2004). Re-sampling of IRS P6 LISS III imagery was carried out at 30 m. pixel size as the other imageries (Landsat TM 1987 and 1999) were of 30 m. resolution. Subset operation of satellite imageries of 1987, 1999 and 2008 was carried out by creating an area of interest (AOI) layer of the vector layer of forest boundary of RG Orang NP, which was digitized from the published maps of department of forest and environment, Govt. of Assam at 1:50,000 scale. After sub setting, the images of the study area were processed through spectral enhancement technique using ERDAS imagine 9.1 software. Principal component analysis (PCA) was carried out to all the images. All the images were converted in to three principal components. PCA is often used as a method of data compression. It allows redundant data to be

compacted into fewer bands—that is, the dimensionality of the data is reduced. The bands of PCA data are non-correlated and independent, and are often more interpretable than the source data (Jensen, 1996; Faust, 1989). After generating the hybrid PCA images for all the years a supervised classification technique was used using maximum likelihood algorithm to assess the land cover change dynamics in RG Orang NP from 1987 to 2008. Since supervised classification is a process where the image analyst supervised the pixel categorization process by specifying to the computer algorithm, numerical descriptors of the various land cover types present in a scene (Lillesand, et al 2004). Many researchers have been using supervised classification technique to extract the features from the remotely sensed imagery, as it demonstrates the classification that can incorporate both the spectral and spatial features of the pixels in the image resulting in better defined categories in terms of its homogeneity (Fortain, et al., 1999, Idbrain, et al., 2006 and Dubeni, et al 2008). Ground verification was made during the period from March 2008 to March 2009 and based upon the ground data, classes were assigned in the PCA based images. After classifying all the images of 1987, 1999 and 2008 the post classification comparison method was used to detect the changes in land cover types in RG Orang NP. The method consist in overlaying, using a cross operation, the two images to be compared, previously classified. The cross operation allows the analyst to know the extent and nature of the changes observed, in other words, the transition between different land cover classes and the corresponding areas of change. Applying this method finally land cover change analysis of RG Orang NP was done. The output resolution of all the classified images was at 30 m. All these image processing operations were carried out in ERDAS Imagine 9.2 software.

Result and Discussion:

The entire RG Orang NP was classified using supervised classification technique in to nine land cover types based upon field knowledge and collected training sets of vegetation types. The nine classes are as follows

a) Mixed Moist Deciduous Forest (Dense)

b) Mixed Moist Deciduous Forest (Open)

c) Dry Savannah Grassland

d) Wet Alluvial Grassland

e) Seasonal Swamp Forest

f) Degraded Grassland

g) Water Body / River

h) Moist Sandy Area

i) Dry Sandy Area

The composition and distribution of land cover types is as follows

a) **Moist Deciduous Forest (Dense and Open) :** This comprises of tree species mostly belonging to moist deciduous forest represented by *Bombax ceiba, Lagerstroemia flosreginae, Careya arborea, Terminalia bellerica and Gmelina arborea* and their distribution is mainly concentrated in the relatively high altitude areas of the park. This land cover type covers an area of 13.22 sq. km of RG Orang National Park out of 78.8 km².

b) **Dry Savannah Grassland:** This type of grassland is dominated by tall grasses such as *Narenga porphyrocoma, Imperata cylindrica, Phragmites karka, Arundo donax, Saccharum spontaneum, Themeda arundinacea, etc.* This land cover type is mainly concentrated in the transition zones of high and low lying areas of the park. This land cover type covers an area of 21.39 km² of the RG Orang National Park.

c) **Wet Alluvial Grassland:** The area under this category of land cover is 22.78 km². This land cover type is scattered in all over the park area. It is characterized by pure patches of grassland and presence of water during the rainy season. This wet alluvial grassland plays a critical role in rhinoceros habitat utilization pattern as rhinoceros prefer to use this habitat throughout the year. This grassland type is mainly composed of *Alpinia allughas, Mikania scandens*, etc.

d) **Seasonal Swamp Forest:** This land cover type occupy an area of 4.1km² in RG Orang National Park. This is mainly found along the river Brahmaputra and the streams of the park. This is mainly composed of *Barringtonia* type of vegetation

e) **Degraded Grassland:** This type of grassland covers and area of 5.77 km² area of RG Orang National Park. These are mainly found in the eastern and western boundary of the park.

