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RESEARCH ARTICLE

Population Pressure and Changing Land Use Land Cover in Morigaon District, Assam, India - A Geospatial Analysis

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Abstract

Objective: This study intends to prioritize the underlying mechanisms underpinning the spatial-temporal variations in Land Use and Land Cover (LULC) change in the Morigaon district, located in the middle part of Brahmaputra valley of Assam, India covering an area of 1498 km^2.At the same time, this study focuses on the impact of population pressure on changing LULC in the study area. **Methods:** This research adopted geospatial approach for analysing land use land cover change in the study area. Satellite images from the years 1992 to 2022 have been utilized to identify the land transformation. The analysis of the land transformation has taken into account the five main LULC classifications of agriculture, forest, water bodies, built-up lands, and sand deposits. It has been discovered that the LULC classes identified in this study, which comprise both natural and anthropogenic elements, have a very strong link with the population growth in the Morigaon district. To show the relationship between population expansion and LULC indicators Pearson correlation method is used. **Findings:** Water bodies, forests and agriculture have significantly decreased by 0.13%, 4.66% and 1.64% respectively due to substantial anthropogenic activity during the past 30 years. In contrast, sand deposits and built-up lands increased by 3.13% and 3.30%. To show the relationship between population expansion and LULC indicators Pearson correlation method is used. Very significant relationships have been found between population and built-up lands with rho value 0.95. The relationship between population with agriculture, forest, water bodies and sand deposits have been seen with rho value -0.51, -0.89, -0.64 and 0.97 respectively. The loss of the geographic extent of natural classes like water bodies, forests, signifies that the geometrical progression in the human population has greatly amplified anthropogenic activities. **Novelty:** The novelty lies in adopting geospatial techniques that would certainly enhance land resource conservation. Environmental concerns have been increasing due to significant land surface change, which is predominantly the result of human-induced activities. In the studied area, socioeconomic, demographic, and proximity factors have a significant impact on the LULC change processes. The findings can be utilized to forecast potential LULC scenarios and offer direction for land management strategy.

Keywords: LULC; Satellite Images; Anthropogenic; Pearson Correlation; Proximity Factor

1 Introduction

Land is the basis of all terrestrial ecosystem services and an essential natural resource for the survival of humans [1,2]. But in time, the quantity and quality of natural resources that are present on Earth's surface are significantly impacted by the imbalanced man-land ratio [3]. The increasing population expansion puts stress on the finite natural resources, accelerating the transformation of the land surface. Changes in LULC in a spatiotemporal context are indicative of the effects of human intervention in nature. To evaluate the interaction between human activity and the environment, LULC classification is a crucial technique [4,5]. Remote sensing and geographic information systems (GIS) have been used extensively throughout the world for LULC mapping and change detection [2,6–10] and provide more effective approaches to conservation and management of natural resources than the conventional techniques [3,11]. Monitoring changes in Earth's surface over time through remote sensing is a valuable tool for detecting changes in Land Use and Land Cover (LULC). There are several classification methods available for evaluating LULC change. [12] Used supervised classification method to classify satellite images and to identify changes of LULC of Bangladesh. This technique aids in classifying the LULC detected via satellite imagery. [13] Investigates the LULC variations in the Bahraich district of Uttar Pradesh and their relationship to changing population pattern in UP. The LULC change in this work has been identified by the author using the statistics oriented change detection technique. [14] Examined population pressure on natural resources of Morigaon district. In this paper, the author produced LULC classification to show the land resources of the study area. Besides, no prior study on this perspective has been conducted so far. In this light, a study has been undertaken in Morigaon district, situated in the middle Assam of Brahmaputra valley. With the aid of the statistics oriented change detection technique, prior to numerous studies have been conducted about the altering LULC in geospatial environments for the study area. But the pixel based digital change detection technique is not used to find out LULC class alteration for the district earlier. Furthermore, the impact of population change on LULC has not been thoroughly investigated before. Therefore, the primary focus of this study is on how the LULC has changed over the last 30 years and how this shift has correlated with population growth in the Morigaon district of Assam. There has never before been any research done in the field of research on this viewpoint. The results of this study will be helpful for local officials and stakeholders to make better decisions for the long-term management of the Land resources by implementing sustainable land use policies and also controlling population expansion to maintain optimum use of natural resources.

