



Elephant Corridor loss due to anthropogenic stress – a study of change in forest cover using satellite data in the Sonitpur District, Assam, India

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Received: 03 May 2022 / Revised: 07 June 2022 / Accepted: 07 June 2022/ Published online: 07 June 2022. Ministry of Sciences, Research, and Technology, Arak University, Iran.

How to cite: Deb, H., Saha, A., Deore, S., Sanyal, S. (2022). Anthropogenic stress and its impacts on the Elephant habitat corridors, A case with Sonitpur district, Assam, India, Journal of Wildlife and Biodiversity, 6(x), x-x. DOI: <https://doi.org/10.5281/zenodo.6627395>

Abstract

Elephant habitats were mainly found in the dense forest regions which is the tropical evergreen forest in Sonitpur District, Assam. The total area of Sonitpur District is approximately 5204 km². Satellite imagery of 1990, 2009, and 2017 was investigated. The current research aims to investigate the huge amount of deforestation that occurred from 1990 to 2017 in the Sonitpur district using a temporal satellite imagery system. The visual data interpretation and change matrix analysis using three-period imagery indicated significant corridor loss and deforestation between 1990 and 2017. The study indicates that a massive number of land-use changes would be occurring within the next few years. So, to protect elephants and forests, agricultural land should be converted into natural forests and anthropogenic activities should be stopped in the corridors and buffer areas. Local communities and government should take various steps to do so and Government should take legal steps against elephant killing. This research focuses on the conservation problems associated with the corridor's decrease over time. The findings also indicated the advanced capabilities of GIS and remote sensing for monitoring and analyzing corridor status.

Keywords: Elephant corridor, Sonitpur, GIS, Remote sensing, Wildlife

Introduction

India is the home to more than 50% of all Asian Elephant population, and as per the 2017 elephant census, India has 27,312 elephants, a 10% decline from the 2012 census, when the country had 30,000 elephants (Aggarwal, 2017). In 2018, the supreme court has given a historic judgment in response to public interest litigation. For violating the legislation, Justice Lokur, S. Abdul Nazeer, and Deepak Gupta asked the Tamilnadu government to halt the development of

39 hotels and resorts along an elephant corridor in the Nilgiri hills. In their judgment they described India's elephants as a "Keystone species (Sundararaju, 2018). The MoEFCC described the elephant as the National Heritage Animal of India" (Sundararaju, 2018).

Elephant Corridors play a vital role to maintain population viability in a broader landscape. Elephant corridors are being destructed gradually due to increased settlement, cultivation, and developmental activities of the human population (Sarma et al., 2021). They studied the elephant corridors in the Tinsukia District of Assam. Nandy et al. (2007) investigated the depletion of elephant corridors caused by the large railway and highway overbridge construction in the Chilla–Motichur wildlife corridor, Uttarakhand. The corridors have been damaged as a result of the development of roads, railway, and hydroelectric canals, as well as the growth of Haridwar, rehabilitation of residents displaced by the development of Dam projects, as well as the establishment of military barracks. Baishya et al. (2021) conducted a study in the Nagaon Forest Division of Assam's Reserve Forests (RF). They said that in winter the number of elephants increases and it becomes very difficult for farmers to harvest crops and that's why Human-Elephant Conflict is very common in that area. Many forest areas in Assam are losing due to immense anthropogenic pressure. Kushwaha & Hazarika (2004) did their study on elephant corridors of Sonitpur and Kameng districts in 1999 and 2002 and said that the average annual rate of deforestation is approximately 1.38% which is greater than the national average and moist deciduous forests are facing maximum deforestation. The maximum rate of deforestation occurred near Reserved Forests, Wildlife Sanctuary, and National Park due to firewood extraction (Mahato et al., 2021). Due to the construction of highways, the activities of the elephant are reduced because of crossroad corridors. It indicates a change in their home ranges. Corridors are short strips of forests that link two larger parts of the forest. A corridor is a continuous two-dimensional landscape structure that interconnects two or more previously linked areas of animal habitats (Soule & Gilpin, 1991). Corridors allow animals to migrate and disperse across habitat fragments, minimizing the effects of separation and, as a result, the risk of elimination (Aalen, 1997). It also relieves strain on habitats and makes habitat rehabilitation easier. Corridors allow animals to enter places that would otherwise be inaccessible to them (Leimgruber et al., 2003). Wilson & Willis (1975) proposed corridor conservation to mitigate the effects of fragmentation. The separation and degradation of habitat and corridor caused by multiple developmental projects impose significant dangers to animals on a worldwide scale. Because of the cumulative effects of such two challenges, the wildlife population, particularly big animals, have lost hereditary continuity (Vidya et al., 2005; Srivastava & Tyagi, 2016). Isolated populations are susceptible to inbreeding and thus are compelled to exploit declining habitats.

