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Changes in Landuse and Landcover along the Dhansiri River Channel, Assam – A Remote Sensing and GIS Approach

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Abstract: Information on landuse/landcover change is a critical input for natural resource management policy decisions. Remote sensing data under GIS domain were utilized to evaluate the changes in land-use/land-cover (LU/LC) spanning a period of thirty three years during 1975 to 2008 along the Dhansiri River channel, Assam, India. Seven different types of LU/LC were categorized and out of them cropland was evident as the most important landuse/landcover practices followed by dense mixed jungle in 1975 and the settlement in 2008. Significant reduction (13.02%) in cropland area to settlement was observed. Moreover, teagarden also occupies 0.77% of the total area from cropland and open mixed jungle. The changes in the areas of swampy land as evident from the present study in turn will impact the environmental quality around it and will help to increase the surface run off leading to enhancement of erosion processes. It is believed that the present study will help to contribute towards sustainable land-use planning and management towards protection of extremely rich biodiversity of the North East India with mighty Brahmaputra River system.

Keywords: Landuse, Landcover, Remote Sensing, GIS, Dhanasiri River channel, Assam.

INTRODUCTION

An intimate knowledge of landcover and landuse, the most valuable natural resource is a prerequisite in any national development plan to provide and meet the requirements of human and livestock population. Moreover, landuse/landcover inventories are assuming increasing importance in various resource sectors like agricultural planning, settlement surveys, environmental studies and operational planning (Li and Shen, 1973; Burrough, 1986; Khoram and John, 1991; Turner, 1995; Goulding and Blake, 1998; Gregory and Gurnell, 1998; Mahajan et al. 2001; Viet et al. 2002; Jayakumar and Arockiasamy, 2003; Shetty et al. 2005; Mahajan and Panwar, 2005; Shamsudheen et al. 2005). Information on landuse/landcover of an area helps to bridge the gap in better understanding of relationship between cropland, forestland, settlement, wetlands etc. with the river morphology flowing through the area. The growing pressure of population coupled with increasing demands made on land resources has brought extra pressure on the available land (Rao et al. 1996). The change in the state of the biosphere and bio-geochemical cycles are driven by heterogeneous changes in landuse and continuation of those uses (Turner, 1995). The change can also be critically linked to the intersection of natural and human influences on environmental change.

Analysis of satellite data in conjunction with drainage, lithology, landuse/landcover and collateral data facilitates effective evaluation of geomorphological conditions and status of degraded land forms. This data set is the core of the Geographic Information System (GIS) that provides an excellent means of spatial data analysis and interpretation. It also provides a powerful mechanism, not only to monitor degraded lands and environmental changes, but also permits analysis of information of other environmental variables (Reddy et al. 2002).

Assam (24°8' to 28°9' N and 89°42' to 95°16'E), covering an area of 7.85 Mha spreads over 26 districts with a population of 22.2 million and contributing 2.4% of the total geographic area (329 Mha) of the country. The major physiography of the state includes three divisions viz. The Brahmaputra Valley, Central Assam Range and the Barak Valley. Occupying 10% area of the valley floor the mighty Brahmaputra River flows through the middle of the valley from east to west with more than 35 tributaries with an antecedent drainage pattern. Central range of Assam comprises Karbianglong and North Cacher Hills districts.

Table 1. Land utilization in Assam (Source: Statistical Hand Book of Assam, 1992,Govt.of Assam)

Sl. No.	Description	Area (.000ha)	Percentage
1	Net sown area	2706	34.5
2	Forests	1984	25.3
3	Barren and non-cultivable land	1541	19.6
4	Land put to non-agricultural use	914	11.6
5	Land put to misc. tree crops and groves	247	3.2
6	Permanent pasture and other grazing land	184	2.3
7	Cultivable waste land	104	1.3
8	Current fallows	88	1.1
9	Fallow land other than current fallow	84	1.1
	Total	**7852.0**	**100.0**

Barak Valley occupies a triangular area surrounded by high hills in all three sides except west, and gets water through Barak River and its tributaries. The state experiences a humid subtropical climate with an average rainfall ranging from 1400 mm (Lumding area) to slightly above 3000 mm (Silchar area). The principal crops in Upper Assam are tea and paddy; jute and paddy in Middle Assam, while Lower Assam is dominated by paddy only.

