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Identifying Two Decades of Land use land cover change in Nazira revenue circle of Assam: A Spatial Data Generation Approach using Landsat Imagery

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ABSTRACT

Land use and land cover change detection and analysis are one of the most important aspects of studying the human environment relation of an area. This study integrated Landsat satellite data with remote sensing and GIS technology. The present study shows the land use and land cover (LULC) pattern of Nazira circle over two decades, 2003 to 2023. The primary objectives of the study are to analyze the land use pattern, produce LULC maps for the two decades, and assess land cover change metrics. For the year 2003 LANDSAT 5 image and 2023 LANDSAT 8 images were used. Also, seven land use land cover classes were identified with supervised image classification and maximum likelihood algorithm. Change matrix analysis has been done based on the data generated from the analysis of the change metrics for 2003-2023. This study also calculates the confusion matrices to determine the accuracy of the maps. The accuracy of the map for 2003 is 93% and for the map of 2023 is 87%.

Key words*: Land use and land cover, Change detection, Accuracy assessment, Maximum likelihood.*

Introduction

The alteration of land use and land cover is a worldwide environmental concern (Rwanga and Ndambuki, 2017). The land resource is playing an important role in production development for both nation and region (Juliev *et al.*, 2019). The Scientific study and analysis of land use and land cover change involves a quantitative estimation of land use and land cover at a particular location (Roy and Roy, 2010). Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes (Kaul and Sopan, 2012). Remote sensing is one of the tool which is very important for the production of Land use and land cover maps through a process called image classification (Illán-Fernández, Tiede and Sudmanns, 2024). Classifying remote sensing imageries to obtain reliable and accurate land use and land cover (LULC) information still remains a challenge that depends on many factors such as complexity of landscape, the remote sensing data selected, image processing and classification methods, etc (Seyam *et al.*, 2023). Land use and land cover (LULC) change analysis is a systematic technique that aids in the comprehension of physical and non-physical interaction with the natural habitat and the pursuit of environmental sustainability (Gebrehiwot *et al.*, 2024). Rapid and uncontrolled population growth along with economic and industrial development, especially in developing countries during the late twentieth and

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early twenty-first centuries, have increased the rate of land-use/land-cover (LULC) change many times (Das and Angadi, 2022). Consequently, LULC represents the result of human-environment interaction within a given area (Li *et al.*, 2017). Landscapes are visible as an integral part of terrestrial ecosystems (Bagwan and Sopan Gavali, 2023)..

Study area

The study area is the Nazira revenue circle of Sivasagar district of Assam, India. The Sivasagar district extends to latitudes of 26.45°N and 27.15°N, and to longitudes of 94.25°E and 95.25°E. The total area of the circle is 409.9 sq km.. Fig. 1 represents the location map of the study area.

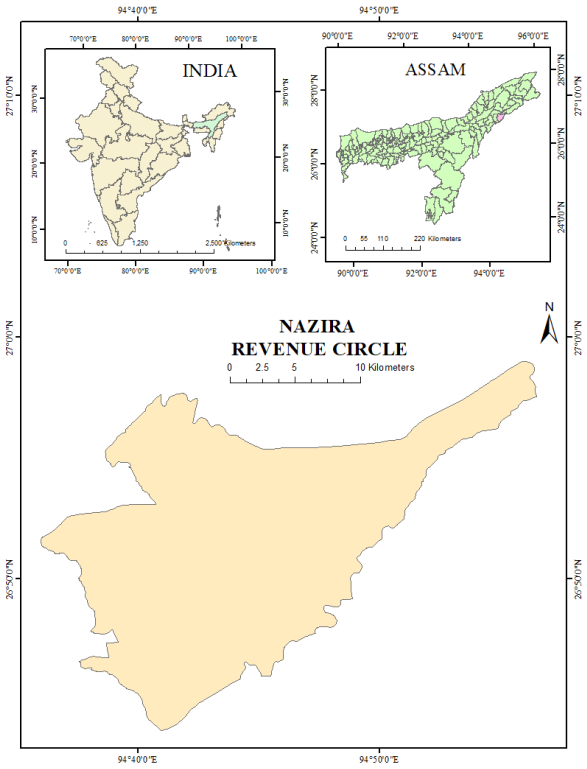

Fig. 1. Location map of the study area

Objectives: To conduct the study on the land use pattern, the prime objectives are

A) To produce LULC maps for the study during the period from 2003 to 2023, which is two decades.