Under anthropogenic impact, the fragmented areas disintegrate extremely quickly. According to the equilibrium hypothesis of island biogeography, a species' survivability is influenced by the magnitude of the habitat island it inhabits (Williamson et al., 1969). The higher the habitat area, the more the chance a population will be viable. The concept of utilizing corridors as conservation strategies were originally promoted in Sri Lanka. Given the benefits of corridors, a system of protected areas linked by corridors has been suggested as a conservation approach in India (Edge & Sukumar, 1991). Numerous corridors were identified as a consequence of this study around the nation (Vidya et al., 2005; Srivastava & Tyagi, 2016; Johnsingh & Williams, 1999; Sunderraj et al., 1995). Over the last 40 years, elephant corridors have shrunk to become small patches of land. In 2017, the Wildlife Trust of India undertook research in partnership with "Project Elephant" and the "Elephant Family" organization. Researchers discovered that India has 101 elephant corridors. There are 28 in South India, 37 in North East India, 25 in Central India, and 11 in northwest India (Fig. 1). This survey also discovered that approximately 70% of corridors are utilized on a routine basis, 25% are used infrequently, and 6% are hardly used (Sundararaju, 2018).

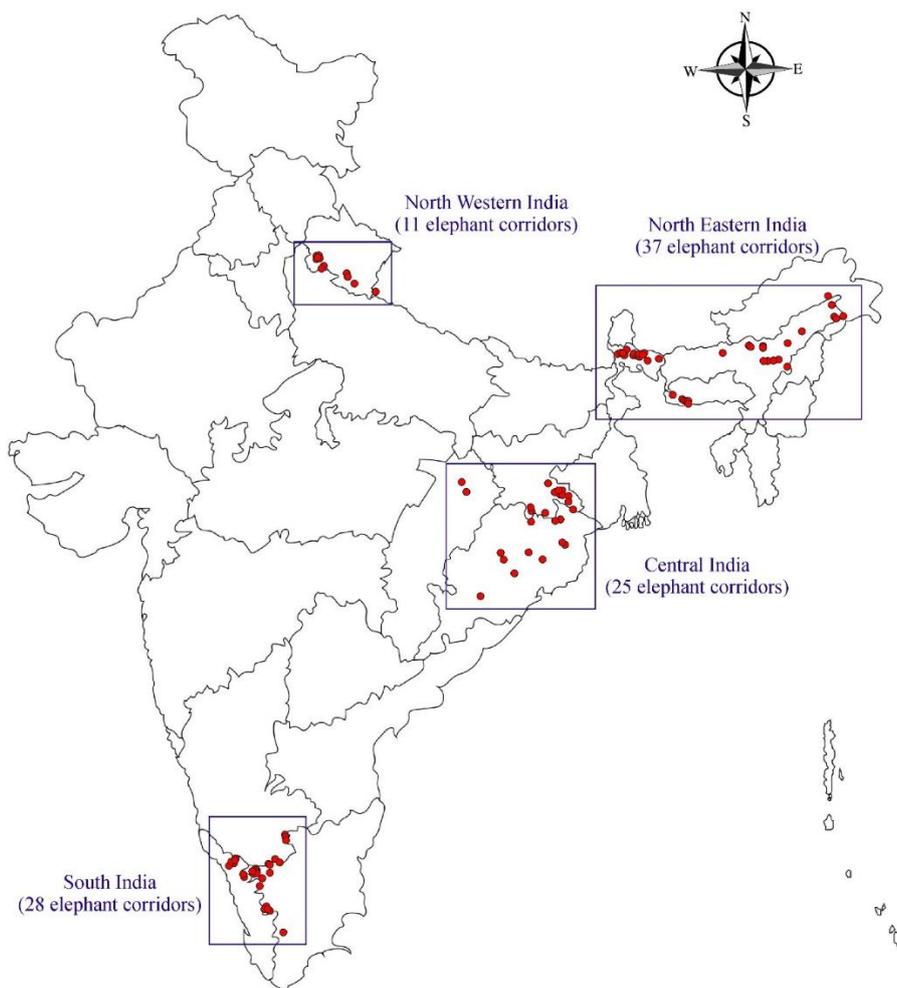


Figure 1. Known elephants' habitat corridors throughout India

Infrastructure prosperity and natural wildlife fragmentation have all been observed throughout the north-eastern region of India. For this, an acute conflict has recently occurred between humans and Asian elephants, as both elephants and the human population are gradually expanding, as enormous swaths of forests are turned into cropland, military barracks, and urban civilization (Naha et al., 2019). According to the most recent population estimates made by the Indian Government, the population of elephants is estimated to be 27,000 individuals scattered over 23 Indian states covering an area of around 1,09,500 square km (Lenin & Sukumar, 2011). Sonitpur district belongs to Eastern India. It is one of the largest districts of Assam, situated in the north Assam division. Its headquarter is Tezpur. It is located at latitude 26.7°N and longitude 92.85°E and occupies an area of approximately 5324 km². Out of total areas the forest coverage area is 960 km² of which 56 km² is a very dense forest, 280 km² is a moderately dense forest and 624 km² is an open forest.