A statistical review on land utilization of Assam is given in Table 1. The cropping pattern is diversified depending upon soil, microclimate and socio-economic status. The existing industries of the state are: (1) Agro-based, (2) Mineral-based, (3) Forest-based and (4) Miscellaneous. The agro-based tea industry of the area produces about 52 per cent of the country's total tea, contributing 10 per cent of the state's income.

STUDY AREA

A stretch of 216 km (as per base map of 1975) out of the total length of 368.13km is considered for the present study (Fig.1). The area has suffered perennial flooding and erosion problem of the Dhansiri River Channel ($93^0 30'$E - $94^0 00'$E Long and $25^0 58'$N-$26^0 45'$N Lat), Assam, India. The present first hand approach was made to undertake the study with the objectives of analyzing landuse/landcover changes in the area and their contribution to the existing geomorphology using SOI toposheets and remote sensing data.

A 1400 km^2 area covering 5km buffer zone on both sides of the Dhansiri River is considered for the present study. The area falls in the districts of Golaghat and Karbianglong, Assam. Physiographically, it is an alluvial plain within the vast Brahmaputra Valley Alluvium with an altitude from

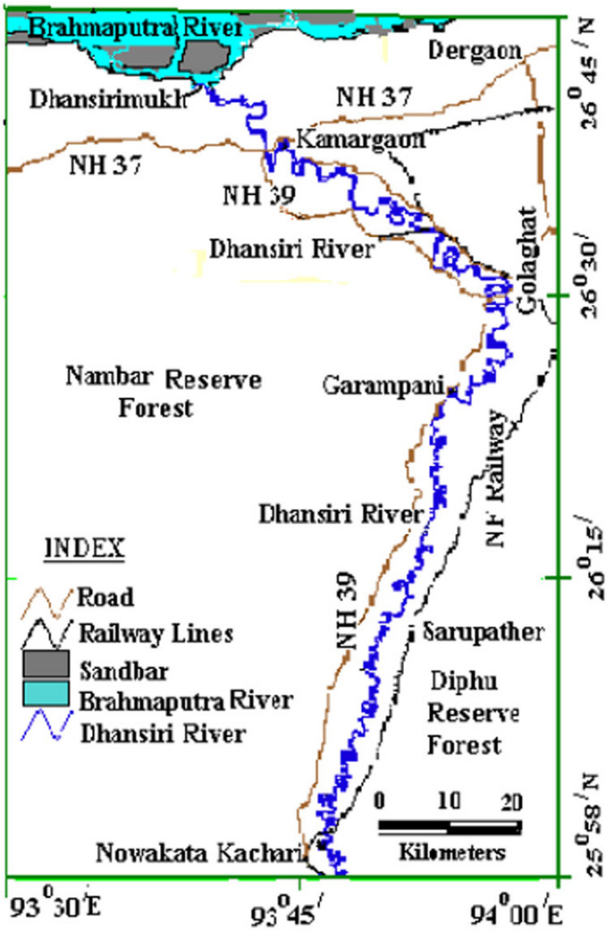

Fig.1. Location map of the study area.

80 m at downstream to 160 m at upstream. The slope of the region is very gentle. The mean annual rainfall is 1223 mm which is received mostly between May to August. Annual mean maximum and minimum temperature are 32ºC and 18ºC respectively. Small hillocks having height from 213 m to 274 m covered with dense mixed jungle are also present in the study area (near the National Highway 39).

