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Land Use and Land Cover Change of Santijan Beel, Assam (India): A Geographical Analysis Using Geospatial Tools and Techniques

Arup Jyoti Bora[1*],Ashok Kumar Bora[2]

[1*]Research Scholar, Department of Geography, Gauhati University, Guwahati, 781014, Assam, India
[2]Professor, Department of Geography, Gauhati University, Guwahati, 781014, Assam, India

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Abstract

The purpose of the present investigation is to unravel the cause of changes in land use and land cover pattern in the Santijan *Beel*, Assam (India) covering an area of 81.96 sq km. An analysis has been made to draw the attention to concerned authorities for better understanding in terms of the pattern and magnitude of the changes in LULC along with examination of the interlinkages of such changes with wetland environment and socio-economic set-up of the native land. This research obtained geospatial techniques for scrutinizing land use land cover change in the study area. Satellite images from the years 2013 to 2020 have been utilized to recognize the areal changes. The LULC classifications of the study area are comprises with six classes like vegetation cover, agricultural land use, culturable waste land, built-up area, water bodies and fallow land which indicate the drastic change of the wetland environment. Notably there have been decreased agricultural land, water body, vegetation cover by 1%, 10% and 1% respectively. On the other hand, there have been seen built up area, culturable waste land, fallow land by 7%, 1% and 4% which lead to indicate the human interventions in the natural environment. Remote sensing data and techniques and Geographical Information System (GIS) provide efficient methods for analysis of land use and land cover aspects and tools for LULC planning and modelling. This type of analysis therefore is useful for managing and conserving the wetland environment.

Keywords: *LULC; Water body; Human intervention, Degradation, Santijan*

Introduction

Wetlands are the most diverse and highly productive ecosystems on Earth, occupying 4–6% of the planet's land area [1]. Over the earth surface, wetlands are the major component of the landscape ecology [2]. They also maintain the water quality, groundwater storage, reducing erosion, and mitigate the flood like situations during peak flows, because wetlands are the natural storehouse of water [3]. In recent years there has been an increase in the destruction of wetlands which has caused tangible and intangible changes on landscape diversity and has caused some species to go extinct [4]. Among the all changes happen in a native environment, land use land cover (LU/LC) is considered as one of the most important factor for global environmental changes which is directly or indirectly influenced by humans [5]. Changes in soil, land use and cover, climate variability and change, and other environmental factors all interact to impact natural resources by influencing the structure and operation of ecosystems [6].

Previous studies have mostly discussed about LULC [7], wetlands [1], human-water interaction [8,9] and others related to rivers [10] in Nagaon district of Assam, India. However, no previous research work has been done in terms land use and land cover changes in relation to Santijan *Beel*. This study, therefore, tries to bridge this research gap with a noble approach to investigate the land use and land cover changes in and around Santijan *Beel* in Assam, India. The beel along with its surrounding areas face numerous environmental related problems aggravated by activities associated with the local population. Due to human encroachment along the boundaries of the Santijan, the beel has lost a significant amount of area. Santijan is surrounded by several villages: Meleka Dhing, Sonaibera Gaon, Sola Pathar, Rampur Satra, Kadamani Gaon, Haidubi Pathar, Keri-Meri, Batamari village, Bhumura Guri, Dhania Bheti Pathar, Dhania Bheti Gaon, and Kuji Satra, Dhupa Guri and Batadraba. In Sonaibera, there has been significant land encroachment, with many fisheries being created for business purposes. These activities have adversely affected

the natural flow of water in the Beel. Near Haidubi Pathar, people are establishing agricultural fields on both banks of the Santijan. Additionally, near Dhania Bheti village, numerous small to large fisheries have been dug, further encroaching on the wetland area at a high level in Santijan *Beel.*

Despite the increasing recognition of the ecological and socio-economic importance of wetlands like Santijan *Beel* in Assam, there remains a limited understanding of the specific impacts of land use and land cover change (LULC) on these ecosystems. Existing studies at a district level often focus on broad regional assessments or fail to incorporate the latest geospatial tools and techniques, such as remote sensing and geographic information systems (GIS), to analyze temporal changes at a granular level. Moreover, there is a lack of comprehensive research that examines the interplay between anthropogenic activities, climate change, and their cumulative effects on wetland health and biodiversity. This study aims to address these gaps by employing advanced geospatial methodologies to provide a detailed analysis of LULC in the untouched Santijan *Beel*, thereby contributing to better management and conservation strategies for this vital ecosystem.