The main cause behind the formation of degraded grassland is the over grazing by cattle that comes from the nearby villages.

f) **Water Body:** The area under water bodies is 6.35 km². The river Brahmaputra flows along the southern boundary of RG Orang National Park which covers and area of 5.78 km² in the park. Besides this there are several wetlands which are also recognized as good habitat for rhinoceros.

g) **Sandy Area (Dry and Moist):** The area under this category is 5.39 km². River sand banks devoid of any vegetation are mainly concentrated around the dried river bad of Brahmaputra.

The change in course by river Brahmaputra along with excessive siltation during the rainy season has resulted in the expansion of such areas

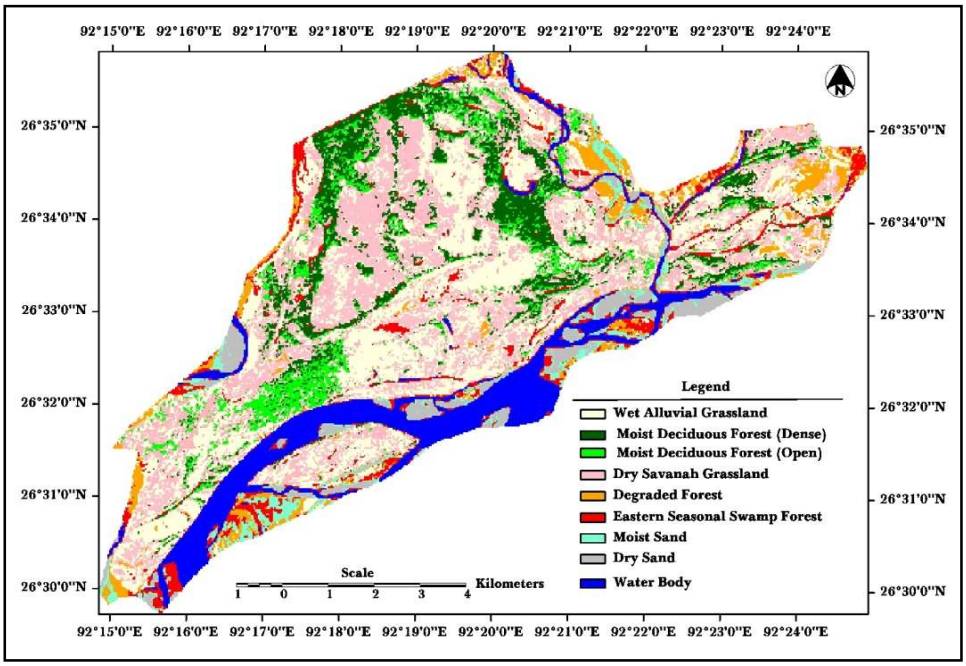


Fig. 2 . Land Cover types of RG Orang National Park as on 2008

Land Cover Change Dynamics Analysis:

For analysis of land cover change dynamics in RG Orang NP three datasets of satellite imageries were used pertaining to the year of 1987, 1999 and 2008. A supervised classification