MATERIALS AND METHOD

The survey of India toposheets Nos. 83 F/10, F/14, F/15, F/16, G/9 and G/13 (Scale 1:50,000) of 1975 were scanned, georeferenced, mosaiced and used as resource maps. The status of landuse/landcover (LU/LC) during 1975 was assessed from the prepared map based on the Survey of India (SoI) toposheets. IRS-P6 LISS-III, path 112, row 53, digital image of November 2008 on 1:50,000 scale obtained from National Remote Sensing Centre (NRSC), Hyderabad, were used to map the landuse/landcover status during 2008. The digital image was registered to the base map using a set of Ground Control Points (GCPs) and preprocessed in the

ERDAS IMAGINE 8.5 software environment. Map to image georectification process was adopted for geometrical correction of satellite images. 'Polyconic' projection was used with spheroid and datum as 'Everest'. Ground control points were obtained from Survey of India 1:50,000 toposheet. The landuse/landcover map of 1975 and 2008 were prepared by digitizing in Arc View GIS and incorporated in a GIS domain for change analysis. Two attribute tables were created for 1975 and 2008 to store the information such as area in square kilometer, name, and type etc. of the various landuse/landcover categories. Area statistics of each land use/land cover classes was derived from these attribute tables. Hybrid system of LU/LC classification (NRSC, 2006) combining automated and manual approaches various landuse/landcover categories of 1975 and 2008 were created and rasterized to carryout spatial analysis. LU/LC Changes from one category to another were also analysed and utilized for the present study. Ground checks were also made for confirmation of the results obtained for different land use characteristics.

RESULTS AND DISCUSSION

Changes in land use/land cover were evaluated from the differences between 1975 and 2008 status (Table 2 and Figs. 2 and 3). Seven major LU/LC types (namely, Cropland, Dense Mixed Jungle, Open Mixed Jungle, Grassland, Teagarden, Settlement and Bil (or Swamp) were registered and characterized for the study area. The different categories of landuse/landcover till 1975 in order of abundance can be represented as Cropland (43.56%) >Dense Mixed Jungle (20.57%)>Settlement (15.88%)> Teagarden (7.75%)> Grassland (6.52%)> Open Mixed Jungle (3.90%)>Bils (1.82%). The situation as observed from the 2008 LULC map is however different and can be represented as Cropland (31.10%)>Settlement (29.68%)> Dense Mixed Jungle (20.43%) >Tea Garden (9.68%)> Grassland (4.57%)>Open Mixed Jungle (2.82%)>Bils(1.72%). A reduction of 12.46% in the cropland area was observed in the year 2008 (31.10%) in comparison to the cropland of 1975(43.56%). The growth in settlement area bears a positive relationship with the decreasing tendency of cropland area. This was clearly evident from the increase in settlement area by 13.8% from 15.88% in 1975 to 29.68% in 2008. The small decrease (0.14%) in dense mixed jungle area is of specific concern and warrants immediate proper attention as it provides sustainable environmental conditions for the existing flora and fauna. The open mixed jungle area was reduced by about 1.08% which is observed to be mainly related to expansion of settlement and non-planned occupation of grazing land by the existing tea industries of the area.

The distribution of different land-use/land-cover types

Table 2. Area under different landuse/landcover categories around 5 km buffer zone of the Dhansiri River, Assam in 1975 and 2008

Land use Category	Area in Km²		Percentage of total area		Change	
	1975	2008	1975	2008	Km²	%
Cropland	609.36	435.05	43.56	31.10	-174.31	-12.46
Dense mixed jungle	287.66	285.78	20.57	20.43	-1.88	-0.14
Open mixed jungle	54.55	39.50	3.90	2.82	-15.05	-1.08
Grassland	91.21	63.91	6.52	4.57	-27.30	-1.95
Tea garden	108.38	135.42	7.75	9.68	27.04	1.93
Settlement	222.17	415.12	15.88	29.68	192.95	13.8
Bil	25.46	24.01	1.82	1.72	-1.45	-0.1
Total	**1398.79**	**1398.79**	**100.00**	**100.00**	**-**	**-**