Asian Elephant (*Elephas maximus*) is listed by IUCN as endangered species. In spite of major threats, they still exist (Lenin & Sukumar, 2011). Habitat loss, fragmentation of elephant population, human-elephant conflicts, and illegal killing of elephants adversely affected elephant conservation. Human-animal conflict adversely affected human life in the form of loss of crops and property, as well as the death of local people (Chartier et al., 2011). These incidents aggravated the crudeness of local communities which leads to the retaliatory killing of elephants and undermining of conservation efforts (Hoare & Du Toit, 1999).

The IUCN designates the Asian Elephant (*Elephas maximus*) as an endangered animal. Despite serious dangers, they continue to survive. Elephant conservation has been hampered by habitat degradation, elephant population segmentation, man-elephant conflict, and illicit elephant poaching. Human-animal conflict harmed people's lives by causing agricultural and economic losses, and the deaths of residents in the area. These occurrences reinforced the offensiveness of local tribes, leading to vengeful elephant killings and weakening wildlife conservation (Chartier et al., 2011).

In India, around 22% of habitats of elephants fall within protected areas and around 30% of elephants live within dense huge forest areas. But the majority of the population is in a highly fragmented landscape with human densities. With these backgrounds as there is a chance of extensive overlap with humans for sharing resources. Therefore, every time conflicts are inevitable. As a result, the elephant population has a lower chance of long survival.

Due to the increase in human population and development in northeast India, wildlife habitat has been reduced and fragmented. As a result, human-wild conflict arises. Between 1980-2003 due to the human-elephant conflict in North East India 1150 humans and 370 elephants died. Fragmentation of habitats occurred due to an increase in human immigration from neighboring

regions. The prime elephant habitat has been occupied by humans. This leads to human-elephant conflict now and then (Choudhury, 1999). Expansion of local land usage, deforestation, grazing land alteration, agricultural expansion, and urbanization, as per existing literature, all made significant contributions to land-use changes (Lambin et al., 2001; Chartier et al., 2011). For this reason, human-elephant conflict is increasing day by day.

