

# Application of GIS and Remote Sensing Technology to Detect Landscape Change in Hollongapar Gibbon Wildlife Sanctuary, India

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**Abstract:** The present study stated on an evaluation into the use of remote sensing technology and geographic information systems (GIS) integration to detect land use/cover trajectories in Hollongapar gibbon wildlife sanctuary in Assam, India. Remote sensing technology was used to utilize multi-temporal satellite imagery including Landsat TM (Thematic Mapper) and Landsat OLI (Operational Land Imager) data to perform LU/C change detection from the year 1986 to 2018. The results revealed significant and unequal land conversion in the region of study. The paddy fields and tea gardens in and around the 4 km buffer of the wildlife sanctuary had increased sharply during the period 1986-2018. Remote sensing and GIS integration has been found to be effective in tracking and analyzing trends of LU/C trajectories and assessing the effects of land conversion on biodiversity of the study region.

**Key words:** remote sensing technology, Landsat data, supervised classification, paddy fields, tea gardens.

## I. INTRODUCTION

Land use/cover (LU/C) is the product of human land use and impacts on the Earth's surface from global climate change. LU/C plays a significant role in the climate system through standing as an origin and sink of carbon (Kim 2016). A frequent monitoring of LU/C changes is, therefore, helpful in understanding the magnitude and effect of the cultural and natural landscape changes on the Earth surface at different spatial scales. Remote sensed data and GIS domains were commonly used to identify LU/C and provide estimates of their respective areas. Remote sensing merged with field estimations has been instrumental in determining forest cover loss since the 1990s (Asner 2005). Various kind of satellite data types are used in classifying LU/C, particularly for forest depletion and decline (Gibbs et al. 2007). Sensor technology advances have provided for a variety of scales ranging from large image resolution of 1 kilo-meters (km) to moderate image resolution of about 20 meters (m) to 30 m (e.g., Landsat TM/OLI), as well as high resolution of less than 5 m (e.g., QuickBird). Because of the wide sensing range and higher frequency signal processing, large image resolution optical sensors were useful for mapping LU/C on a regional and continental scale. (Langner et al. 2007). Many widely used moderate resolution image including Landsat TM/OLI for LU/C mapping.

Moderate resolution images are a realistic and efficient key source of data to identify deforestation, particularly for REDD surveillance. Classification of remote sensing images is a complicated procedure requiring several actions, including defining a LU/C classification system, collecting data sources, choosing a classification method, extracting thematic information and evaluating accuracy (Jensen 2005). Since the 1990s, technological progress in the classification of images has been achieved and most work has been carried out to identify land use and forest losses, particularly for tropical forest patches (Foody et al. 1996). The most suitable dataset for REDD reference setting is satellite data with a moderate resolution, such as Landsat TM/OLI imagery. Landsat imagery is used for tracking tropical LU/C in developing nations with global coverage, the largest historical database and publicly available geographic observations of the earth (Zhuravleva et al. 2013). The purpose of the present work is to examine LU/C changes using satellite imagery, specifically those relating to deforestation and forest loss in and around Hollongapar Gibbon wildlife sanctuary. Deforestation is characterized as the anthropogenic conversion of forest patches into non-forest patches, including the permanent or long-term loss of forest patches. Degradation of the forest is a loss of the crown cover or woodland stocking.

## II. METHODOLOGY

### A. Study area

The Hollongapar Gibbon Sanctuary, previously recognized as Hollongapar Reserved Forest, is a fragmented protected area of wildlife and forest situated in the district of Jorhat, Assam, India. The sanctuary was formally established in 1997, and was called the Gibbon Wildlife Sanctuary after the only primates residing in North-East India: the Hoolock gibbon (Hoolock species). It was renamed "Hollongapar Gibbon Sanctuary" by the Assam government on 25th May, 2004 via notification no. 37/97/20 FRP.