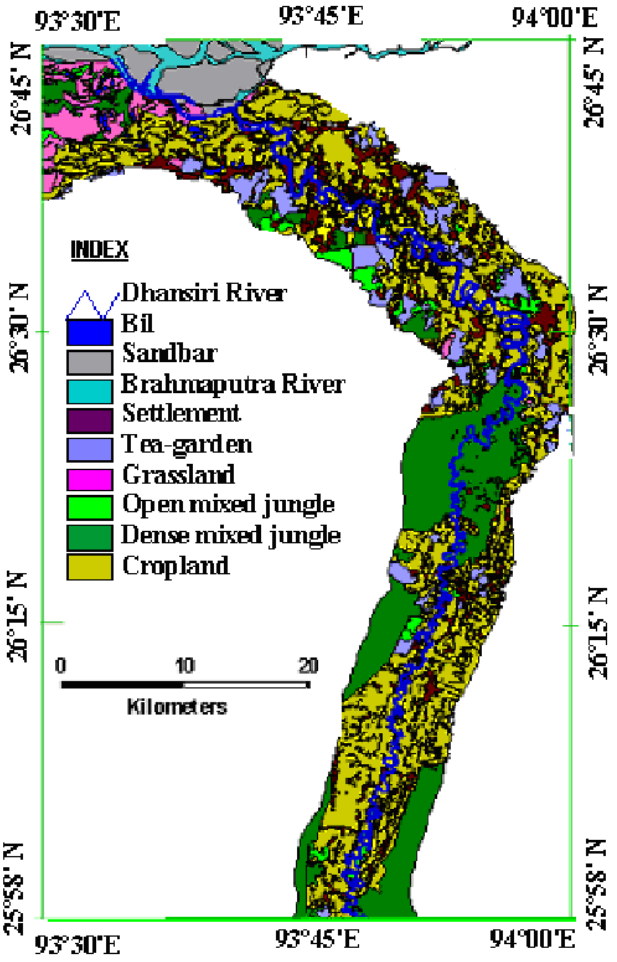

Fig.2. Land-use/Land-cover map of the study area in 1975 (Source:SoI topomaps).

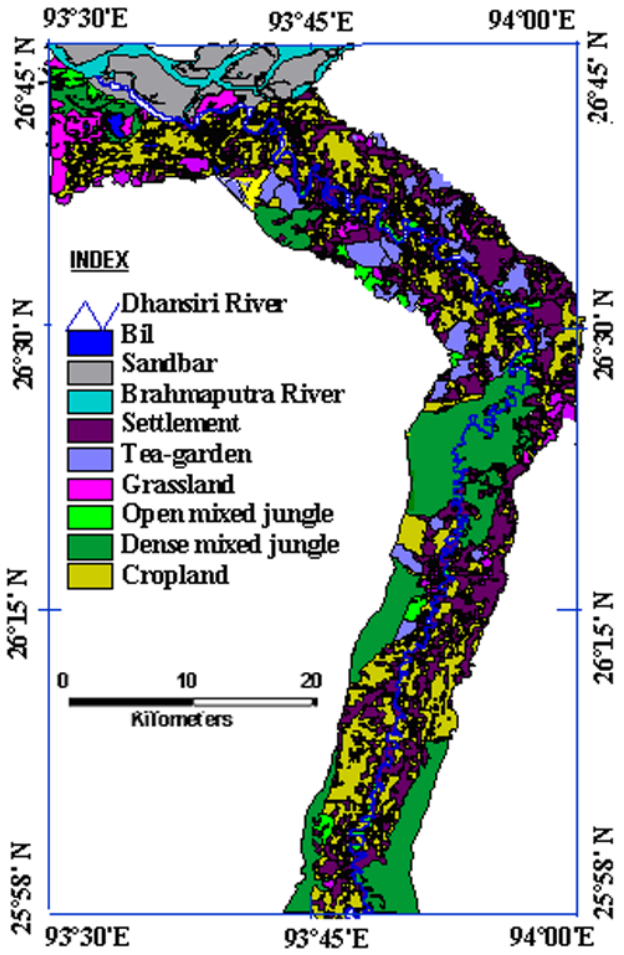

Fig.3. Land-use/Land-cover map of the study area in 2008 (Source:IRS-P6 LISS-III data).