Remote sensing technology is a useful approach for analyzing alterations in corridors because of its capacity to offer actual information with comprehensive and recurrent coverage, which is a substantial advantage over conventional techniques. Land use/cover alterations can be detected using spatiotemporal satellite photos. Satellite imagery data combined with GIS and GPS enable the acquisition, analysis, and interpretation of animal habitats information on a variety of time periods and at a low cost (Kushwaha, 2002; Kushwaha & Roy, 2002). Remote sensing already has contributed significantly to the collection of valuable data on forest cover, plant varieties, and land-use changes. During the last 30 years, several research has employed these approaches to analyze animal habitats (Botkin et al., 1984; Kushwaha, 1997; Houghton & Woodwell, 1981; Malingreau, 1991). This study aimed to: analyze the change in land use pattern, estimate the extent of land use land cover change in the area of study, and determine the source of elephant habitat loss and degradation in the study area.

Materials and methods

Study Area

The present study was conducted throughout Sonitpur District, Assam, India. The total area of Sonitpur District is 5204 sq. km. It extends from 92°20'E to 93°50'E and 26°15'N to 27°21'N. Sonai-Rupai Wildlife Sanctuary, Nameri Tiger Reserve (including Nameri National Park), Bura-Chapori Wildlife Sanctuary, Chaduar, Balipara, Noeduar, Biswanath, and Behali Reserve Forest are in Sonitpur District. The Forest area of Sonitpur District is very important to stretch of elephant habitat which extends from northern West Bengal through the Himalayan Foothills and Dooars covering Southern Bhutan. The total forest cover area of Sonitpur District is 1069.61 sq. km. So 20.55% area is under forest in Sonitpur District.

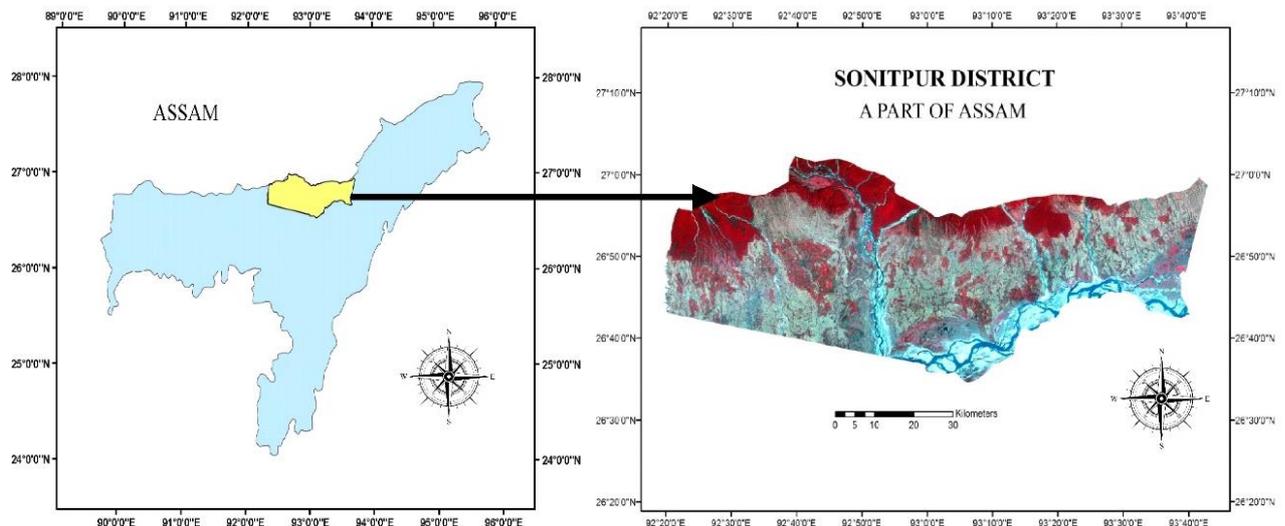


Figure 2. A map of the study area and sampling location. The current study was initiated in view of a proper assessment of forest cover change as the Man-Elephant Conflict has reached alarming proportions in recent years.

