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ORIGINAL ARTICLE

Land Use Land Cover (LULC) Change Detection Analysis between 2013 and 2023 in Karbi Anglong District, Assam, using Geo-Informatics

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Abstract

Background/Objectives: Land Use Land Cover (LULC) is an important factor in monitoring the land use area of a region. This study aims to examine LULC change in Karbi Anglong District of Assam. **Method**: The study is conducted using data from remote sensing, geographic context, and field research findings. The study used Google Earth Pro Satellite Images using Arc GIS 10.5 software to map the LULC change detection for the years 2013–2023. Six primary categories of land use and land cover classification are used to categorize the research area: built-up areas, agricultural land, ginger cultivated area, and forest, wasteland, and water bodies. **Findings**: The results reveal a 30.31 sq. km increase in built-up areas, a 26.69 sq. km increase in agricultural land, and a significant 51.69 sq. km rise in ginger-cultivated area. Conversely, forest cover declined by 108.56 sq. km and water bodies by 4.03 sq. km. The increase in the wasteland, agricultural, ginger-cultivated land and built-up areas are evident in the outcome. Conversely, there is a decline in water and forest areas. **Novelty**: This study offers a detailed micro-level temporal analysis of LULC using field-verified remote sensing data and provides a baseline for future environmental planning in Karbi Anglong District of Assam. LULC is crucial because inappropriate land use can have negative impact on the environment as well as in the society and economy.

Keywords: Remote sensing; GIS; LULC; Google Earth; Ginger Cultivation

1 Introduction

Land Use and Land Cover (LULC) analysis plays a critical role in understanding environmental change and sustainable resource planning. Land use and land cover (LULC) techniques are essential for analyzing spatial patterns and temporal dynamics of landscapes, particularly for sustainable regional planning and environmental management[1]. LULC studies help in understanding the impact of natural processes and human activities such as urban expansion, deforestation, and agricultural intensification. A study in 1976 provided one of the earliest standardized frameworks for LULC classification, forming the basis for modern land cover monitoring[2]. The advancement of remote sensing and geographic information systems (GIS) has significantly improved the accuracy and efficiency of LULC analysis[3]. Additionally, another study demonstrated that multi-temporal satellite imagery combined with advanced classification methods can effectively monitor land change, especially in rapidly developing regions. These techniques have become indispensable for regional planning, environmental conservation, and policymaking[4]. Recent studies have applied remote sensing to detect landscape changes, yet few have addressed micro-level temporal variations in hill districts of Northeast India[5].

This study investigates decadal LULC changes (2013–2023) in Karbi Anglong, Assam a tribal-dominated region with unique topography and cropping patterns. Using high-resolution (4-10 m) Google Earth Pro imagery, the study manually classified changes in agricultural land, built-up areas, forest cover and water bodies with a specific focus on ginger-cultivated zones. The aim is to fill the gap in fine high resolution LULC mapping in this region and demonstrate increased settlement and agricultural expansion at the cost of forest and water resources. This research contributes novel micro-level spatial data analysis for local environmental planning.

2 Methodology

2.1 Study Area

The study has been conducted in the Karbi Anglong district (East) which occupies 7366 square kilometresis located in the state of Assam. Its borders are to the east and west by the states of Nagaland and Golaghat District, to the north by Golaghat and Nagaon District, and to the south by Dima Hasao District and Nagaland [https://westkarbianglong.assam.gov.in/]. The district is located within an elevation of 900 meter an above. The temperature ranges from 6°C to 12°C and during summer it ranges from 23°C to 32°C. The region features hills covered in dense tropical forests and low plains. The area has a serene, humid climate (Figure 1 & 2). The district is situated at the center of the state of Assam, with the Brahmaputra River to its north, marking the meeting point of the district's numerous streams. The district has a dendritic drainage system, with the Jamuna and Dhansiri waterways serving as the region's principal waterways. The study area is situated between 25°20'00"N to 26°40'00N latitude and 92°50'00E to 94°00'00"E longitude[6].

The study implemented a three-step method: (i) Data Collection, (ii) Field Survey, and (iii) Image Processing.