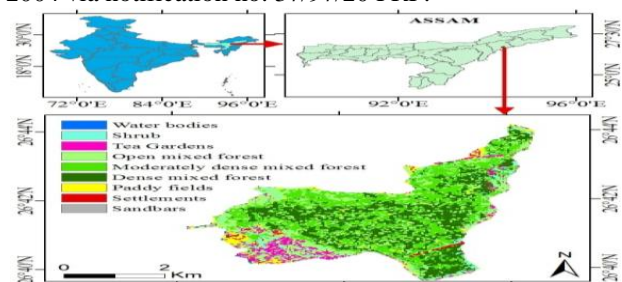


Fig. 1. The Hollongapar wildlife sanctuary.

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The Hollongapar wildlife sanctuary (Fig. 1) includes the only gibbons of India-the hoolock gibbons, and the only nocturnal primate of north-eastern India-the slow loris of Bengal.

The Hollong tree (*Dipterocarpus macrocarpus*) dominates the upper canopy of the forest while the Nahar (*Mesua ferrea*) occupies the intermediate canopy. The lower crown is composed of shrubs and herbs. The ecosystem of the sanctuary is threatened by deforestation, human encroachment, and destruction of wildlife habitats.

The Hollongapar Gibbon wildlife sanctuary is listed with semi-evergreen and wet evergreen forest. It generally receives on average 251 cm (99 in) of rainfall per annum. At the other side, it is located at an elevation between 101 and 121 m, and the topography slopes gently down from south-east to north-west. The Bhogdoi, a tributary of Brahmaputra River creates a waterlogged region occupies by semi-hydrophytes plants adjacent to the sanctuary's boundary, assisting in the formation of three distinct ecological regions within the sanctuary: the up-slope region, the down slope region, and the flood affected region.

### B. Remote sensed data and analysis

Multispectral images from the Landsat TM/OLI (Thematic Mapper/Operational land imager) satellite were collected for 1986 and 2018, during the cloud free season. All the Landsat images were geometrically corrected using about 50-70 field based points and a second-order polynomial transformation (root mean square error of 0.22 pixels). The nearest neighbour resampling technique was used. When the two images were collected the sky was free of cloud. Atmospheric corrections (ATCOR) were placed on the data to account for variations in the degree of solar azimuth. ATCOR was a necessary step to increase the clarity of the two images i.e. 1986 and 2018. It also helps in classification stage of the imagery.

This knowledge not only provides a deeper insight of readability but also plays a key role in the LU/C classification. To avoid misclassification and obvious errors, firstly the study region extracted from both images. I used seven bands (1-7) of Landsat TM/OLI images, baring the bands (8-11) of Landsat OLI, to classify LU/C images. Topographical map (Survey of India) at a 1:50000 scales from 1975 were also used as ancillary data.

LU/C maps for 1986 and 2018 were accounted for the study region by one of the important classification tool i.e. supervised classifications via MLC (maximum likelihood classifier). Nine LU/C classes were categorised to assess landscape change: dense mixed forest, moderately dense mixed forest, open mixed forest, shrub lands, teagardens, paddy fields, settlements, water bodies and sandbars. The training polygons were identified by field-to-image interpretation on topographical maps and Google Earth from 1986 and 2018.

Thirty iterations for each class were made to improve the classifications on the basis of field observations. The classification accuracy was checked on the basis of stratified random sample of 98 observation points on classified images, with a sample size relatively the same for each LU/C class (Congalton 1991).