1.1 Study area

Morigaon District is situated in Assam's Brahmaputra Valley's central region. The district's co-ordinate extension is between the latitudes of $26^0$15'23" and $26^0$22'11"N and the longitudes of $91^0$57'37" and $92^0$34'4"E. The study area is bordered on the north by the districts of Darrang and Sonitpur, the south by the districts of Karbi Anglong (West) and Meghalaya State, the east by the districts of Nagaon and Kamrup Metropolitan, and the west by the districts of Darrang and Sonitpur. The district's northern region is where the Brahmaputra River flows. Other significant rivers in the research area are the Kapili, Killing, Kalong, Sonai, and Pokoria rivers. The study area spans a total of 1498.94 square kilometres. The maximum and minimum temperatures in the research area, which has a tropical monsoon climate, are 39°C and 6°C, respectively. The district receives between 1500 mm and 2600 mm of rainfall every year. According to Census of India data from the 2011 census, there are 184050 total households and 957423 people living in the study area as a whole. The population density is 617 people per square kilometer.

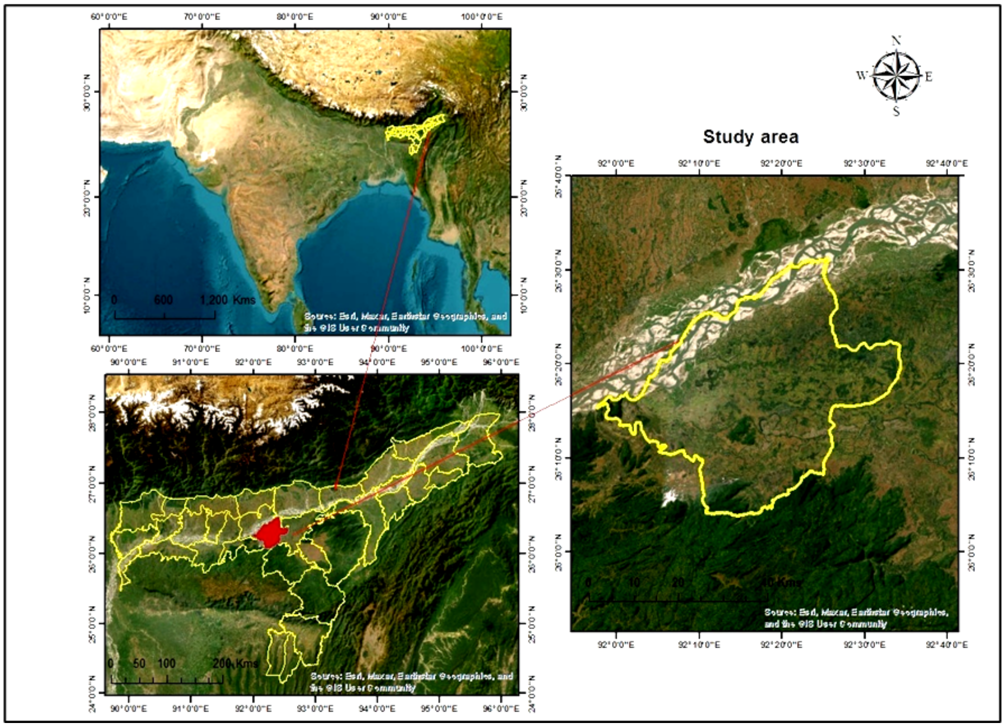

Fig 1. Study area map

2 Methodology

From 1992 to 2022, LULC trends in the Morigaon district have been monitored using satellite imagery. To access and analyze the spatial and temporal variations in various LULC classes, Landsat 4-5 (TM) image for 1992 and 2007 as well as Landsat 9 (OLI and TIRS) image for the year 2022 were downloaded from the USGS Earth Explorer website (https://earthexplorer.usgs.gov/) (Table 1). A thorough and organized methodological flowchart for the research is shown in Figure 2.