(i) Data Collection: High-resolution Google Earth Pro images from 2013 and 2023 were used to identify land use changes. District boundary shape files were obtained from the Survey of India [https://onlinemaps.surveyofindia.gov.in/]. The projection system used was WGS 84 / UTM Zone 46N. Input variables included satellite images and GPS coordinates; output variables included land cover classes built-up area, agricultural land, ginger cultivation, forest, wasteland and water bodies.

(ii) Field Survey: GPS-based field survey has been conducted across the study area to validate ground truth locations. Approximately 150 GPS points were collected, out of which 70% were used for training and 30% for testing image classification accuracy. These points helped in identifying village boundaries, ginger cultivated areas and validation of classification outputs. Additionally, a few points were gathered in order to see and precisely pinpoint the village boundary and Ginger cultivated areas; Google Earth image also has been used to determine the village boundary's exact location.

(iii) Image Processing: Google Earth Pro is used to manually digitize the 2013 and 2023 images using polygon-based LULC classification. Google Earth has been used constantly during the course of the work for processing images. Data sets are used to extract image information. Google Earth Pro's several time series classes are digitized to obtain LULC images of 2013 and 2023. With the Google Earth Pro programme, images are manually digitized. Subsequently, the district and study area are clipped into images, and the images are projected in WGS 84/UTM 46N. After that KML file has been converted into layer format using the Arc GIS 10.5 Machine Learning tool. Agricultural land, areas used for growing ginger, built-up areas, forest cover, wasteland, and water bodies are all included in the LULC categories. The superiority of this manual micro-scale classification was validated by comparing it with open source NRSC/Bhuvan datasets, showing improved resolution and area-specific accuracy.

3 Result and Discussion

This study compares the past land use land cover to the current status (year 2013 and year 2023). The present land use/ land cover of the study area is shown in Table 1 and Figure 3. The findings of the study are as given below-