This research helps to identify the biodiversity within Santijan wetland ecosystem and guiding conservation efforts. This study can identify sustainable management practices that local communities can adopt to utilize wetland resources without degrading the ecosystem. By assessing the health of the wetland, this research can inform locals about the sustainability of their livelihoods, prompting conservation efforts if the ecosystem is at risk. Findings may inform regulations on land use, water quality, and conservation efforts, promoting practices that safeguard wetland resources critical for local livelihoods.

2. Methodology

2.1 Study area

The study area falls under the Dhing revenue circle, district of Nagaon, Assam at a distance of 20 km from the Nagaon main town area. The total area of the study is 81.96 sq km under taking consideration with latitudinal extension of 26°21'12" North to 26°28'33" North and the longitudinal extension of 92°28'59" East to 92°35'10" East. The study area surrounded by villages like Meleka Dhing, Sonaibera Gaon, Sola Pathar, Rampur Satra and Kadamani Gaon in the North, Haidubi Pathar, Keri-Meri, and Batamari village in the North-East, Bhumura Guri in the East, Dhania Bheti Pathar, Dhania Bheti Gaon and Kuji Satra in the South and Dhupa Guri Gaon and Batadraba in the West.

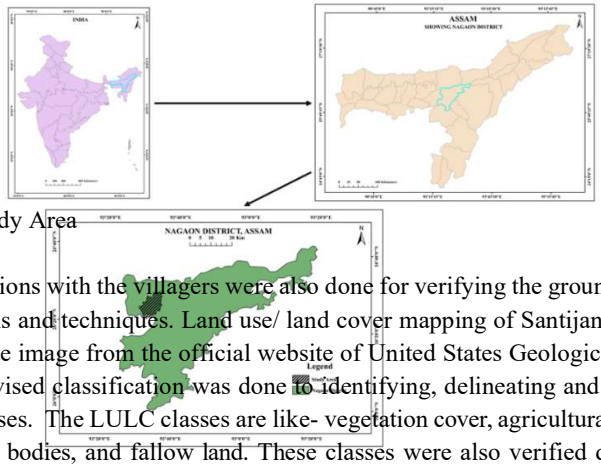

Fig. 1: Location map of the Study Area

2.2 Database

Multiple field visits and interactions with the villagers were also done for verifying the ground reality of the study area before using advanced tools and techniques. Land use/ land cover mapping of Santijan wetland was carried out using Landsat 8 OLI satellite image from the official website of United States Geological Survey (USGS) of the year 2013 and 2020. Supervised classification was done to identifying, delineating and mapping of the land use/ land cover into several classes. The LULC classes are like- vegetation cover, agricultural land use, culturable waste land, built-up area, water bodies, and fallow land. These classes were also verified during field visit and interaction with the villagers. A questionnaire had been prepared for the primary household data collection and total 124 villagers were participated. MS Word, MS Excel and GIS software were used in the analysis, tabulation, classification and generation of final maps and results of the study area.

3. Results and Discussion

1. 3.1 LULC of Santijan

The categories of land use and land covers used by the Govt. of India are forest land, agricultural land (irrigated and non-irrigated), built-up area, area under water bodies, culturable wasteland, (including gauchars and groves), fallow land and area not available for cultivation which can be taken as proxy for settlements and other public uses. Now, the LULC in fourteen villages which cover the Santijan taking an average width of 2 kms on both sides of its banks have been analysed over the period from 2013 to 2020.

3.2 LULC in 2013

3.2.1 Vegetation Cover

Vegetation is very important land cover for any region, be it a village or at global level. It maintains the ecological balance on one hand, and at the same time it helps minimize environmental pollution. There is unanimous agreement in the world community that at least 30% of land of each country shall be kept as forest cover. Unfortunately, forest coverage of the present study area is not very satisfactory. The vegetation cover of the study area was only 9% of its total geographical area in 2013 (Table 1).