Table 1. Characteristics of spatial data products

Sensor	Date/year of acquisition	Resolution	Path/row
Landsat 4-5(TM)	26th March, 1992	30m	136/42
Landsat 4-5(TM)	20th March, 2007		
Landsat-9 (OLI and TIRS)	22nd March, 2022		

Source: https://earthexplorer.usgs.gov/

2.1 Image pre-processing

Pre-processing of images that reduces undesirable distortions or improves some image attributes relevant to later analysis and processing operations. Images are acquired and then pre-processed to reduce the effects of the atmosphere using methods like brightness adjustments, histogram equalization, geometric modification, etc. Cloud-free satellite images were georeferenced and calibrated using the WGS 84 coordinate system in reference to the UTM zone 46^0 N datum during the pre-processing stage.

2.2 Image classification

Image classification, in its broadest meaning, is the act of assigning labels or themes to all of the pixels in any image or the unprocessed remotely sensed satellite data.Supervised classification using maximum likelihood algorithm has been applied for the classification of 1992, 2007 and 2022 image in ArcGIS software. User can choose a sample set of pixels from an image that best represents a given class, and then instruct the image processing software to utilize these training sites as references when classifying all other pixels in the image. Based on the NRSC LULC classification (https://bhuvan-app1.nrsc.gov.in/2dresources /thematic/2LULC/lulc1112.pdf)., the study area is divided into five land use classes, including agriculture, forest, water bodies, built-up areas, and sand bars.

Table 2. Description of LULC classes

LULC class	Description
Agriculture	It includes fallow land, plantations, shifting cultivation area.
Forest	This class includes evergreen/semi evergreen, deciduous, scrub forest, littoral forest
Waterbodies	It includes wetlands, ponds, rivers, canals etc,
Builtup	This class consist of rural and urban builtup areas with settlements, transportation, industrial area etc.
Sand Deposits	These covers accumulate in the flood plain in sheets as a result of river flooding.

2.3 Change detection

The study used the Post-classification Change Detection tool in ArcGIS 10.3. A comparative investigation of several methodologies revealed that the post-classification comparison strategy had the highest classification accuracy. For the purpose of this research, modifications in LULC were computed for each kind of land cover and displayed in distinct images. How precise the results depend on the quality of the thematic maps that image classification generates. Landsat data were utilized to assess land-use changes in Morigaon district using a post-classification comparison technique based on the MLC algorithm.

The following equation was used to calculate the degree of change (C) for each class:

$$Ci = Li - Bi \tag{1}$$

$$Pi = \frac{Li - Bi}{Bi} x100 \tag{2}$$

Where Ci stands for the class "I" change's magnitude, Li for the most recent image, Bi for the baseline image, and Pi for the class "I" change's percentage.

2.4 Accuracy assessment

A proper LULC analysis requires model validation and precise accuracy evaluation. Accuracy on classified maps is primarily considered to be a measure of clarity. The kappa coefficient from 2002 to 2022 was used to calculate the accuracy assessment for the LULC classification section of this study. The accuracy process was supported in this approach by the use of satellite maps and Google Earth data. The matrix table was used to calculate the accuracy for the producer, the user, the overall accuracy, and the kappa accuracy. The confusion matrix was utilized to determine classification accuracy.