### III. RESULTS AND DISCUSSION

Changes in land use/cover (LU/C) were assessed from the differences between 1986 and 2018 status. Nine major LU/C categories including dense mixed forest, moderately dense mixed forest, open mixed forest, shrub lands, teagardens, paddy fields, settlements, water bodies and sandbars were classified for the study area. The data reveal that in 1986, about 10.18% (1807.02 ha) area of the study area was under dense mixed forest, 23.68% (4201.38 ha) under moderately dense mixed forest, 36.3% (6439.59 ha) under open mixed forest, 5.93% (1052.91 ha) under shrub lands, 7.34% (1301.40 ha) under tea gardens, 11.73% (2081.7 ha) under paddy fields, 2.86% (508.68 ha) under settlements, 1.1% (195.48 ha) under water-bodies and 0.87% (153.72 ha) under sandbars. On the other hand, a significant change was observed in different LU/C categories in 2018. During this year the area under these land categories was found about 4.48% (794.43 ha) under dense mixed forest, 6.55% (1162.8 ha) under moderately dense mixed forest, 22.87% (4057.74 ha) under open mixed forest, 8.39% (1488.15 ha) under shrub lands, 22.48% (3988.98 ha) under tea gardens, 28.26% (5014.62 ha) under paddy fields, 4.99% (885.96 ha) under settlements, 1.1% (194.18 ha) under water-bodies and 0.86% (153.61 ha) under sandbars. A sharp increase of 206.51%, 140.89% and 74.17% in the tea gardens, paddy fields and settlements categories respectively were observed during the period 1986-2018 (Table- I). Settlement growth areas show a positive relationship with the increasing tendency of paddy field areas. This was clearly apparent from the increase in settlement areas by 74.17% during the period 1986-2018.

**Table- I: The extent of LU/C change in the study region.**

LU/C categories	Area (hectares)		Change (%)
	1986	2018	
Dense mixed forest	1807.02	794.43	-56.04
Moderately dense mixed forest	4201.38	1162.8	-72.32
Open mixed forest	6439.59	4057.74	-36.99
Shrub land	1052.91	1488.15	41.34
Tea gardens	1301.40	3988.98	206.51
Paddy fields	2081.7	5014.62	140.89
Settlements	508.68	885.96	74.17
Water bodies	195.48	194.18	-0.67
Sandbars	153.72	153.61	-0.07

The conversion of forested area to paddy fields was observed due to repercussion of the growing population pressures and human encroachment into forest region (Fig. 4). Paddy fields or croplands not only provide foods and various other essential agricultural products but it also stands as a tool of socio-economic healthy environment of a province. However, escalating demands of growing population and unplanned LU/C patterns have resulted in a critical concern towards paddy fields expansion. The prime crop of the study area is paddy-rice and expanding paddy fields into forested area has caused severe human-elephant conflict around the wildlife sanctuary. When elephants entered into the paddy fields in the village areas,

the villagers usually try to scare off the pachyderm and create severe human-elephant conflicts. Because of their increasing population and therefore rising needs this issue has grown concurrently for human and elephants. In fact, regular people and pachyderm incursions into the territories of one another have become usual phenomenon in the area. Besides, the growing population pressure has also led to the expansion of a large scale human settlement in the buffer areas of the sanctuary and numerous small villages encroached into forest area of the region. These villages were built during the 1960's to humanize the flood affected landless settlements of Majuli and its nearby areas (Bhattacharjee 2012).

Tea is another important cultivation of agriculture in this area. The increase (2687.58 ha) in area of tea gardens is mainly associated with the expansion of teagardens to the neighbouring dense mixed and moderately dense mixed forest areas and establishment of many small patches of tea gardens by the tea grower of the area. During the past few years people established a large number of tea gardens of diverse aspects of their specific efforts as an attempt to create jobs, which in turn, results a significant decrease in forested area. With the growth of tea gardens over the year the sanctuary gradually got detached from the Naga hills and Dissoi valley reserved forest area, giving rise to the problem of space and food for numerous wildlife species. In addition, the ecosystem in the Hologapar sanctuary is highly deteriorated due to consistent unlawful felling and intrusion by local residents, especially by the adjacent tea gardens workers. (Bhattacharjee 2012). The major causes of forest destruction include expansion of settlements, human activity along roads and tea gardens growth. Certain drivers of forest destruction are human encroachment into forested area, higher poverty levels, the collection of fuel-wood, cattle grazing, large number of illegal saw mills, and lack of governmental initiatives such as reforestation and afforestation, and enormous population growth in the study area. As a result, dense mixed forest stands are slowly turned into a mix of dense and open canopy or shrubland, and tree fallow, with no defined boundaries.