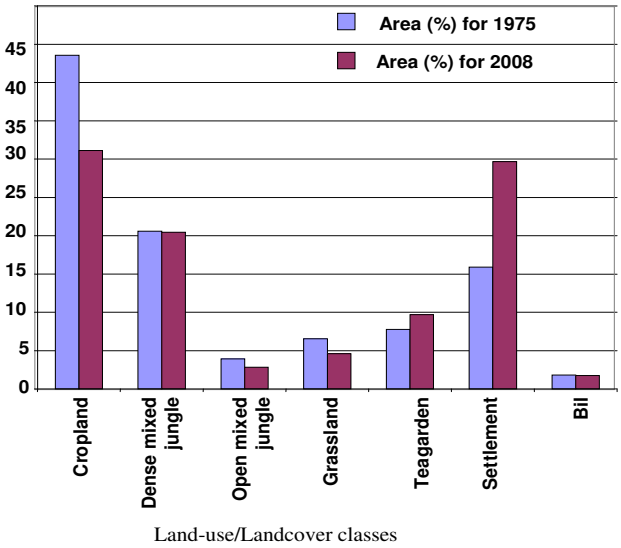

Fig.4. Histogram showing Landuse/Landcover variation in 1975 and 2008.

in 1975 and 2008 has shown that the percent positive change over the years was higher for settlement and then followed by tea garden. However, higher negative changes are manifested by the cropland followed by grassland, open mixed jungle, dense mixed jungle and bil (Fig.4).

Cropland

In the study area (i.e. along the 5km buffer zone on either side of the Dhansiri River), the cropland area mostly utilized for paddy cultivation was decreased by 12.46% during the period from 1975 to 2008. The land area covered by the cropland was 435.05Km^2 in 2008, which was 174.31 km^2 less than the cropland area in 1975 (609.03 km^2). The conversion of cropland area to settlement was observed to be invariably related to the increasing pressure of growing population.

Soil is the essence of prime requisites for sustaining of life forms. Cropland provides foods, vegetables and various other indispensable agricultural products along with socio-economic development of a region. However mounting demands of swelling population and long mismanagement in land use planning have resulted a significant concern towards reduction in cropland. The chief crop of the area under study is paddy and the reduction in cropland will impact on the food grain economy for the area. Tea is another important economic cultivation in this area and non-execution of proper policy decision in land use planning and management has helped in expansion of tea cultivated areas to the existing cropland for cultivation. This type of non-planned expansion can be optimized by proper planning and execution of policy decision in land-use management.

Dense Mixed Jungle

The Nambar Reserve Forest in the upper reach of the Dhansiri River Basin comprising the major portion (about 85%) of the dense mixed jungle area followed by Kaziranga Reserve Forest(about 6%)in the lower reach of the Dhansiri River Channel. Comparatively non-significant (0.14%) reduction in forestland was observed during the period under study. However, it may contribute significantly towards soil erosion and soil fertility of alluvial landforms, which in turn related to sustained growth/yield. These reserve forest area needs immediate protection so as to maintain the ecological balance in the area and to adopt intensive agricultural practices in proportion to the area under vegetative cover (Vohra, 1988).

The degradation of forestland areas in India is not at all satisfactory. India alone is losing more than 1.5 million hectare of forest cover each year and according to Tiwari (1982), 22 million hectare of forestland have been destroyed during the last three decades due to over exploitation, misuse

and conversion. This depletion in forest wealth would simply deprive the inhabitants from economic and environmental values offered by the forests. Moreover, the depletion of forestland significantly affects the species conservation for this naturally rich part of NE-India, which in turn contributes towards destabilization of biodiversity of the region.

The changes in land use related to dense mixed jungle have important environmental consequences for many biological, chemical and physical processes of soil. The conversion of forestland to agriculture of any form (organic or conventional, grassland or arable) bears relationship with the microbial activity related to oxidation of methane up to 80% by the soil and also enhances reduction of soil organic (OM) matter content (Goulding et al. 1995). Cultivation also leads to increase erosion by increasing area of exposure to the surface weathering processes including surface runoff involved therein. Moreover, the preferentially lost of finer, nutrient rich particles of clay and organic matter (OM) have made significant impact on degradation of soil and surface waters qualities.

Open Mixed Jungle

The record as evidenced in 2008 LU/LC map, about 39.50Km^2 areas was covered by open mixed jungle along with scrubs. 15.05Km^2 area in open mixed jungle (2008) was reduced while it is compared with the values in 1975 (54.55 km^2). The loss in the area was mainly due to encroachment by the tea garden. It is indeed an intricacy in management and execution of proper land-use policy decision.