The following formula is used to determine the accuracy of classified images:

$$Overall\ accuracy = \frac{\sum_{.}\overset{r}{i} = 1^{X} ii}{N} x100 \tag{3}$$

$$Kappa\ accuracy = \frac{N\Sigma_i^r = 1^X ii - \sum_{i=1}^{r}\left(x_{j_+ * x + i}\right)}{N^2 - \sum_{i\_=1}^{r}\left(x_i + *x + i\right)} \tag{4}$$

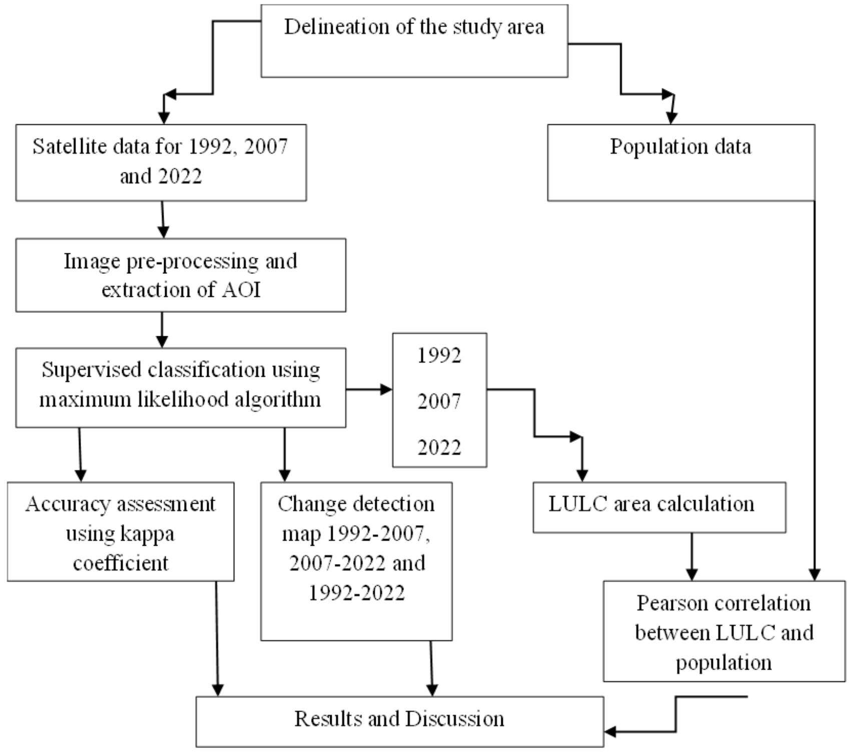

Fig 2. Methodological flowchart

3 Results and Discussion

3.1 Dynamics of land use land cover from 1992-2022

Through five different classes, the multi-temporal change of LULC was observed. Those are agriculture, sand deposits, built-up lands, and forest and water bodies for the year 1992, 2007 and 2022 as shown in the Figure 3. Agriculture is the dominant LULC class in the study area from 1992-2022. In the year 1992, the area under agriculture was 1053.45km^2 (70.30%) and then in 2007 it was steadily decreasing and covered 1010.93 km^2 (67.47%) but in the year 2022, it slightly increased to 1028.90 km^2 (68.66%) of the total area. Forest area experienced decreasing trend of growth. It occupied 304.19 km^2 (20.30 %) in 1992, 306. 49 km^2 (20.45%) in 2007 and 234.30 km^2 (15.64%) in the year 2022. The area under water bodies in the year 1992 was 63.66 km^2 (4.25%), 58.92 km^2 (3.93%) in 2007 and 61.69 km^2 (4.12%) in 2022. On the other hand, the area under sand deposits is sharply increased from 1992 to 2022. In the year 1992, it covered 55.95 km^2 (3.73%), 65.66 km^2 (4%) in 2007 and 102.83 km^2 (6.86%) in 2022. Built-up lands are the most rapidly growing LULC classes in the study area. In 1992, the area occupied by this class was only 21.24 km^2 (1.42%), but after that it grew up to 56.50 km^2 (3.77%) in 2007 and 70.77 km^2 (4.72%) in the year 2022.