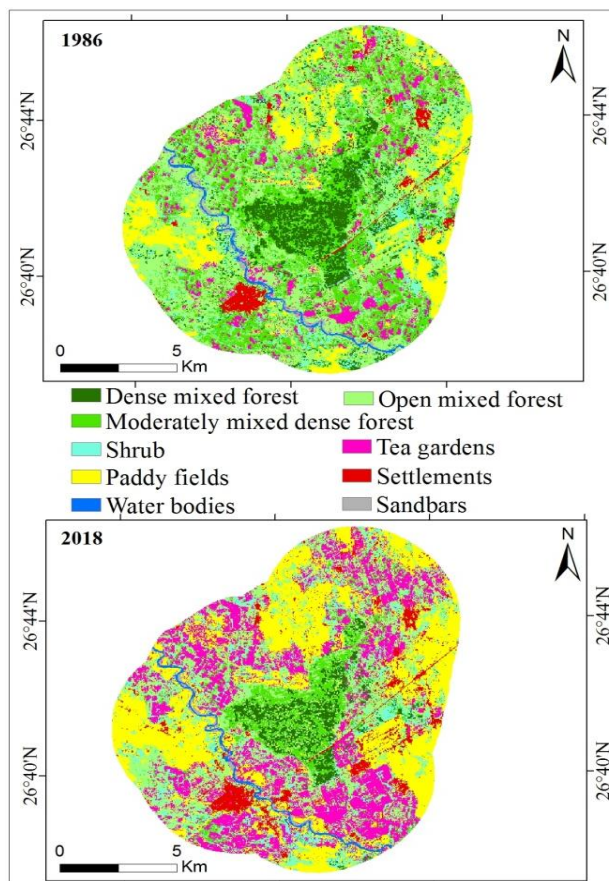


Fig. 2. LU/C maps for the year 1986 and 2018.

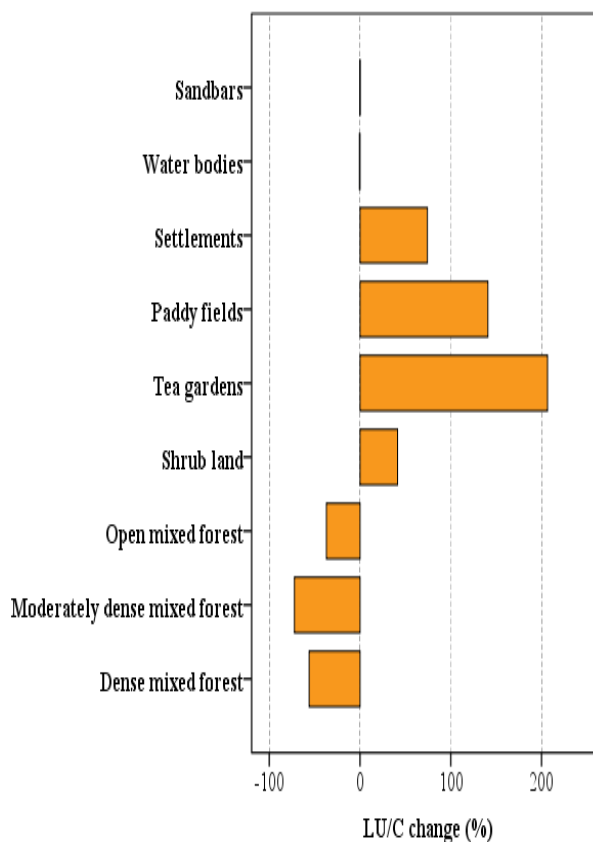


Fig. 3. The rates of LU/C change in the study region.