Data Collection and analysis

Secondary Data were collected from Landsat 5 (for 1990 and 2009) and Landsat 8 (for 2019) satellite images which were downloaded from USGS. Satellite images were used to detect the forest cover as well as land-use change. Acquired images were of the month of January and February to maintain seasonal vegetation characteristics. For data analysis, Remote sensing and GIS techniques were used. Satellite images of 1990, 2009, and 2017 were downloaded from USGS. Then images were geo-referenced through GIS software (ERDAS IMAGINE). Through GIS Software Satellite images were classified (Supervised Classification) as dense forest, open forest, agricultural land, water bodies, sandy areas, etc. to analyze the expansion of agricultural land and destruction of forest area.

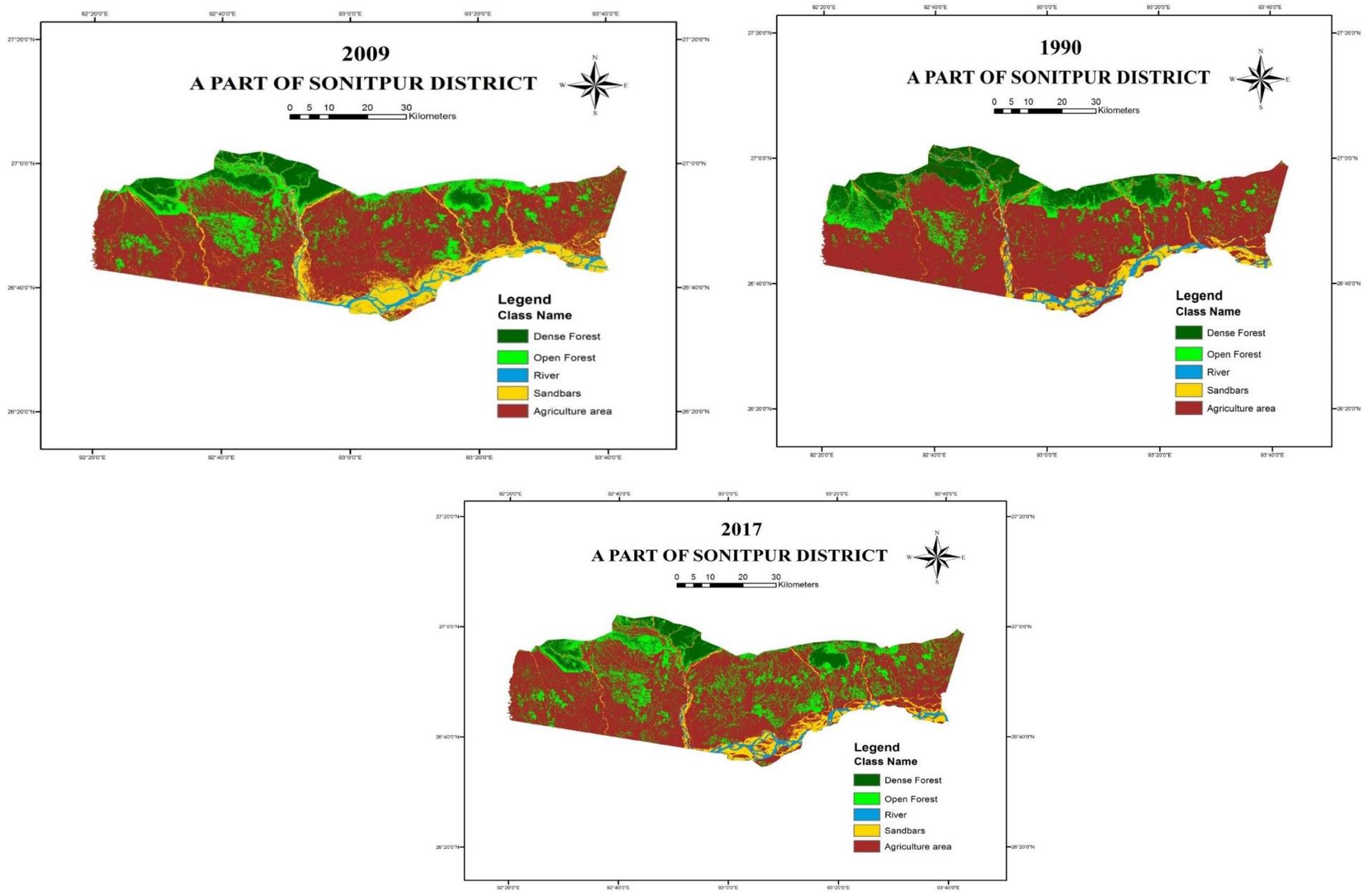


Figure 3. Forest cover change from 1990 to 2017

Result

Figure 3 (a-c) shows the land cover and land-use change in the Sonitpur district area during 1990, 2009, and 2017 respectively. It also indicates the decline of forest cover during that time period. Here five major land use and land cover (LULC) categories were characterized using field investigation data and Landsat data i.e., dense