3.2 Change detection analysis

The area and percentage wise changes in different LULC categories of three periods 1992-2007, 2007-2022 and 1992-2022 are demonstrated in Table 3. In the period, 1992-2007, Morigaon district experienced 9.71 km^2 (0.65%), 2.30 km^2 (0.15%), 35.26 km^2 (2.35%) increase in the area under sand deposits, forest land and built-up area respectively. On the contrary, the area under water bodies and agriculture decreased by 4.74 km^2 (0.32%) and 42.53 km^2 (2.83%) respectively. Moreover, in the period of 2007-2022, the area under sand deposits 37.16 km^2 (2.48%), water bodies 2.78 km^2 (0.19%), built-up area 14.28 km^2 (0.95%) and agriculture 17.98 km^2 (1.20%) is increased. For the period 1992-2022, the area under sand deposits and built-up lands is

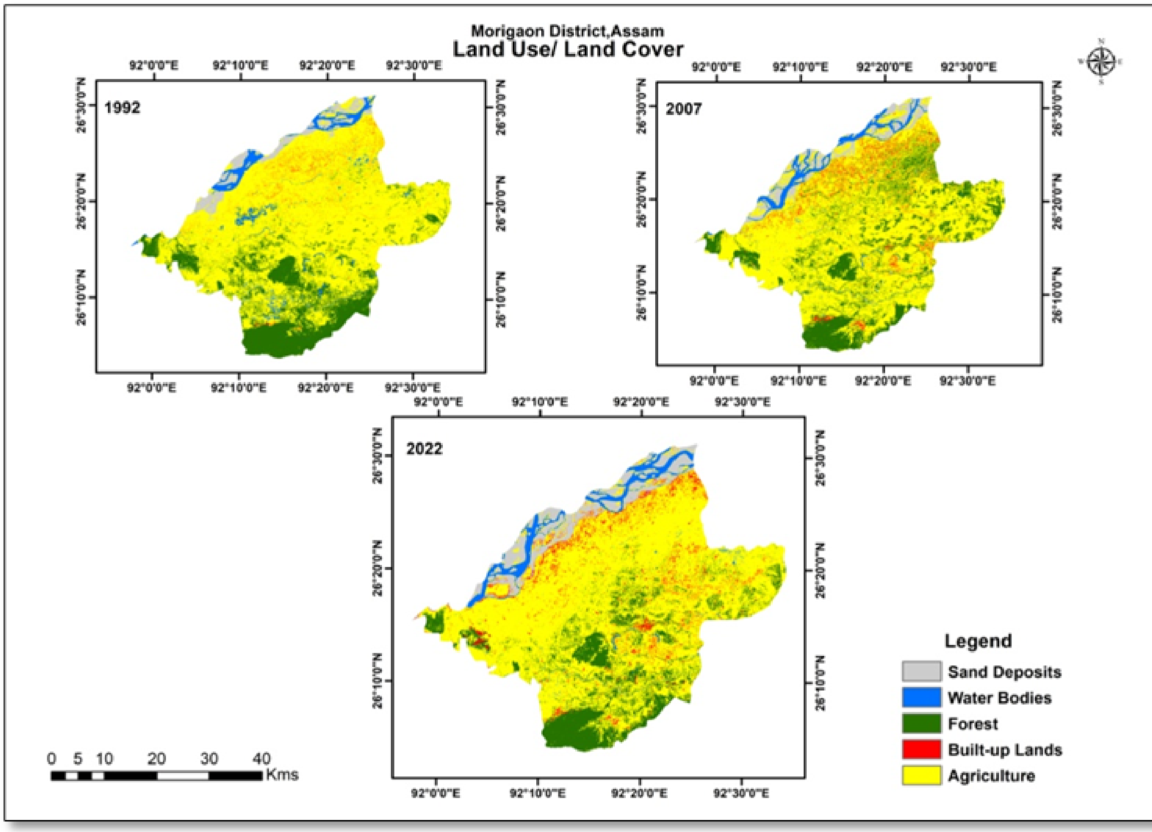

Fig 3. LULC map for 1992, 2007 and 2022

increased by 46.87 km^2 (3.13%) and 49.53 km^2 (3.30%) respectively. In contrast, water bodies, agriculture and forest decreased by 1.96 km^2 (0.13%), 24.55 km^2 (1.64%) and 69.89 km^2 (4.66%) respectively.