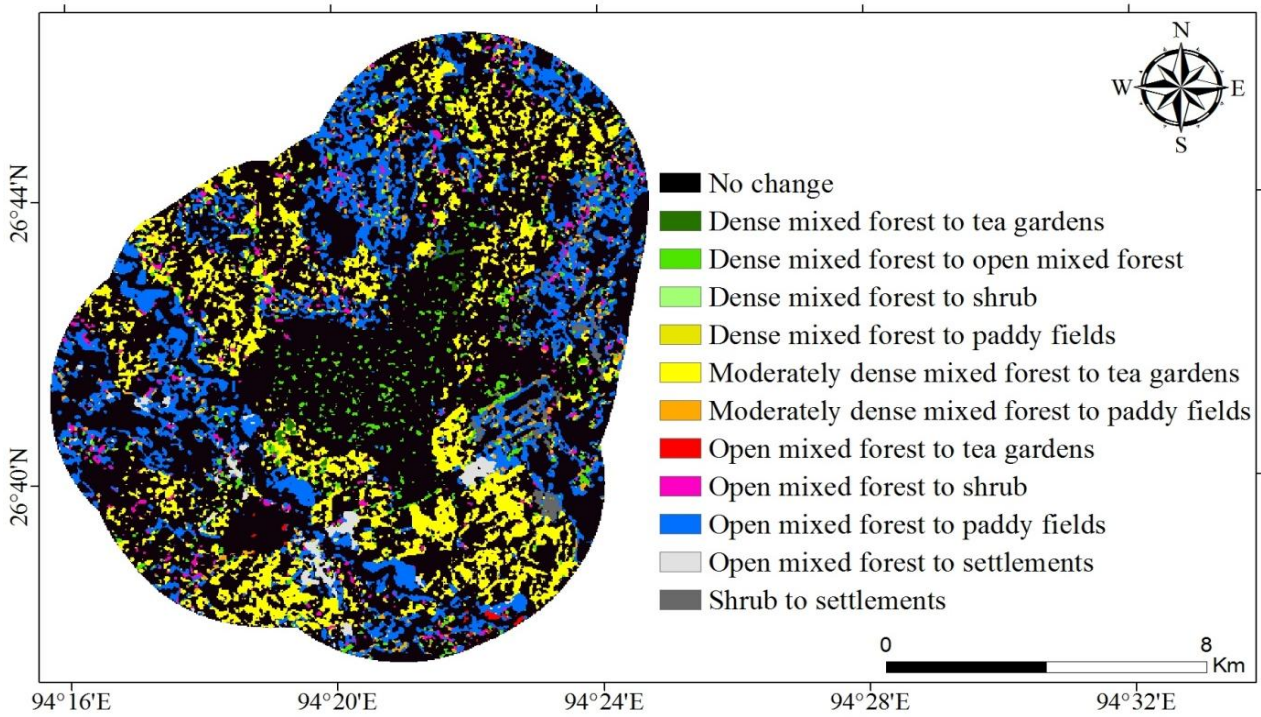


Fig. 4. LU/C change trajectories of the study region.

A large decrease in dense mixed forest area (56.04%) is a critical concern which needs an intensive care as it provides different habitat conditions for the existing numerous wildlife species. The open mixed forest areas were decreased by about 36.99% which is observed due to degradation of this category during 1986-2018. The distribution of different LU/C categories in 1986 and 2018 has shown that the higher positive change over the years was registered in tea gardens category and then followed by paddy fields, settlements and shrub lands. Higher negative detrimental changes are therefore represented by the moderately dense mixed forest followed by dense mixed and open mixed forest, water-bodies and sandbars. Reduction in dense mixed and moderately dense mixed forest may increase soil erosion and, conversely, decreased soil fertilization of alluvial landforms. The degradation of wilderness areas in north-east India is continuously growing. North-east India alone loses more than 1.6 million hectares of forested area every year; particularly 22 million hectares of forest land have been lost over the past many decades owing to over-exploitation, misuse and conversion (Kotoky et al. 2012). This depletion in forest wealth would not only deprive the inhabitants of numerous wild animals, but it also lessens the economic and ecosystem values offered by the biodiversity of the area. Thus, the study wildlife sanctuary needs an immediate conservation planning to maintain the ecological stability of area. The wildlife sanctuary did not have a perennial storage of natural water. During winter season the river channels are dried up rapidly due to quick run-off water of the channels. Water retains only in small patches of the sanctuary. Even though the Bhogdoi River runs closely to the sanctuary, there is a massive scale of anthropogenic activities adjacent to the river. The most perilous part of the area is the presence of railroad tracks which fragmented the sanctuary into two halves. This railroad track acted as a nightmare for various wild animals.