forest, open forest, agricultural land, water bodies, and sandy areas. In 1990, dense forest cover was almost about 15.45% has been decreased by 9.95% in 2009 and only 6.69% in 2017 respectively in the entire district (Table 1). The entire dense forest areas of the Sonitpur district deteriorated during the past several decades in the forms of targeted cutting, burning, grazing, fuels, and timber wood collecting, resulting in the establishment of a secondary ecological succession stage. The report also emphasizes that perhaps the dense forest-covered region has been changed into some other type of land coverage, indicating that the area is under heavy anthropogenic stress. The findings also indicated that the area of water bodies, sandy areas, and dense forests were reduced because of changes in land-use patterns.

Table 1. Land use and land cover change (LULC) of Sonitpur, Assam, India

Class Year	Dense Forest	Open Forest	Agricultural Land	Water Bodies	Sandy Areas
1990 (%)	15.45	12.63	62.49	2.50	6.93
2009 (%)	9.95	15.85	65.95	2.03	6.22
2017 (%)	6.69	18.65	66.87	1.87	5.92
Net Change (%) 1990-2009	-5.5	3.22	3.46	-0.47	-0.71
Net Change (%) 2009-2017	-3.26	2.80	0.92	-0.16	-0.3
Net Change (%) 1990-2017	-8.76	6.02	4.38	-0.63	-1.01