After creating the change detection map shown in the Figure 4, it is observed that subsequent LULC class alterations have been seen. Sand deposits to water bodies changes with the area of 19.48km^2 in the period 1992-2007, 17.40 km^2 in 2007-2022 and 19.11 km^2 in 1992-2022. From 1992-2007, the sand deposits area is converted to forest area by 0.15 km^2, 0.29km2 in 2007-2022 and 0.12 km^2 in 1992-2022. Moreover, sand deposits area is converted to built-up lands in 1992-2007 by 0.27 km^2, 2.29 km^2 in 2007-2022 and 0.69 km^2 in 1992-2022. Sand deposits area is again transformed to agricultural land by 14.84km^2 in the period 1992-2007, 11.52 km^2 in 2007-2022 and 7.46 km^2 in 1992-2022. From 1992-2007,2007-2022 and 1992-2022, the area under water bodies altered to sand deposits by 14.64 km^2, 24.2 km^2 and 22.80 km^2 respectively. Water bodies are changed to forest land by 4.28 km^2 in 1992-2007, 1.03 km^2 in 2007-2022 and 2.04 km^2 in 1992-2022. Water bodies converted to built-up lands by 0.46 km^2, 1.34 km^2 and 0.79 km^2 in the period1992-2007, 2007-2022 and 1992-2022 respectively. Again, water bodies are transformed to agriculture land by 25.96 km^2 in 1992-2007, 13.15 km^2 in 2007-2022 and 23.65 km^2 in 1992-2022. Besides, forest area is altered to sand deposits from the period 1992-2007 is 015 km^2, 0.79 km^2 in 2007-2022 and 0.33 km^2 in 1992-2022. From the period 1992-2007 the area under forest cover converted to water bodies by 1.10 km^2 in 1992-2007, 1.65 km^2 in 2007-2022 and 1.05 km^2 in 1992-2022. In the year 1992-2007, 2007-2022 and 1992-2022 the area under forest is converted to built-up lands by 3.26 km^2, 3.02km^2 and 4.17 km^2 respectively. Forest area is shifted to agriculture land by 139.23 km^2 in 1992-2007, 128.24 km^2 in 2007-2022 and 135.70 km^2 in 1992-2022. Furthermore, for the period 1992-2007, 2007-2022 and 1992-2022 the area under built-up lands are converted to sand deposits by 0.46 km^2, 2.73 km^2 and 0.86 km^2 respectively. Built-up lands are again changed to water bodies by 0.16 km^2 in 1992-2007, 1.11 km^2 in 2007-2022 and 0.33 km^2 in 1992-2022. Another land conversion has seen in built-up lands converted to forest land by 1.91 km^2, 3.42 km^2 and 1.82km^2 in the period 1992-2007, 2007-2022 and 1992-2022 respectively. Built-up lands are altered to forest by 1.91 km^2 in 1992-2007, 3.42 km^2 in 2007-2022 and 1.82 km^2 in 1992-2022. On the other hand, agriculture land is converted to sand deposits by 31.03 km^2 in 1992-2007, 41.53 km^2 in 2007-2022 and 52.69 km^2 in 1992-2022. For the period of 1992-2007, 2007-2022 and 1992-2022, the area under agriculture transformed to water bodies by 19.97 km^2, 22.34 km^2 and 26.83 km^2 respectively. Agriculture area is converted to forest area in the period 1992-2007 by 139.07km^2, 126.20 km^2 in 2007-2022 and 136.18km^2 in 1992-2022. The area under agriculture again shifted to built-up lands by 42.54 km^2 in 1992-2007, 41.07 km^2 in 2007-2022 and 48.94 km^2 in 1992-2022.