There are many mishap incidences of elephants and their casualties in the sanctuary due to higher traffic volume of trains.

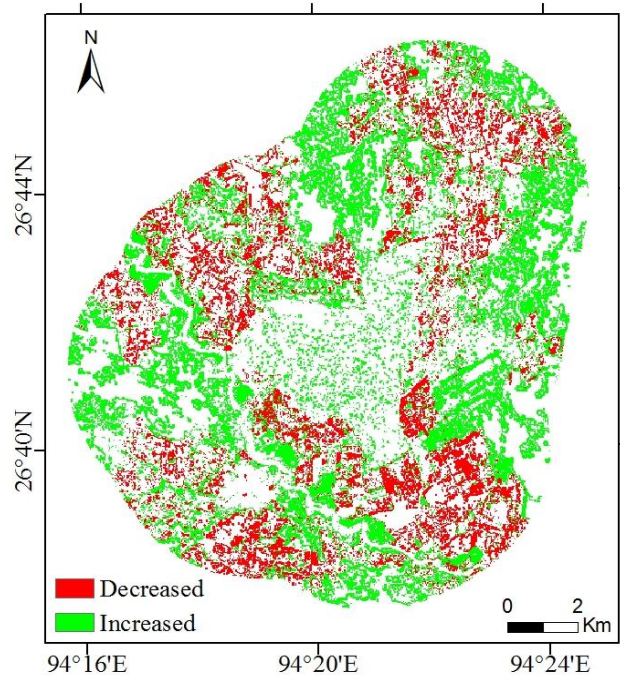


Fig. 5. Image difference map of the study years.

#### IV. CONCLUSION

Utilising remote sensed data (1986-2018) in GIS domain land use/cover (LU/C) change was assessed between 1986 and 2018 status. Nine major LU/C categories i.e., dense mixed forests, moderately dense mixed forests, open mixed forests,

shrub lands, teagardens, paddy fields, settlements, water bodies and sandbars were characterized within a 4 km buffer zone around the Hologapar Gibbon wildlife snacturay. The present study brought to light that tea gardens as the most dominant and sandbars as the minor categories of LU/C types within the study region. During the period (1986 to 2018), out of the total LU/C area, 1041.36 ha remains unchanged, which is equal 5.87% of the total area. However, 1867.65 ha (10.53%) of the open mixed forest areas were transformed to tea gardens, which can be taken as one of the critical LU/C practices. Significant conversion of open mixed forest to paddy fields up to 16.32% was evidenced within the study area. The transformation of forest to unplanned agriculture and settlements will make significant impact on the existing biodiversity of the wildlife sanctuary as the area is identified for the habitat of endangered *hoolock gibbon* and many such plant and animal species. The current investigative study has clearly stated that a comprehensive approach is needed for the conservation of the region's natural resource in view of its rich biodiversity within the efficient Bhogdoi river system under the planning and management of land use/cover change.

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**Rekib Ahmed** is a doctoral student of Geography at Gauhati University, India. He has post-graduated with a Master's degree in Geography, specializing in cartography and remote sensing technology. He currently conducts work on landscape change, particularly in forest cover dynamics and Asian elephant.