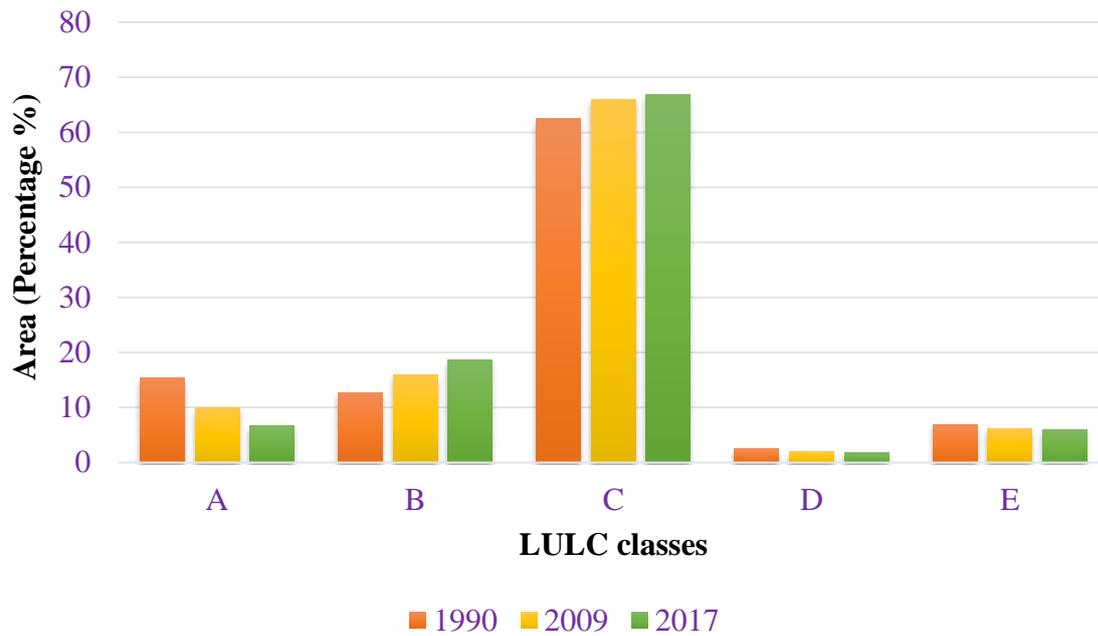


Figure 4. Change in land use and land change (1990 to 2017) in different land use (A: Dense Forest, B: Open Forest, C: Agriculture land, D: Water bodies, E: Sandy areas).

Discussion

In the Sonitpur district, elephant habitats were mainly found in dense forest region which is tropical evergreen forest. The result indicates that dense forest decreases more in-between the years 1990 to 2009 than in the interval between 2009 to 2017. But the percentage of open forests increased from 1990 to 2017. In 1990 there was 12.63% open forest but in 2009 it was increased to 15.85% and further in 2017 it was increased to 18.65% and the total increment of open forest area is almost about 6.02% during the period of 1990 to 2017 due to huge amount of deforestation. In 1990 there was almost 62.49% agricultural land cover and it increased to 65.95% in 2009 and further increased to 66.87% in 2017 (Fig. 4). Agricultural land was increased from 1990 to 2017 and the major changes occurred in the period 1990 to 2009. So, a massive amount of land-use changes was detected from 1990 to 2017. Changes were also observed in waterbodies land cover changes. Land cover of water bodies also decreased during the period 1990 to 2017 and it also affected the other land cover changes. These changes were mostly caused by increasing biotic stress as a result of the district's rising human population, particularly along elephant corridors. The dense forest corridor regions were found to be transformed into open forest and agricultural land.

The forest has been deforested due to socio-political problems as the area is dominated by the Bodo tribe and they are demanding a separate Bodo province for a long time. The other cause is that the paddy is a major crop in that area and the increase in agriculture is resulting in a huge

amount of deforestation. On the other hand, the paddy crop attracts elephants and as a result, the loss of elephant and human lives occurs due to man-elephant conflict (Kushwaha & Hazarika, 2004).

Conclusion

Now a day's destruction of the Elephant Corridor is a burning issue in North-East India as well as in the whole of India. From 1990-to 2017 huge amount of dense forest was degraded because of the rapid rate of deforestation. So the corridors should be identified as restricted areas by the concerned authorities so that the elephant can move freely along the corridors and can move from one habitat to another. Plantation along Corridors should be done because this will ensure the uninterrupted movement of elephants across their habitats and plantation drive may help in the reduction of the human-elephant conflict. To protect the elephant habitats and corridors, illegal agricultural lands should be converted into natural forest areas. Besides these, anthropogenic activities should be stopped in the corridors and buffer areas. Local communities as well as govt. should take various steps to do so. Govt. should take legal steps for killing elephants. Some precautionary actions must be adopted, as well as future research is necessary to mitigate ongoing forest area degradation.

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