B) To find out the metrics for land cover changes in the study area from 2003 to 2023.

Material and Methods

Figure 2 highlights the methodology for generating and handling the data for this study.Data acquisition-For this study Landsat 5 ETM data of 13th November 2003 and Landsat 8 OLI data from 12th November 2023 provided by the USGS Earth Explorer database were used for producing LULC maps. The spectral resolution of both the images is 30 m. The datasets were geometrically and radiometrically corrected. The ground reference data was obtained by visual interpretation of the images using Google Earth.

Data preparation : All the preprocessing and post-classification steps were completed using the ArcGIS software. The composite image was subset

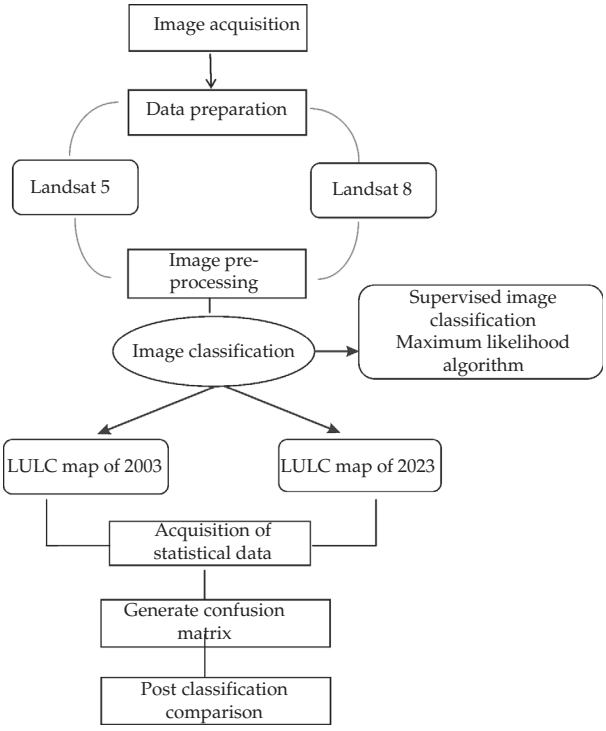

Fig. 2. Methodology of the study area.

Table 1. Satellite images and their characteristics used in this study

Sl.No	Image type	Sensors	Swath (KM)	Spectral resolution (m)	Source	Date & Year
1	Landsat 5	ETM	183	30	USGS	13/11/2003
2	Landsat 8	OLI-TIRS	185	30	USGS	12/11/2023

in a study area after that enhance the image processing and analysis. From the true color composite, it can be identified that there are 7 classes in Nazira circle area. The classes can be described as 1) Water body 2) Vegetation 3) Agricultural land 4) Built up 5) Grassland 6) Swamps and marshes 7) Barren land was identified.

Image preprocessing- For satellite image analysis, pre-processing is necessary for LULC classification

Image classification- Supervised classification methods and the maximum likelihood algorithm were used for preparing LULC maps. This study performs post-classification comparison and change detection techniques. Respectively, accuracy assessment was performed to verify the quality of the obtained results for the classified maps. The classification process is mainly conducted in three steps training sample selection, classification, and evaluation of accuracy assessment. This classification method helps in grouping the LULC sensed from satellite imagery. Training sites are chosen as examples of known land cover types, which are used to create a key that assigns numerical values to different land covers based on their spectral features. About 50 training sample were created for each class. After that, each pixel in the data collection is statistically compared to each category and labeled as the particular category. Finally, the results were processed to extract the various class statistics by calculating by the corresponding numbers of pixels for the study area.

Maximum Likelihood (ML) is one of the widely used algorithms in supervised classification to classify images. Also Microsoft Excel has been used for making tables, diagrams, and the calculations of land cover change. For the study the workflow has been shown in the Fig 2 to easily understand the process.

Change detection- In order to find areas of change, the post-classification comparison technique includes classifying images and comparing the relevant classes. Post classification comparison techniques were conducted by converting the classified raster data into vector layers. The overall changes in all the land use land cover classes are shown in different maps for both the circles in the study for better understanding. The following equation was used to calculate the degree of change for each class.