technique was used to prepare the land cover types of RG Orang NP from 1987 to 2008. Nine land cover types were identified from all the images based on prior ground information as mentioned earlier. From the land cover change analysis of RG Orang NP it has been observed that mixed moist deciduous forest (dense) has an increasing trend from 6.8 km² in the year 1987 to 8.63 km² in the year 1999 and it increased up to 9.84 km² in the year 2008. The moist deciduous forest (open) has also an increasing trend from 1987 to 2008. The area covered by moist deciduous forest (open) in the year 1987 was 7.6 km² and it increased up to 10.54 km² in the year 2008. It is mainly due to the natural succession of woodland from moist deciduous forest (open) to moist deciduous forest (dense) from the year 1987 to 1999. But from 1999 to 2008 it has been observed an increasing trend of moist deciduous forest that is from 5.04 sq. km in the year 1999 to 5.12 km² in the year 2008. It is also mainly due to the natural growth of woodland during that ten years of time period. In case of dry savannah grassland it has also been observed an increasing trend from 6.88 km² to 12.41 km² and up to 14.87 km² in the years of 1987, 1999 and 2008 respectively. This is mainly due to the natural succession of dry savannah grassland from wet alluvial grassland. In case of wet alluvial grassland we have observed a decreasing trend from 1987 to 2008 covering areas of 30.63 km² to 20.54 km² respectively. It is mainly due to the impact of the invasive species named as *Mimosa invisa*. Mimosa is a native of tropical America and was imported by tea gardens from East Asia in the 1960s, as a nitrogen fixer prior to planting tea (Vattakkavan, et al 2005). The presence of *Mimosa invesa* is a major threat to the RG Orang NP. *Mimosa invesa* scrambles vigorously over other plants, forming dense tangled thickets up to 2 m high. It is commonly seen in roadsides and moist places (Waterhouse, 1994). In fact that it can invade the growth completely, competing with other plants and smothering herbaceous growth implies habitat degradation and loss of biodiversity (Vattakkavan, et al 2005). RG Orang NP is one of the salient examples of habitat degradation caused by *Mimosa invesa* in recent time. This rapid change of wet alluvial grassland in RG Orang NP has a major impact on the habitat of large herbivores like greater one horned rhino. Rhino prefer to use wet alluvial grassland as their prime habitat throughout the year because it provide sufficient amount of food and nutrition for their survival. RG Orang NP is a prime habitat for rhino and this change in wet alluvial grassland is a serious concern for many rhino conservation agencies working in Assam. In case of degraded grassland we have observed that it has increased from 6.86 km² in the year 1987 to 10.35 km² in the year 1999. Similarly from 1999 to 2008 it has an increasing trend and reaches up to 12 km². The degraded grassland is mainly

found in the eastern most and western most part of RG Orang NP. The degradation of grassland in those pockets of RG Orang NP are mainly due to the over grazing by cattle from the nearby villages. Another cause behind the increasing trend of degraded grassland is the impact of *Mimosa invesa*. In case of seasonal swampy forest we found that it reduced from 3.1 km² in the year 1987 to 2.51 km² in the year 1999. It has also a decreasing trend from 1999 to 2008 covering an area of 1.36 km². The main cause behind the reduction of seasonal swamp forest in RG Orang NP is also the impact of *Mimosa invesa.* In case of water body we found that it reduced from 5.76 km² in the year 1987 to 3.13 km² in the year 1999. It is mainly due to the deposition by the river Brahmaputra in the south eastern part of the park. But from 1999 to 2008 it increased up to 6.48 km² which is mainly due to erosion by river Brahmaputra, Dhansiri and Pachnoi. The RG Orang NP is situated along the northern bank of river Brahmaputra. The park has a 20 km long river bank along its southern boundary. In case of river sand or sandy area we found a decreasing trend from the year 1987 to 2008. The area under sand in the year 1987 was 10.45 km² which reduced to 5.6 km² in the year 1999 and finally it reduced up to 5.76 km² in the year 2008. It indicates that the sandy areas are gradually decreasing from the year 1987 to 2008. It is mainly due the deposition in the eastern most part of RG Orang NP. From the literature survey it was clear that from 1914 to 1975 erosion is much more prominent in RG Orang NP (Sharma, 2004, Kotoky, 2005). But in this study we have observed an increasing trend of silt deposition in the park by the river Brahmaputra during the year 1987 to 2008. It was observed that from 1987 to 1999 only 0.23 km² was eroded in RG Orang NP whereas 9.48 km² was deposited during that period in the park. Similarly from 1999 to 2008 almost 2.54 km² was eroded in the park and 0.18 km² was deposited by the river Brahmaputra in the park during the same period. It shows that the depositional trend is more prominent during the period from 1987 to 1999 in comparison to 1999 to 2008.The erosion and depositional scenario in RG Orang NP from 1987 to 2008 is shown in figure 3 and also in table – 3.

The figure 2 shows the changes in land cover types in RG Orang NP from 1987 to 2008. The table 2 shows the statistics of land cover change in RG Orang NP.