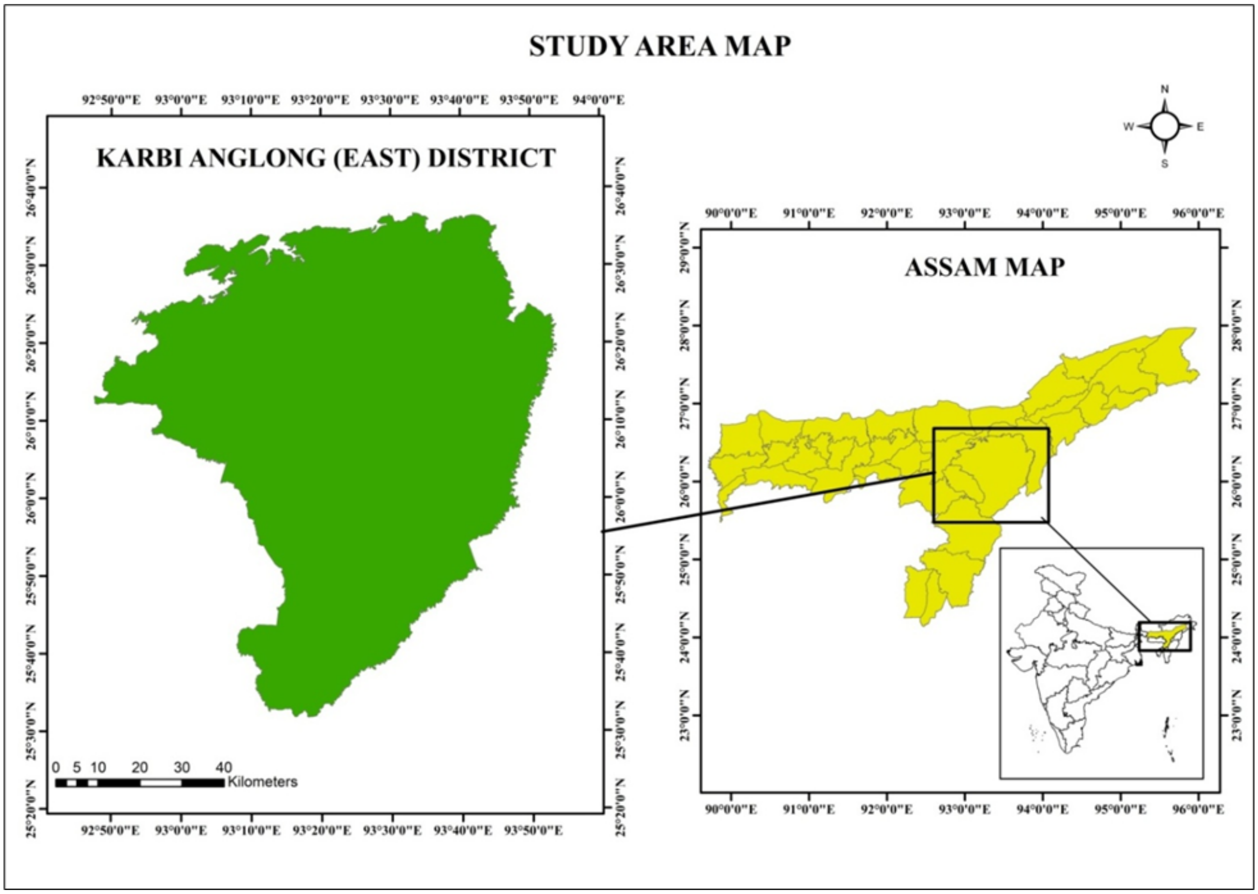

Fig 1. Map of Study Area Karbi Anglong District

Table 1. Land use Land cover of Karbi Anglong District, 2013 & 2023

Land use / land cover categories	Area in sq km (2013)	Area in sq km (2023)	Change (in sq. km)
Built-up	337.95	368.26	30.31
Agricultural land	1109.39	1136.07	26.69
Ginger cultivation	17.65	69.34	51.69
Forest	5810.36	5701.80	-108.56
Wasteland	21.63	25.53	3.90
Waterbody	22.14	18.11	-4.02

3.1 Built up

Areas like concrete-covered land, roads, commercial industries, and various man-made appliances, buildings, transportation, etc., are included in built up areas. According to the Land use land cover change classification, about 337.95 sq. km of area was covered in 2013 as built-up area and 368.26 sq. km in 2023; the change within the 10 years of tenure is about 30.31sq. Km.

3.2 Forest

The district's largest geographical area is covered by forest area. The forest cover is divided primarily into four classes [https://karbianglong.gov.in/information-services/general-data-of-karbi-anglong]:

- Moist semi-evergreen forest-

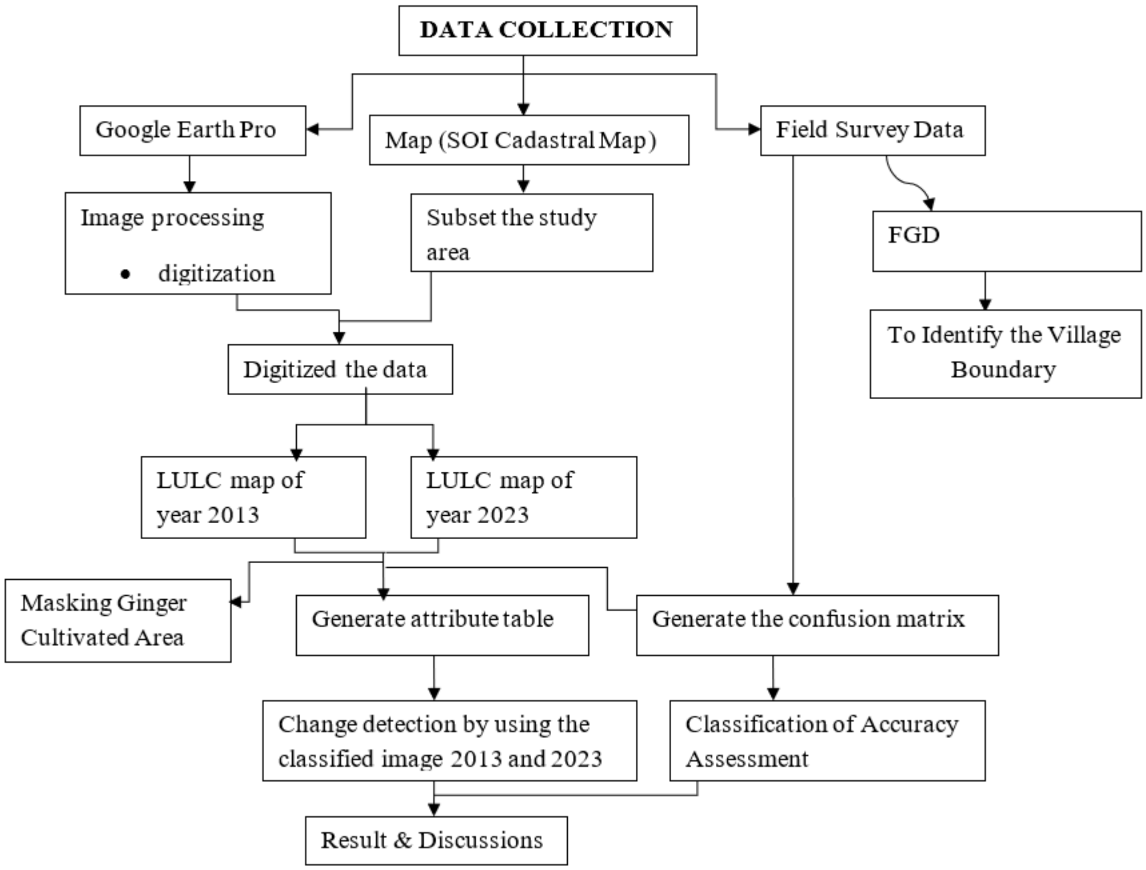

Fig 2. Flow Chart of Methodology followed in the Present study

Moist semi-evergreen forests are the type of forest that is mostly found in the district. It is mostly found in the north-eastern and north-western part of the district.

- Moist mixed deciduous forest
- Riverine type
- Miscellaneous type with scattered pure or mixed patches of bamboo. It encompasses over 5810.36 sq. km of the entire land area in 2013 and approximately 5701.80 sq. km in 2023. Out of the district's total land area, the forest area has shrunk by-108.56 sq. km.

3.3 Water Body

The district enriched with a large number of minor water bodies and several tiny streams and rivers, manually digitizing the water bodies proved challenging. Within the forest area also there are many rivers and streams which are difficult to digitization and consider for classification so far. As a result of which the classified areas are only the areas which are visible in the image (Google Earth Pro images). The visible areas of this class are the road side, open area, a built-up area, etc. The overall geographical area covered by water bodies in 2023 is estimated to be 18.11 sq. km, compared to 22.14 sq. km in 2013 based on manual digitization.

3.4 Agricultural land

Cultivated land areas, paddy, jhum/shifting cultivation, fallow land and plantation are included in agricultural land areas in this study. Jhum/shifting cultivation is identified by identifying the cropped area in the forest area. The area covered in 2013