LULC classification on 2003- Fig. 4 shows the land use and land cover created from LANDSAT 5 and the pie chart showing the percentage of different land use categories. Table 2 shows the total area and percentage change in the study period. The distribution of land types is measured in sq km. The vegetation class occupies the largest area at 176.36 sq km, followed by agricultural land at 130.38 sq km. Other classes, like water bodies occupies 6.33 sq km of area, built up occupies 35.14sq km of area grassland occupies 13.13 sq km of area, and barren land occupy13.17 sq km of area were occupies. The lowest among all the classes are swamps and marshes which occupies 12.94 sq km of area.

LULC classification in 2023- Fig 5 shows the land use and land cover classification generated from LANDSAT 8. The areas are shown in sq km. The highest area occupied by the class is vegetation with 172.33 sq km of area, followed by agricultural land with 127.50 sq km. Other classes like water bodies took 5.82 sq km, built up is 71.18 sq km grassland 2.18 sq km and swamps and marshes is 6.99 sq km of area. The lowest of all the classes is barren land with 1.45 sq km of area.

Change detection from 2003- 2023-The change matrix of the area has been summarized in the following Table 2. The change matrix analysis shows that each land use land cover class changed to the other class. This matrix analysis has been produced

Table 2. Total area and their percentage of the Nazira revenue circle.

LULC classes	Area in sq km		Area in %		% change
	2003	2023	2003	2023	2003-2023
Water bodies	6.33	5.82	1.63	1.51	-0.12
Vegetation	176.36	172.33	45.51	44.47	-1.04
Agricultural land	130.38	127.50	33.64	32.90	-0.74
Built up	35.14	71.18	9.06	18.37	9.31
Grassland	13.13	2.18	3.38	0.56	-2.82
Swamps and marshes	12.94	6.99	3.33	1.80	-1.53
Barren land	13.17	1.45	3.39	0.37	-3.02
Total	387.45	387.45	100	100	

by the superimposing of two land use land cover maps of different times (2003 and 2023). In the study period, the barren land and grassland shows the highest percent of decrease of area. The barren land shows -3.02 % and grassland shows -2.82%. Maximum classes shows negative conversion, which includes water bodies, vegetation, agricultural land and swamps and marshes, only the built up class changes positively and the area is increased, the. The built up increased from 9.06 % to 18.37 %. Fig. 3 represents the year wise changes of the study area.

Changes in water bodies- Thetotal unchanged area in the class is 2.74sq km. The area changed to other land use land cover classes were 3.04 sq km and a total of 3.62 sq km of area was converted from other classes..

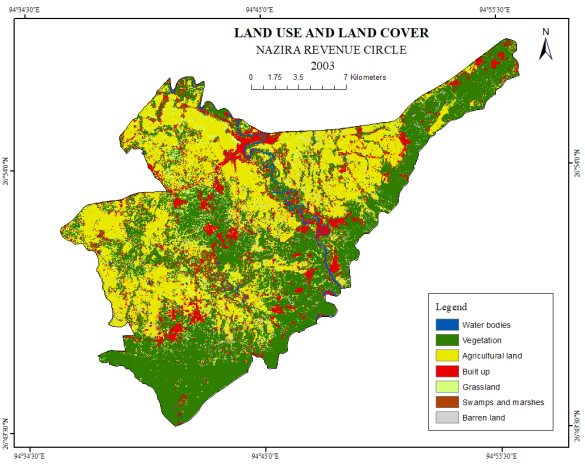

Fig. 3. Land use land cover map of Nazira revenue area 2003 LANDSAT-TM

Changes in Vegetation- The vegetation class is the dominant class in the study. The class went from 176.36 sq km to 172.33 sq km which is showing negative conversion of land with -1.04 %. The total unchanged area of the class is 137.72 sq km. Also the total 34.47 sq km of area that were converted into another class where 8.19 sq km of area were converted to built up and 12.49 sq km of area were converted to agricultural land. The total area that changed from another class is 38.48 sq km in this class.

Changes in agricultural land - The total unchanged area in the class of 96.55 sq km. The area changed to the other class is 30.88 sq km of land and total of 33.75 sq m of area were converted from the other class.

Changes in built up: The total unchanged area in this class is 22.24 sq km. The total area that changed to another class is 48.86 sq km. The total area that changed from other classes is 12.85 sq km.The changes in this class may be primarily due to the rapid population growth in the area.