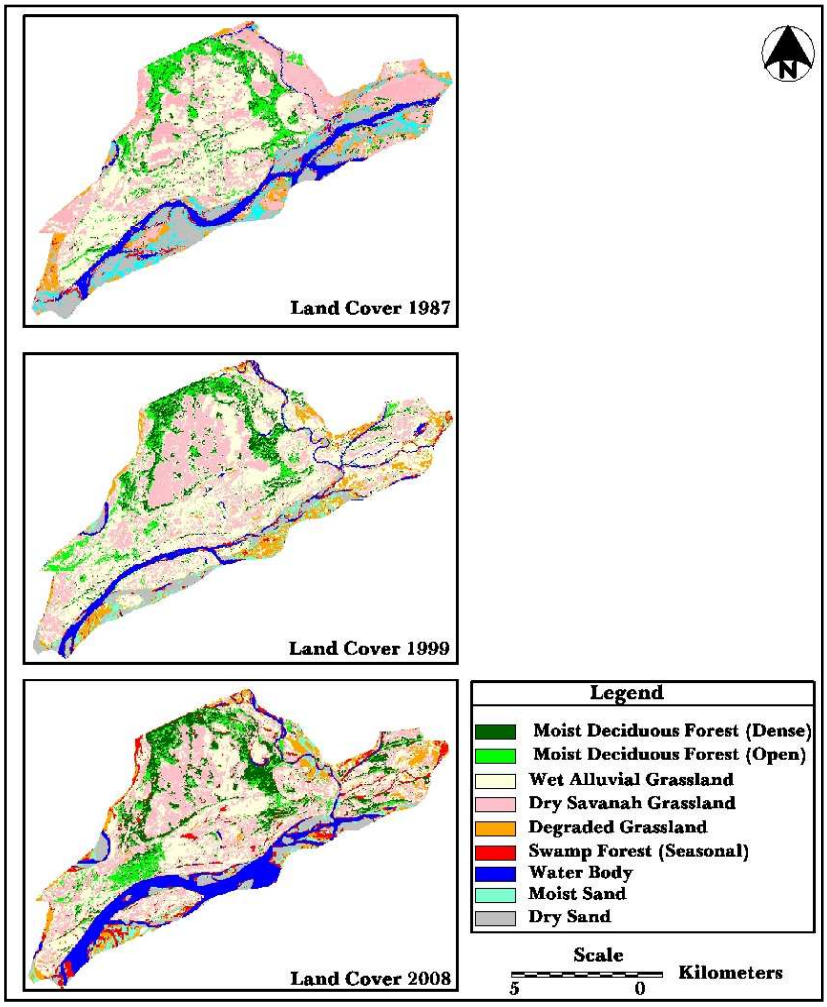


Fig. 2. Land Cover Change in Orang National Park

Table 2 Land Cover Change Dynamics in RG Orang NP

	1987	1999	2008	Net Change in %	
Land Cover Class	Area in km^2			1987 - 1999	199 9 -2008
Eastern Himalayan Moist Mixed Deciduous Forest (Dense)	6.8	8.63	9.84	+ 2.33	+ 1.53
Eastern Himalayan Moist Mixed Deciduous Forest (Open)	7.6	10.58	10.54	+ 3.78	- 0.05
Dry Savannah Grassland	6.88	12.41	14.17	+ 7.01	+ 2.24
Wet Alluvial Grassland	30.63	26.5	20.54	- 5.24	- 7.56
Degraded Grassland	6.86	10.35	12	+ 4.42	+ 2.09
Eastern Seasonal Swamp Forest	3.1	2.51	1.36	- 0.75	- 1.46
Water Body	5.76	3.13	6.48	- 3.34	+ 4.25
Moist Sand Area	3.4	1.8	1.02	- 2.03	- 0.99
Dry Sand Area	7.05	2.89	2.85	- 5.28	- 0.05