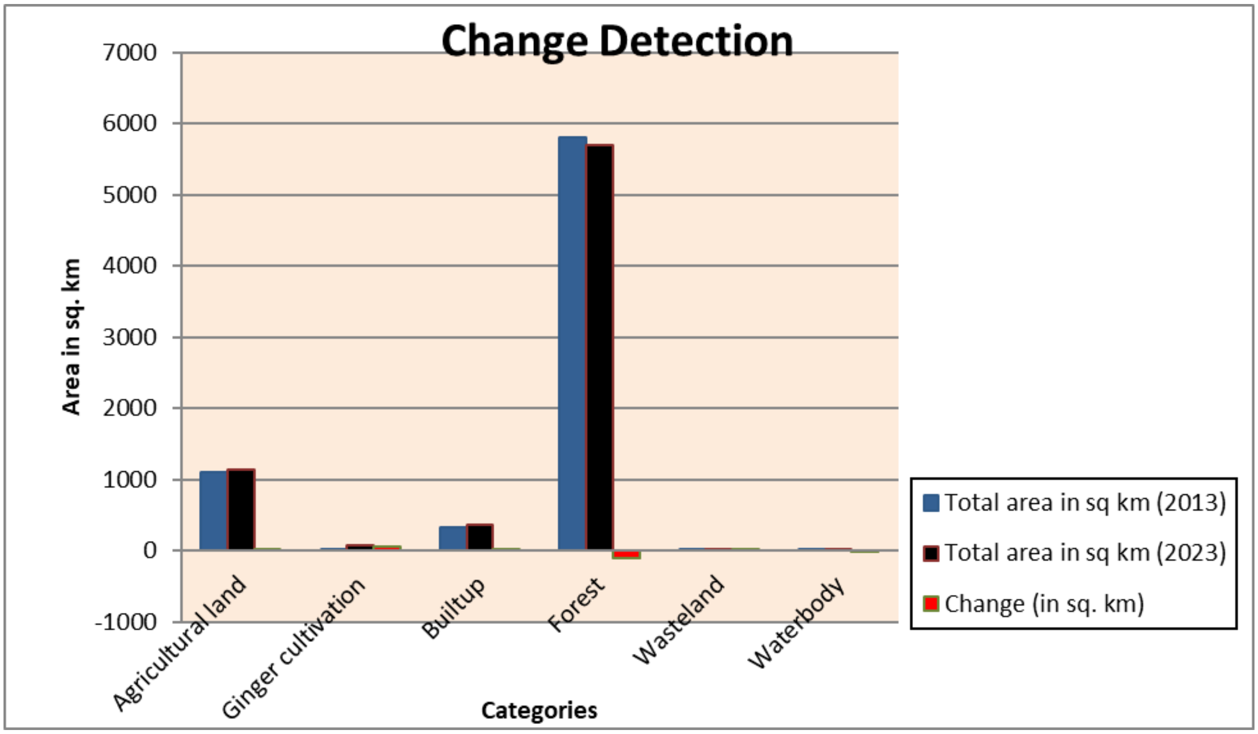

Fig 3. LULC Change Detection of the year 2013 to 2023

was approximately 1109.39 sq. km, and in 2023 it is 1136.07 sq. km according to the LULCC Classification. This means that throughout the duration of ten years, the region's agricultural area increased by 26.69 sq. km.

3.5 Ginger Cultivation

The cultivation of ginger in the study area continues to expand with time. As the population grows, so does the agricultural area, resulting the area used for ginger cultivation is growing as well. The area under cultivation of ginger increased from 17.65 sq. km in 2013 to 69.34 sq. km in 2023. The area has expanded in 10 years is 51.69 sq. km. This classification is done with the help of GPS data collection through primary data survey. Further with the help of pixel size and pixel color of the images.

3.6 Waste land

The study area is found with exposed land surface in the mid of the forest, defoliated area and gravelly waste area, which are classified as barren land in both the image of 2013 and 2023 LULC images. Only small portion of barren area can be seen in the study area as classified in the images, about 21.63sq. km area is covered as barren in 2013 and about 25.53sq. km area in 2023 (Figure 4).

Accuracy Assessment Analysis:

Accuracy assessment of the image classification is necessary. For the accuracy assessment for the LULC image, the classes' points are picked through random selection according to their area of coverage by the selected classes. The data were extracted from Google Earth Pro (satellite images) for the years 2013 and 2023 to assess the land use cover change in the study area. An attribute table was generated for both images to evaluate the accuracy of the images. The user's accuracy is the unofficial level from the verge of the map user and the producer's accuracy in the form of the map accuracy of the map producer. The formulae generated for overall accuracy, producer's accuracy, user's accuracy and kappa coefficient (K) are given below:

Formulae:

$$Overall\ Accuracy = \frac{Total\ no.\ of\ Correctly\ Classified\ pixels\ (diagonal)}{Total\ number\ of\ Classified\ pixels\ in\ that\ category\ (the\ row\ total)}$$