3.2.2 Agricultural land use

Assam is an agrarian state dominated by agricultural activities and associated agricultural land use. As in the case of Assam, the major land uses of the study area is the agricultural land use. According to the census of India the agricultural land uses are divided into two categories. First, the irrigated land and the other is un-irrigated land. With increasing population, the demand and requirement for food is obviously increasing. As a result, more lands are being converted to agricultural lands. The study area has fertile soils which are capable of producing crops for two times in a year. Therefore, the expansion of agricultural lands in the study area has occurred up to its maximum extent. Agricultural land use in the study area was 18% in the year 2013 (Table 1).

3.2.3 Culturable waste land

As per the Census of India, culturable waste includes *gauchar* and *groves*. This area is considered as waste land and it is expected that the land falling under this category can be used either for cultivation or for settlement purpose. Most of the times the culturable waste land are located in the marginal lands. Culturable waste land in the study area was 16% in the year 2013 (Table 1).

3.2.4 Built-up area

Areas of human habitation which have a cover of houses, buildings, transport and communication, utilities in association with little bit of plants, vegetables and usable water bodies may be called as built-up area. All man-made constructions covering the land surface are included in this category. There are noticeable changes in the built-up area of the study area. The built-up land was 14% of the total geographical area of the study area in the year 2013 (Table 1).

3.2.5 Water bodies

This class as seen in the study area mostly comprises surface waters either impounds in the form of ponds, lakes, fisheries, wetlands, water logged areas, flowing streams, canals etc. The total area under water bodies were 34% (28.03 sq. km) in 2013 in Santijan (Table 1).

3.2.6 Fallow land

The fallow land includes the areas which are left uncultivated in the both summer and winter seasonal crops. The physical of setup of the study area is naturally a flood plain zone of river Brahmaputra. The small stream and tributaries which directly or indirectly connecting with Santijan are like Rasuti Jan and Mora Leteri river. Presently, many parts of the study area, especially in and around the outlet zone of Santijan remains covered with marshy, swampy lands which are uncultivable. The total area under fallow lands was 9% in 2013 (Table 1).

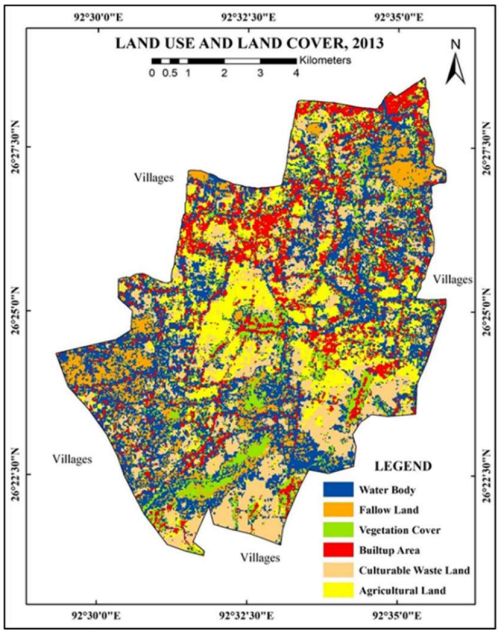

Fig. 2: Land use Land cover of the study area, 2013.

3.3 LULC in 2020

3.3.1 Vegetation Cover

The coverage has experienced slight change getting reduced to 8% of its total geographical area in the year 2020 (Table 1). The main reason for this decrease in forest cover between 2013 and 2020 is due to vegetation degradation. But after ground truth verification it is estimated that the vegetation cover is further low, i.e., 7.6% as the water bodies covered by green hydrophytes and phytoplanktons are also recorded and included under vegetation cover area. As regards vegetation degradation, it has been observed in the field that some parts on the banks of the wetland, especially the upper part experience degradation of vegetation cover due to newly created built-up areas and ponds and fisheries for commercial purposes. Along with vegetation degradation, there is also degradation of wetland ecology and ecosystem. It is thus necessary to think on the part of the concerned authorities, NGOs and public about the serious ecological problem of Santijan and how to retain the vegetation cover without further loss.

3.3.2 Agricultural land use

There is thus continuous decrease in the distribution and status of agricultural lands. Due to the lack of irrigation system and modernized technology coupled with increasing population in the study area, the agricultural lands have been converted to built-up areas or put for creation of ponds and fisheries. It has already been said that the agricultural land area has decreased from 18% to 17% of the total land area during 2013 to 2020. The decrease in agricultural land can be attributed to the increase in built-up area and fallow land (Table 1).