Grassland

The grassland is often called as rangeland that provides natural pasture for grazing animals. The grassland in the study area was mainly located near the confluence of river Dhansiri with the mighty Brahmaputra River and in the Kaziranga Reserve Forest. The area covered in this class was 91.21Km^2 in 1975, which was decreased by 27.30 km^2 during the study period and covered by 63.91 km^2 in 2008. The loss is mainly observed to be related to the conversion of grassland (1.37%) to cropland with a subordinate amount to open mixed jungle (0.56%). It is expected that this will give a significant input towards evaluation of cover management factor to assess the universal soil loss in relation to the adopted practices. The cover management factor(C) represents variables/conditions that can most easily be managed to reduce soil erosion. Thus the changes in cropland, grassland, mixed forest or forest areas, which impart significant changes in cover management factor warrants in-depth field based studies to evaluate the impact of land use/land cover on erosion resistance. Moreover, the proliferated action of flood also played a great role in reduction of grassland within this alluvial plain.

There is increasing need to restore the depleted and degraded grassland not only out of economic (livestock production) but also ecological consideration to restore the rich biodiversity of the region since, grassland depletion would also cause problems like soil erosion, spread of pests etc. Over the last few decades there has been increasing recognition of the role of vegetation on river channel processes and form. Particular attention has been paid to the influence of in-channel vegetation on flow resistance (Li and Shen, 1973), and to the role of bankline vegetation and debris dam in influencing bank strength and channel morphology (Huang and Nanson, 1997; Gregory and Gurnell, 1998).

Tea Garden

In 1975 the area under tea garden was 108.38 Km^2 which became 135.42 km^2 in 2008. Tea generates a major part of the economy of Assam. This increase (27.04 km^2) in area is related to the expansion of teagardens to the neighboring open mixed jungle area and establishment of smaller teagardens by the tea grower of the area. During the past few years people developed teagarden of various dimension at their personal initiatives as an effort of employment generation. Increasing interest of the people of Assam in tea plantation results an increase in tea garden area, which in turn, results a significant decrease in cropland with subordinate amount in open mixed jungle and grassland areas.

Settlement

The use of land area covered by settlement is related to the population. The growth in population is directly related to decrease in cropland and grassland areas, which in turn related to food production and other environmental attributes.

The area under study constitutes mostly the rural settlement along with urban settlement like Golaghat town, Bokajan, Bokakhat, Numaligarh Refinery and its township. In 1975 the areas covered by the Numaligarh Refinery and its township were mainly covered with grassland and open mixed jungle. The total area occupied by this land cover category in 1975 was 222.17Km^2 which has increased to 415.12 km^2 in 2008 i.e. 87% increase. It was observed as the third major land use category (15.88%) in 1975 after cropland (43.56%) and Dense mixed jungle (20.57%) but became second major land use category (29.68%) in 2008 after cropland (31.10%). The conversion of 13.02% of the cropland area to settlement followed by open mixed jungle (0.41%)

and then by dense mixed jungle (0.36%) was also evident from the changes in land-use/land cover studies.

Bils

The wetlands developed during geomorphic transformation and related tectonic activities of the region are known as 'Bils' in local parley. These wetlands are conspicuous features of the flood plains of the Brahmaputra River Basin. The biological interaction of soils, water, plants and animals allows wetlands to perform certain functions and generate healthy wildlife, fisheries and forests resource. This makes these wetland ecosystems invaluable to people all over the globe.

The location of the river Dhansiri in a varied geomorphic setup in a valley filled with recent alluvium and morphological adjustment of the channel have developed many low lying areas along the channel. However, associated land use pattern have also influence the development of many wetland areas. The highly meandered nature of the river channel and consequent migration of meander bends have contributed significantly towards generation of higher amount of ox-bow type swamps followed by linear type (Dutta, 2007). These wetlands were actually the paleo-channels of the Dhansiri River. Comparatively higher amount of wetlands are developed on the western side of the river channel. Swampy land or wetlands have represented potentially very rich areas with geomorphologic and ecologic significance. These low lying areas act as storage basins during flood, reducing the flood impact and minimising the intensity of erosion. These wetlands are also helpful in maintaining the rich bio-diversity of the region and can be used as an important eco-potential resource.