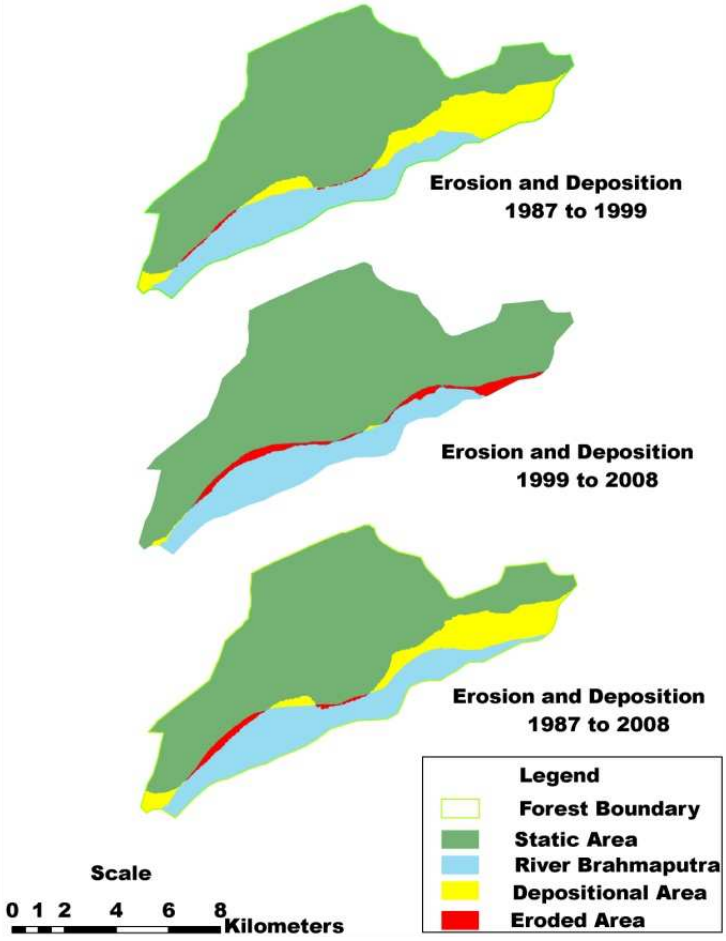


Fig. 3. Erosion and depositional scenario in RG Orang NP

Table 3 Erosion and depositional scenario in RG Orang NP

Erosion & Deposition Status	1987 to 1999	1999 to 2008	1987 to 2008
	Area in km²		
Eroded Area	0.23	2.54	0.94
Deposited Area	9.48	0.18	8
Static Area	55.96	62.68	55.24
River Brahmaputra	13.11	13.6	14.82

Conclusion:

This study utilizes remote sensing and GIS technology to assess the land cover change dynamics, in RG Orang NP. From the study it has emerged that the land cover of RG Orang NP has changed rapidly from 1987 to 2008. It is also observed that the open moist deciduous forest is gradually converting to dense moist deciduous forest and dry savannah grassland is gradually converted to open moist deciduous forest. Similarly area the wet alluvial grassland is gradually reducing and it converted to dry savannah grassland or degraded grassland areas. It is mainly due to the impact of *Mimosa invesa* in the wet alluvial grassland areas. Immediate attention is required to intensify the management practices of wet alluvial grassland with sustainable habitat interventions, so that the desired species composition is attained. The seriousness of the situation can be judged from the fact that remaining conducive grassland areas are now supporting the threatened one-horned rhino. Scientific measurement should be taken to maintain the wet alluvial grassland e.g. patch burning and suitable cover during the time of re-growth of wet alluvial grass. Uprooting of *Mimosa invesa* manually should be done in RG Orang NP. Uprooting needs to be done before the seeds set in and could be by October or mid of November every year. A second removal should also be done in the month of April to remove the germinating seedlings and saplings. Similarly to reduce the degradation of grassland in the eastern and western boundary of the park, proper protection measures should be taken so that cattle from the nearby villages could not come inside the national park. Considering the erosion and depositional changes in RG Orang NP, it is observed that deposition is prominent in comparison to erosion with in the park boundary of RG Orang NP by the river Brahmaputra, Dhansiri and Pachnoi. It is also observed that 8 km^2 of area has been deposited in Orang National Park since 1987 to 2008, whereas only 0.94 km^2 area is eroded from 1987 to 2008. This indicates a good scenario in RG Orang NP. Depositional activities by rivers lead to formation of new wildlife habitat in RG Orang NP. Regular monitoring of changes in these front using remote sensing and GIS tools could further assist management decision to enhance conservation of flagship species like the rhino in this grassland predominant habitat within RG Orang NP.