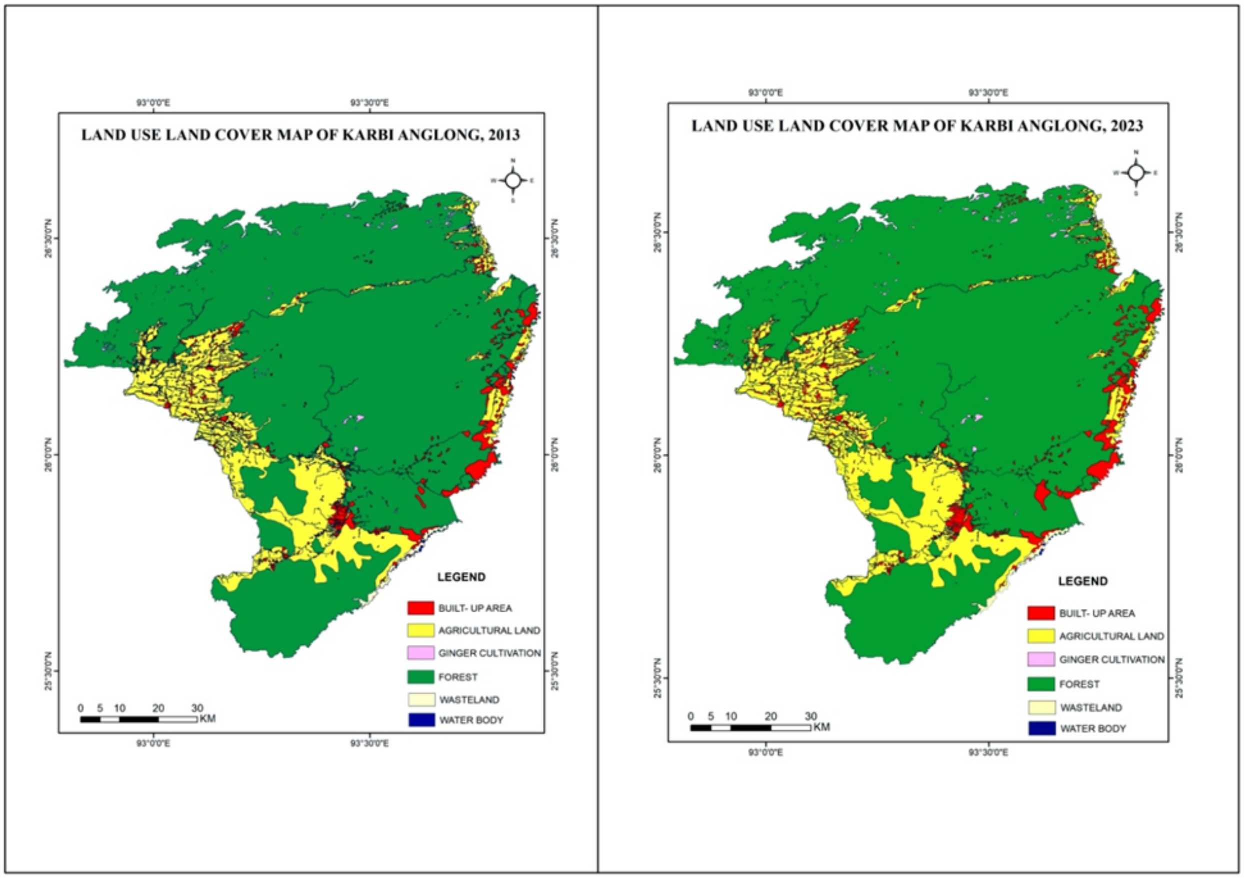

Fig 4. LULC map of Karbi Anglong District, 2013-2023

$$User's\ Accuracy = \frac{Number\ of\ correctly\ classified\ pixel\ in\ each\ category}{Total\ number\ of\ Classified\ pixels\ in\ that\ category\ (the\ row\ total)}$$

$$Produce's\ Accuracy = \frac{Number\ of\ correctly\ classified\ pixel\ in\ each\ category}{Total\ number\ of\ reference\ pixels\ in\ that\ category\ (the\ column\ total)}$$

$$Kappa\ Coefficient\ (T) = \frac{(Total\ Sample\ X\ Total\ Corrected\ Sample) - \sum\ (Column\ Total\ X\ Row\ Total)}{Total\ Sample\ X\ Total\ Sample - \sum\ (Column\ Total\ X\ Row\ Total)}$$