Bils in 1975 LU/LC map occupied 1.82% of the total area under present study. However, in 2008 a minor reduction by 0.10% in total land area was observed. The present study has clearly demonstrated that the reduction in the area occupied by the wetland is related to the conversion of wetland to cropland. The use of wetlands (Bils) for production of crops in relation to the population growth is inevitable and directly related to socio-economic condition of the region.

Changes in Landuse/Landcover (LU/LC)

The study on changes in Land use/Land cover and its implications to environment and societies have gained significant momentum during recent years (Chaurasia and

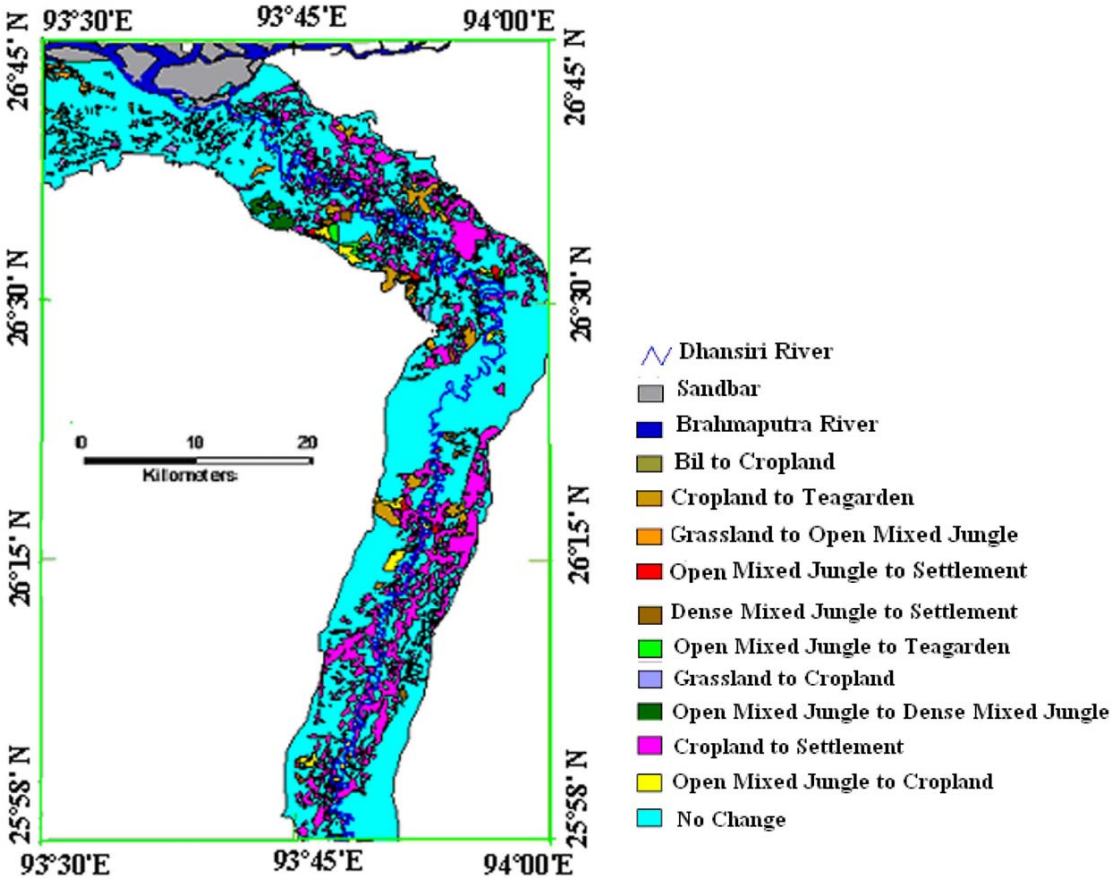

Fig.5. Landuse/Landcover change map of the study area.