Changes in grassland - The class went from 13.13 sq km in 2003 to 2.18sq km in 2023 with total negative conversion of -2.82. The total unchanged area of this class is 0.05 sq km. The total area that changed to

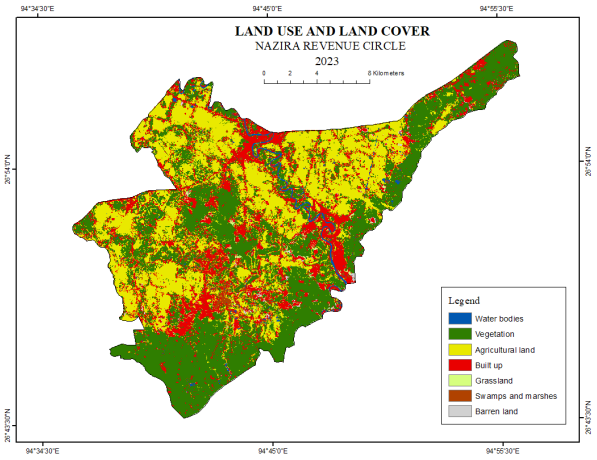

Fig. 4. Land use land cover map of Nazira revenue circle LANDSAT-OLI.

Table 3. Gain and loss status of the study area from 2003-2023.

LULC Classes	Water body	Vegetation	Agricultural land	Built up	Grassland	Swamps and marshes	Barrenland	Total
Water body	**2.74**	0.89	0.95	0.28	0.03	0.82	0.07	5.78
Vegetation	0.64	**137.72**	12.49	8.19	5.59	2.87	4.69	172.19
Agricultural land	0.70	12.27	**96.55**	3.50	5.41	3.75	5.25	127.43
Built up	1.62	22.02	16.90	**22.24**	1.74	3.82	2.76	71.1
Grassland	0.01	1.26	0.40	0.29	**0.05**	0.03	0.10	2.14
Swamps and marshes	0.58	1.43	2.43	0.51	0.26	**1.56**	0.19	6.96
Barren land	0.07	0.61	0.58	0.08	0.02	0.04	**0.08**	1.48
Total	6.36	176.2	130.3	35.09	13.1	12.89	13.14	

Table 4. Total changed and unchanged area of all classes for the last 2 decades

Classes	Total unchanged area	Area change to other classes	Area change from other classes
Water Body	2.74	3.04	3.62
Vegetation	137.72	34.47	38.48
Agricultural land	96.55	30.88	33.75
Built up	22.24	48.86	12.85
Grassland	0.05	2.09	13.05
Swamps and marshes	1.56	5.4	11.33
Barren land	0.08	1.4	13.06

other class is 2.09 sq km and total area that changed from other class is 13.05.

Changes in Swamps and marshes: The total unchanged area of the class is 1.56 sq km. The total area that has been changed to other classes is 5.4 sq km. The total area that changed from other class is 11.33 sq. The class went from 12.94 sq km in 2003to 6.99 sq km in 2023 with -1.53 % of negative conversion.

Changes in barren land: The class went from 13.17 sq km in 2003 to1.45 sq km in 2023 showing the highest percentage of negative conversion with -3.02 %. The total unchanged area of the class is 0.08 sq km. The area that has been changed to another class is 1.4 sq km. The area that been converted from other class is 13.06. The gain and loss status of all the LULC classes were shown in Table 3.

Accuracy assessment

Calculation of the accuracy of the outcome of image classification provides confirmation of information extraction from the image. To calculate the accuracy, the KAPPA coefficient measures are used. A kappa value of 1 represents perfect agreement, while a KAPPA value of 0 represents no agreement. KAPPA analysis is a discrete multivariate technique which calculates the producer's and user's overall accuracy as well as the Kappa accuracy level. The formula given determines the correctness of user and producer accuracy.

Here are the formulas that can be used to calculate the overall accuracy and the Kappa coefficient-

$$\text{Overall accuracy (OA)} = \frac{1}{2}\sum_{k=1}^{r} n_i$$

$$\text{Kappa coefficient (K)} = \frac{N\sum_{k=1}^{r} x_{kk} - \sum_{k=1}^{r}(x_{k+}x_{+k})}{N^2 - \sum_{k=1}^{r}(X_k + x_{+k})}$$

In this formula, N stands for the pixels in total, r for the classes number, and X_{kk} for the sum of pixels in rows "k" and columns "k" respectively. In this study both the accuracy assessment indicate high Kappa values, which are close to 1. In this confusion matrix the Kappa coefficient is 0.90for the LULC map of 2003 and 82 for the LULC map for 2023. The overall accuracy for the LULC maps of the study area for 93% for 2003 and 87% for the year 2023.

Conflict of Interest- None

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