Overall accuracy for the LULC 2013 is 0.976, and for 2023 is 0.973, required to see whether the reference site is classified correctly. To see the overall accuracy, we need to add the number of correctly classified pixels and divide it by the total number of reference sites. User's accuracy is conducted to see the map accuracy of the map from the perspective of the map user. Producer's accuracy is adopted to see map accuracy from the point of the map producer. The Kappa Coefficient is generated to evaluate the accuracy assessment of the classification of the image. The Kappa Coefficient can range from -1 to 1. 0 indicates randomly classified images to be moderate, -1 as significantly worse and 1 as the best result of image classification. However, the value for the Kappa Coefficient is found to be 0.950 for the year 2013 and 0.944 for the year 2023, which is given below. It can be assumed that the classification of the Google Earth Pro satellite image is adequate (Table 2).

The findings of this study align with, yet significantly advance previous research on land use and land cover (LULC) changes in Assam and Northeastern India. For instance, a recent study analyzed Jhum cultivation in Karbi Anglong's Amri block and

Table 2. Accuracy Assessment Table for LULC Classification in 2013 and 2023

Classes	Users Accuracy, 2013	Users Accuracy, 2023	Producers Accuracy, 2013	Producers Accuracy, 2023
Built-up Area	1.000	1	1	1
Agricultural Land	0.933	0.955	0.893	0.86
Ginger Cultivation	0.900	0.9	1	1
Forest	0.983	0.974	0.987	0.991
Wasteland	1.000	1	1	1
Waterbody	1.000	1	1	1

noted that shifting cultivation covered approximately 127.15 sq. km, but did not distinguish specific crops such as ginger[7]. In contrast, the current study uniquely isolates ginger cultivation, revealing a substantial increase from 17.65 sq. km in 2013 to 69.34 sq. km in 2023, thereby offering more granular insights into crop-specific land use shifts[7]. Another study reported general LULC changes in Assam's Morigaon district, including a moderate forest decline and increase in built-up areas[8], the current study documents a sharper forest reduction of 108.56 sq. km and a measurable rise in agricultural land (+26.69 sq. km), highlighting intensified land pressure in hill regions. Unlike many earlier studies that lacked detailed accuracy assessments or used outdated satellite data, this work employs high-resolution imagery from Google Earth Pro with a strong classification accuracy ($\geq$97%) and high Kappa coefficients (0.950 in 2013 and 0.944 in 2023), ensuring greater reliability. Furthermore, previously, landscape-scale analyses focused primarily on protected areas and ecological corridors[9]; in contrast, this study presents a district-level evaluation incorporating both anthropogenic and ecological land transformations. By combining recent data, field-based GPS validation, and detailed thematic classification, this research offers a more updated, accurate, and context-specific assessment of LULC changes in Karbi Anglong than prior studies.

4 Conclusion

This study successfully quantified land use and land cover (LULC) changes in the Karbi Anglong district of Assam between 2013 and 2023 using high-resolution Google Earth Pro images and GIS techniques. The results showed a notable increase in built-up areas 30.31 sq. km and agricultural land 26.69 sq. km, while forest cover declined by 108.56 sq. km and water bodies by 4.03 sq. km. significantly, the area under ginger cultivation increased from 17.65 to 69.34 sq. km. These findings highlight the expansion of agriculture and settlement in ecologically sensitive zones. The objective of capturing micro-level LULC changes was effectively achieved, and the results provide valuable baseline data for regional planning.

Compared to previous LULC studies in Northeast India that relied on coarser resolution data; this study offers more precise, village-level insights using manual digitization and field GPS validation. However, the study is limited by the manual classification method and reliance on only two time-point datasets. Future work should incorporate spectral classification, multiple time-steps, and machine learning techniques for more robust LULC modeling. Overall, the study underscores the urgency of continuous LULC monitoring for ensuring ecological sustainability and informed land use planning in Karbi Anglong.Non-Cited References[10], [11], [12], [13], [14], [15], [16]