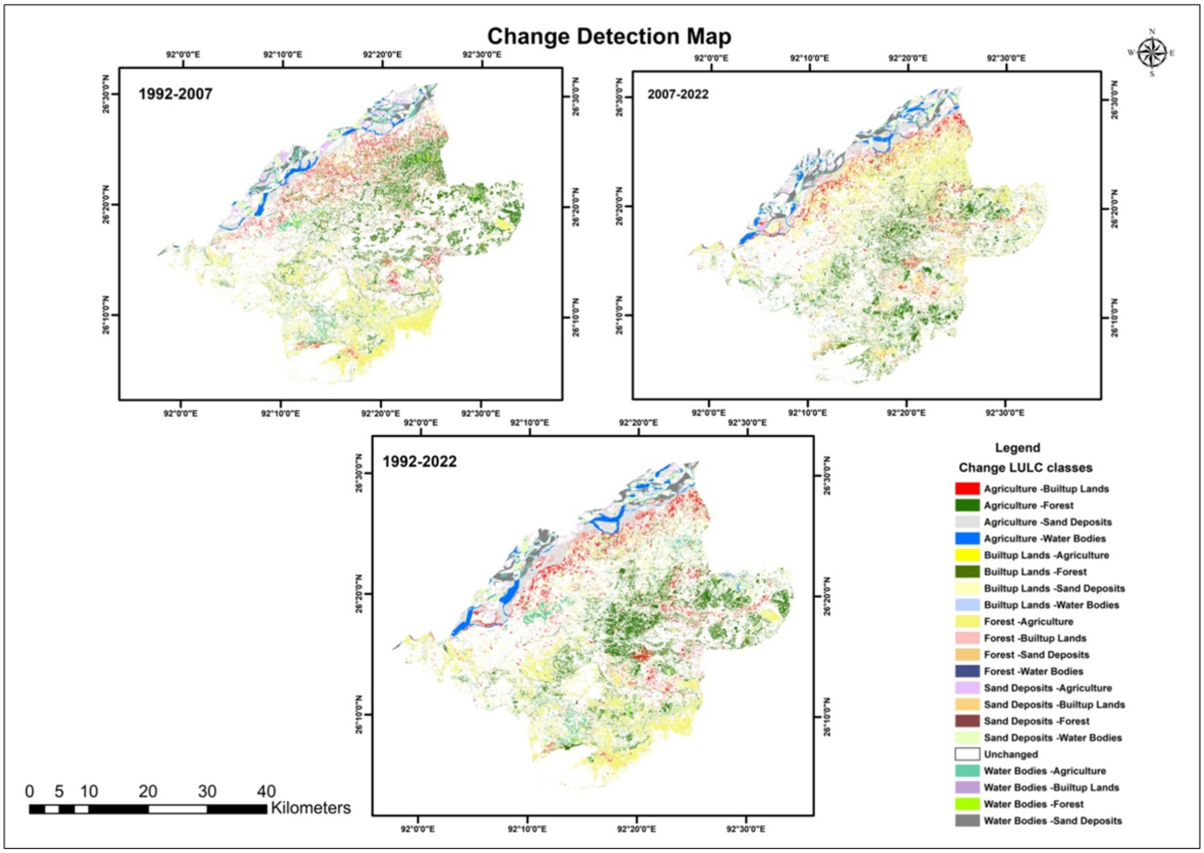

Fig 4. Change classes of LULC for 1992-2007, 2007-2022 and 1992-2022

3.3 Accuracy assessment

An essential component of image classification is accuracy evaluation, which determines whether a pixel has been correctly assigned to its matching class or not. The procedure compares the categorized data using specified physical reference points. Overall accuracy in 2002 was 92.7%, in 2011 it was 90.2%, and in 2022 it was 93%. The kappa coefficient for those years was 90.85%, 87.88%, and 90.22%, respectively. It is very reliable for analysis when both the overall accuracy and the kappa continue to maintain an accuracy rate of 85% or higher.