3.3.3 Culturable waste land

The study area experiences slight increase in culturable waste land from 13.28 to 13.75 sq. km. amounting to 16% and 17% respectively in year 2013 and 2020 (Table 1). Efforts may be made as there is scope for converting the culturable waste lands of the study area to agricultural or other productive purposes.

3.3.4 Built-up area

Built-up area of the study which has increased to 21% in 2020 (Table 1). Increase in population is the primary cause of such rapid increase in built-up area. Substantial increase in built-up area is mainly at the cost of water bodies (decrease from 34% to 24%) with less decrease in agricultural land and vegetative cover (Table 1).

3.3.5 Water bodies

Water bodies of the study which has largely decreased to 24% (19.61 sq. km) in 2020 (Table 1). It is important to note that there was maximum extent of area under water bodies in 2013 as compared to the other categories. This is mainly due to increase of built-up area, culturable waste lands and also the fallow lands. Growing unwise

human activities has led to degradation and decrease in water bodies.

3.3.6 Fallow land

Fallow land of the study which increased to 13% in 2020 (Table 1). Because, the outlet part of the wetland is getting swampy and marshy because of growing waterlogging problem as a result of decreasing hydraulic efficiency of the Santijan. Because it is interlinked with these small streams and tributaries of Brahmaputra. Moreover, some local people are interested in creating ponds, tanks etc. for fishery activities which are most profit-making business.

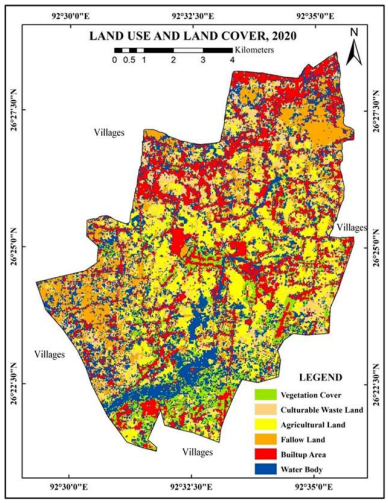

Fig 3: Land use Land cover of the study area, 2020.3.4 Changes in LULC and Causes

Land use and land cover pattern of the study area has been analysed taking two time periods, i.e., 2013 and 2020 (Fig. 2 and 3). It has been observed that declining trend in LULC is found to occur in the categories of agricultural land, water bodies and vegetation cover, while increasing trend is experienced in the categories of built-up area, culturable waste land and fallow land. As regards areal changes (Table 1), the area under the agricultural land has declined from 14.42 sq. km in 2013 to 13.09 sq. km in 2020 (Table 1). On the other hand, water body has undergone significant decline being 28.03 sq. km in 2013 to 19.61 sq. km in 2020 (Table 1). Similarly, vegetation cover has been reduced from 7.23 sq. km in 2013 to 6.53 sq. km in 2020 (Table 1). As regards expansion of areal extent, most significant areal increase is seen in the case of built-up area which increased from 11.74 sq. km to 17.17 sq. km (Table 1). The cultural waste land has also increased from 13.28 sq. km to 13.75 sq. km (Table 1). In the same way there has been increase in fallow land area from the extent of 7.26 sq. km to 10.95 sq. km (Table 1). Changes in LULC have their obvious impacts on the environment of the study area (Table 1). Decrease in agricultural land has its negative effects on agricultural production needed to feed the growing population. Substantial increase in built-up area takes place at the cost of water bodies, vegetation cover and agricultural land. In order to expand built- up area to meet the needs of housing for the growing population, the agricultural lands are converted, vegetations are removed and water bodies are filled up. Such changes in land use have exerted adverse environmental and ecological impacts on the study area. Decrease in water bodies and increase in population density have caused the ground water table to drop. Decrease in vegetation cover is also harmful for the local environment. Against these fallow lands are increasing which indicates that lands are not properly used for productive purpose in the study area. Thus, under the pressure of population and their growing dimension of economic activities, the lands of the study area are subject to both negative and positive impacts, which ultimately affect the natural life of the Santijan. This is the reason why Santijan is presently going to get degraded and die.