References

1) Pelorosso R, Apollonio C, Rocchini D, Petroselli A. Effects of Land Use-Land Cover Thematic Resolution on Environmental Evaluations. *Remote Sensing*. 2021;13(7):1232. https://doi.org/10.3390/rs13071232.
2) Anderson JR, Hardy EE, Roach JT, Witmer RE. A land use and land cover classification system for use with remote sensor data. *US Geological Survey*. 1976;964. https://doi.org/10.3133/pp964.
3) Lillesand TM, Kiefer RW, Chipman JW. Remote sensing and image interpretation. 7th ed. Wiley. 2015. Available from: https://www.bkbcollege.in/upload/dpt_book/1669887716.pdf.
4) Lu D, Weng Q. A survey of image classification methods and techniques for improving classification performance. *International Journal of Remote Sensing*. 2007;28(5):823–870. https://doi.org/10.1080/01431160600746456.
5) Sarkar R, Bora AK, Sharma T. Spatial Distribution pattern on Jhum Cultivation and Landuse Land Cover Status in Amri Block of Karbi Anglong District Assam. *Palarch's Journal of Archaeology of Egypt/Egyptology*. 2020;17(10). Available from: https://shorturl.at/hNZBt.
6) Basumatary L, Borthakur P, Simhachalam A. Women participation in Agriculture: A case study of Karbi Anglong District, Assam, India. *Eco Env & Cons*. 2024;30(3):1362–1367. http://doi.org/10.53550/EEC.2024.v30i03.061.
7) Sarkar R, Baruah R, Timungpi D. Analysis of land use and land cover changes in Amri block, Karbi Anglong. *Journal of Archaeology of Egypt / Egyptology*. 2021;18(6). Available from: https://archives.palarch.nl/index.php/jae/article/view/5006.
8) Bora P, Bora R. Population pressure and changing land use in Morigaon district, Assam: A geospatial analysis. *Indian Journal of Science and Technology*. 2024;17(1). Available from: https://indjst.org/articles/population-pressure-and-changing-land-use-land-cover-in-morigaon-district-assam-india-a-geospatial-analysis.

9) Sharma A, Sarma K. Land use and land cover change and its impact on biodiversity corridors in Kaziranga–Karbi Anglong landscape, India. *Journal of Landscape Ecology*. 2014;7(2):62–74. https://doi.org/10.2478/jlecol-2014-0015.
10) Fei Z. Research on Rural Land Planning based on Traditional Farming Culture. *Acta Agriculturae Scandinavica, Section B- Soil & Plant Science*. 2021;p. 1–12. https://doi.org/10.1080/09064710.2021.2001041.
11) Saikiam K, Saikia S, Medhi B. Changing Trends of Landuse Landcover In Nagaon District And Its Impact on Agricultural and Environmental Sustainability. *European Journal of Molecular & Clinical Medicine*. 2020;7(3):1388–1410. Available from: https://shorturl.at/itYee.
12) Ravi K, Shekhar S. Multi-Temporal Analysis of Urbanisation and Slums in Chennai, Tamil Nadu Using Remote Sensing and Geospatial Techniques. *Researchgate*. 2023;43(1):108–133. Available from: https://shorturl.at/Hmn98.
13) Saikam K, Saikia S, Medhi B. Changing Trends of Landuse Landcover in Nagaon District and Its Impact on Agricultural and Environmental Sustainability. *European Journal of Molecular & Clinical Medicine*. 2020;7(3):1388–1410. Available from: https://shorturl.at/oRvvj.
14) Satpalda. Significance of Land Use/ Land Cover (LULC) Maps. 2023. Available from: https://shorturl.at/il1oG.
15) Thien BB, Sosamphanh B, Yachongtou B, Phuong VT. Land Use/ Land Cover change in the period of 2015-2020 in Angyai village, Sikhottabong District, Vientiane Capital, Lao PDR. *Geology, Geophysics & Environment*. 2020;48(3):279–286. https://doi.org/10.7494/geol.2022.48.3.279.
16) Vivekananda GN, Swathi S, Sujith A. Multi-Temporal Image Analysis for LULC Classification and Change Detection. *European Journal of Remote Sensing*. 2021;54(S2):189–199. https://doi.org/10.1080/22797254.2020.1771215.