References:

1. Chopra, R., Verma, V.K., Sharma, P.K., (1997) "Assessment of natural resources for conservation of Harike wetland (Punjab), India through remote sensing technology."*GIS Development*, online publication. www.gisdevelopment.net/aars/acrs/1997/ts7/ts7008pf.htm

2. **Dudeni, N. and Debba, P., 2008** "Classification *of remotely sensed images"*, South Africn Statistical Association conference, Pretoria, South Africa, October 27-31

3. **Forman, R.T.T.,1995 "***Land Mosaics: The Ecology of Landscapes and Regions,"* Cambridge University Press, Cambridge, UK

4. **Jensen, J.R., 1996 "***Introductory digital image processing, second edition"* Prentice hall Press, New Jersey, USA, 318

5. Kotoky, P., Bezbaruah, D., Baruah, J., Sarma, J.N., (2005) "Nature of bank erosion along the Brahmaputra river channel, Assam, India." *Current Science, Vol. 88 (4), 634-639.*

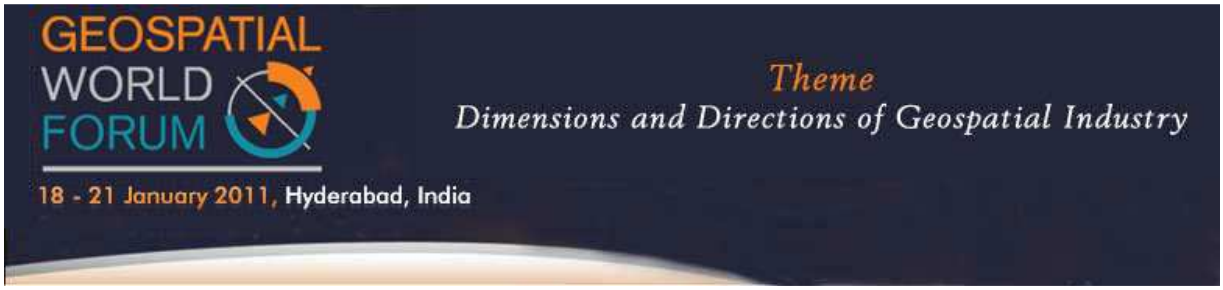
6. **Lillesand, T.M., Kiefer, R.W., Chipman, J.W., 2004 "***Remote Sensing and Image Interpretation"* John Wiley, New York, 2004, 5th edn.

7. **Nagendra, H., Southworth, J. and Tucker, C., 2003** "*Accessibility as a determinant of landscape transformation in western Honduras: Linking pattern and process"*. Lands. Ecol., 2003, **18**, 141–158.

8. **Nagendra, H., Munroe, D.K. And Southwood, J., 2004 "***From pattern to process: landscape fragmentation and the analysis of land use/land cover change*." Arric., Ecosyst. Environ.," 101, pp 111-115.

9. **Vattakkavan, .J, Vasu, N.K., Varma, S. Gureja, N., Aiyadurai, A,, 2005** " *Silent Stranglers: Eradication of Mimosa in Kaziranga National Park, Assam"* an occasional report of a habitat recovery project conducted by the Wildlife Trust of India. pp11 -15

10. **Waterhouse, D.F., 1994. "***Biological control of weeds in south eastern Asian prospects."* AICR, Canberra, Australia.



Brief Biography:

Pranjit Kumar Sarma has passes his M.Sc in Geography from Gauhati University in the year 1999 with specialization in Advance Geomorphology. He has gathered knowledge in the field of Remote Sensing and GIS technology from National Remote Sensing Agency, Hyderabad, India. From the year 2000 to 2008 he has completed four nationwide mapping project entitle "Wasteland Mapping of India", "Disaster Management Mapping Programme of India" " Land Use Land Cover Mapping Project of India" and " Nationwide wetland inventory mapping project of India" sponsored by Department of Space Govt. of India.

Pranjit Kumar Sarma is associated with Aaranyak from the year, 2004 and he is working in Aaranyak as a Programme Head of the Remote Sensing and GIS division .His main task in Aaranyak is integrate and manage biodiversity related information into GIS domain and make people aware about the technology of remote sensing, GIS and GPS through training and capacity building.