Table 1: Land use types, pattern and changes in the study area during 2013 and 2020

Land Use and Land Cover	Area in sq. km.		Area in percentage (%)		Nature of Impact
	2013	**2020**	**2013**	**2020**	
Agricultural Land	14.42	13.09	18	17	**Decreasing** with negative effect on agricultural production.
Built up Area	11.74	17.17	14	21	**Increasing** and causing negative effect on waterbodies, vegetative cover and agricultural land.
Culturable Land	13.28	13.75	16	17	**Increasing** slightly causing negative effect.
Water Body	28.03	19.61	34	24	**Decreasing** and causing adverse effect on the ecology of the area.
Vegetation Cover	7.23	6.53	9	8	**Decreasing** and causing adverse effects on the ecology and environment of the area.
Fallow Land	7.26	10.95	9	13	**Increasing** and causing land unusable for productive purpose.
Total Area	**81.96**	**81.96**	**100**	**100**	

Source: Based on author's calculation and the LANDSAT data from USGS Earth Explorer.

This study offers valuable insights into the dynamics of land use and land cover (LULC) changes in Santijan *Beel*. This study can be effectively compared to several related articles that investigate LULC changes in different contexts, revealing both similarities and distinctions in findings, methodologies, and implications. Many studies in the field of conservation of environment [11-13], utilize similar geospatial techniques to assess LULC changes. For instance, employed satellite imagery and GIS to analyse wetland changes in the north-eastern part of India specially Assam state [1,14-16], demonstrating the effectiveness of remote sensing in capturing temporal changes. The current research reinforces this methodology, showcasing the precision and detail that geospatial tools can provide when analysing LULC in Santijan *Beel*. However, unlike some studies that focus solely on quantitative data, this research integrates qualitative assessments, providing a more holistic view of the socio-economic impacts of LULC changes, akin to the approach taken [17,22,23], which emphasized the socio-economic context in their analysis. The findings regarding the expansion of agricultural land and built-up areas in Santijan *Beel* are consistent with trends observed in other regions, such as in lower Gangetic plain of India and north-eastern wetland ecosystem of Bangladesh [6,18], where high population growth was found to significantly encroach upon wetlands. This comparison highlights a broader pattern of land use pressure on wetland ecosystems across various geographical contexts. The research highlights the ecological ramifications of LULC changes, particularly concerning biodiversity loss and habitat degradation in Santijan *Beel* [19]. This aligns with findings from Hahila *Beel* in [1, 24], which documented similar impacts on wetland biodiversity in Nagaon District, Assam. Both studies emphasize the urgent need for conservation strategies to mitigate these effects. Conversely, while some articles suggest that LULC changes have led to improved agricultural productivity in certain regions, the current study raises concerns about the sustainability of such practices in the context of wetland conservation. This points to a critical divergence in how LULC changes are perceived in different ecological and socio-economic contexts. The examination of socio-economic factors in this study complements findings from the scenario of population pressure face by Morigaon district [20], where socio-economic pressures were identified as significant drivers of land cover change. The current research reinforces the notion that local communities' livelihoods are intricately linked to wetland health, suggesting that sustainable management practices must consider both ecological and human dimensions. Additionally, comparisons with other wetlands present in the north-eastern state of Assam [1,14,16] reveal that while some regions have successfully integrated community participation in LULC management, Santijan *Beel* faces challenges due to limited concerned authorities' engagement. This underscores the need for tailored strategies that incorporate local voices in conservation efforts.

4. Conclusion

Santijan *Beel* is an important wetland in Assam, India, and this research specifically targets the changes within this ecosystem. By focusing on a distinct and untouched geographical area, the study contributes to the understanding of localized environmental changes and their implications for biodiversity and ecosystem services. The use of advanced geospatial tools and techniques, such as satellite imagery and geographic information systems (GIS), provides a robust framework for analyzing LULC changes. This methodological innovation enhances the accuracy and precision of the data collected, allowing for a more detailed examination of spatial patterns over time. By examining satellite images from 2013 to 2020, the research captures a significant period of change, enabling the identification of trends and patterns in LULC dynamics. This temporal aspect is crucial for understanding how external factors, such as population growth and agriculture, influence the wetland environment. The study goes beyond mere quantitative analysis by also exploring the socio-economic implications of LULC changes. This interdisciplinary perspective enriches the findings, making them relevant not only to ecologists and geographers but also to policymakers and local communities concerned with sustainable development. By providing insights into the specific challenges and changes affecting Santijan Beel, this research contributes to local and regional planning efforts. It offers valuable information that can aid in the development of strategies for wetland conservation and sustainable land management practices.

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