Table 3. Matrix of LU/LC change categories during 1975 to 2008

Class → ↓	Open mixed jungle	Dense mixed jungle	Grassland	Bil	Cropland	Tea garden	Settlement	Change
Open mixed jungle	0.00	-0.23 (3.19)	0.56 (7.76)	0.00	-0.45 (6.20)	-0.56 (7.76)	-0.41 (5.71)	-1.09 (15.16)
Dense mixed jungle	0.23 (3.19)	0.00	0.00	0.00	0.00	0.00	-0.36 (5.07)	-0.13 (1.88)
Grassland	-0.56 (7.76)	0.00	0.00	0.00	-1.37 (19.17)	0.00	0.00	-1.93 (11.41)
Bil	0.00	0.00	0.00	0.00	-0.12 (1.71)	0.00	0.00	-0.12 (1.71)
Cropland	0.45 (6.20)	0.00	1.37 (19.17)	0.12 (1.71)	0.00	-1.38 (19.28)	-13.02 (182.17)	-12.46 (174.31)
Tea garden	0.56 (7.76)	0.00	0.00	0.00	1.38 (19.28)	0.00	0.00	1.94 (27.04)
Settlement	0.41 (5.71)	0.36 (5.17)	0.00	0.00	13.02 (182.17)	0.00	0.00	13.79 (192.95)

Figures in parenthesis indicate area in km2; negative sign indicates decrease and positive sign indicates increase in respective classes.

Sharma, 1999; Jaiswal et al. 1999; Joshi et al. 2002; Sikdar et al. 2004; Sullivan et al. 2004, Mahajan and Panwer, 2005; Serra et al. 2008, Pelorosso et al. 2009, Schulz et al. 2010).

The land use changes derived over a period of thirty three years (1975 to 2008) are shown in Fig.5 and Table 3. In general, it was observed that during the study period out of the total 1398.79 km^2 area, about 1140.60 km^2 area remain unchanged which is 81.54% of the total area under study. The areas nearby the national highway, meandered Dhansiri River Channel exhibited a relative transitory nature in relation to migration of the Dhansiri River Channel and associated erosion/deposition processes (Dutta, 2007).Considering its transitory nature and associated other complexities, such areas were also covered and considered under the category of no change for the present study. Out of all the changes from one category to another maximum of 182.17km^2 (13.02%)and 19.28 km^2 (1.38%) area covered by the cropland was converted to settlement and teagarden respectively. However, a portion (27.14 km^2) of the loss in cropland area was compensated by the transformed contribution of grassland (19.17 km^2), open mixed jungle (6.26 km^2) and wetland (1.71 km^2).Covering a total of 10.78 km^2 (0.77%) of forestland area was observed to be converted to settlement.

CONCLUSIONS

Utilising Survey of India toposheets (1975) and Remote Sensing data (2008) in GIS domain land use/land cover changes were evaluated between 1975 and 2008 status. Seven major LU/LC types i.e., Cropland, Dense Mixed Jungle, Open Mixed Jungle, Tea Garden, Settlement, Grassland and Bils were characterized within a 5km buffer zone along the Dhansiri River Channel. The present study has demonstrated cropland as the most dominant (43.56 to 31.10%) and bils as the minor (1.82 to 1.72%) categories of land-use types within the area of study.

During the period (1975 to 2008) under observation, out of the total land area, 1140.60 km^2 remains unchanged, which is equal to 81.54% of the total area. However, 19.28 km^2 (1.38%) of the cropland area was converted to tea garden, which is considered as one of the significant changes in land use practices. Significant conversion of cropland area to settlement up to 13.02% was observed within the studied stretch. The conversion of land area to nonplanned settlement will make significant impact on the existing biodiversity of the area around it as the area is adjacent to the World Heritage site Kaziranga, famous for endangered one horned Rhinoceros and many such plant and animal species. However, conversion of grassland to cropland (1.37%) helps to compensate a portion of total loss in cropland area. The present exploratory study has clearly indicated that an integrated approach is warranted to protect the natural land resource of the region in view of its rich biodiversity within the mighty Brahmaputra River System under the ambit of land use planning and management.

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