Table 3. User and producer's accuracy assessment

LULC classes	1992		2007		2022	
	Producer's accuracy	**User's accuracy**	**Producer's accuracy**	**User's accuracy**	**Producer's accuracy**	**User's accuracy**
Agriculture	100%	89.00%	92%	100%	88.42%	90%
Forest	100%	97%	100%	100%	95.33%	93.24%
Ware bodies	83%	100%	75%	85.71%	87.90%	90.43%
Builtup	100%	86.7	100%	60%	96.11%	95.56%
Sand deposits	85.70%	100%	100%	100%	89.48%	90.00%
Overall accuracy	95.70%		93..2%		93%	

Continued on next page

Table 3 continued

Kappa accuracy	92.85%	89.88%	90.22%

3.4 Changing Population Pattern and Land Use Land Cover

Population plays a significant role in changing LULC pattern in the study area. Population growth and land use change are two interconnected factors that have significant implications for the environment, society, and the economy. It delicately addresses the variables that, among other things, lead to ecological degradation, wetland and habitat loss, eradication of coastal zones, and destruction of rainforests. Demographically, Morigaon district is dynamic in nature. This dynamic nature brings drastic change in the changing landscape from 1992-2022. In the year 1992, the population of the district was 639682 persons, while in 2001 population is increased to 776256 persons and in 2011 population of the district are 957423 persons. The projected population for the year 2021 is 1180885 persons presented in Table 4. On the other hand, for the decade 1991-2001, the growth rate is 21.4%, from 2001-2011 the growth rate is 23.34% and projected growth rate for 2011-2021 is 23.33% depicted in the Figure 5.

Table 4. Population data of the study area

Year	Population
1991	639682
2001	776256
2011	957423
*2021	1180885

Source: Census of India *Projected population

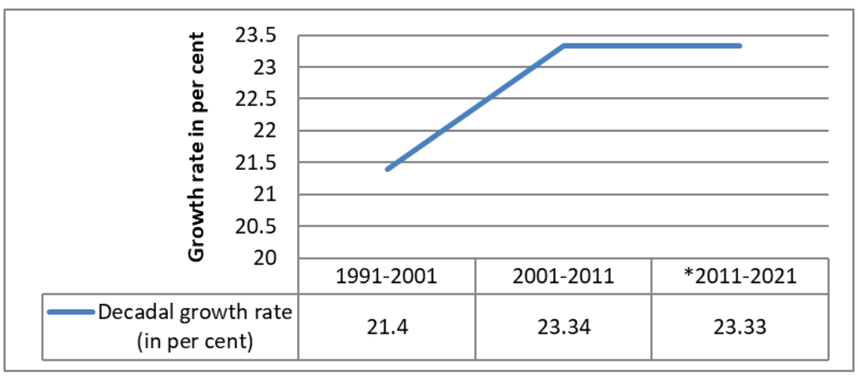

Fig 5. Decadal growth rate from 1991-2021

The Pearson's correlation coefficient rho (q) has been applied in order to determine the relationship between the increase in human population and changing land surface cover. Variables and population growth have been shown to be significantly connected. Population growth and built-up areas show a positive association with rho (q) 0.95. It represents the idea that as human population grows, more land will be needed for anthropogenic activity. As a result, built-up land is rising. Additionally, a positive association with rho (q) 0.97 may be detected in the relationship between population and sand deposition.

Table 5. Pearson correlation with population and different LULC classes

Population Rho(q) value	Built-up Lands	Agriculture	Forest	Water bodies	Sand deposits
	0.95	-0.51	-0.89	-0.64	0.97

The area covered by sand deposits increased as a result of the built-up land area expanding quickly, which causes frequent flooding in the study area. In contrast, the expanding human population has a negative link with water bodies, agriculture, and forests with rho (q) -0.64, -0.51 and -0.89 respectively. To determine a correlation between built-up lands and other LULC classes, Pearson correlation is also used. Other LULC groups, such as water bodies (-0.62), forests (-0.70), and agriculture (-0.75), have been found to have a negative connection with built-up. Consequently, when the built up gets greater, other natural traits get worse.

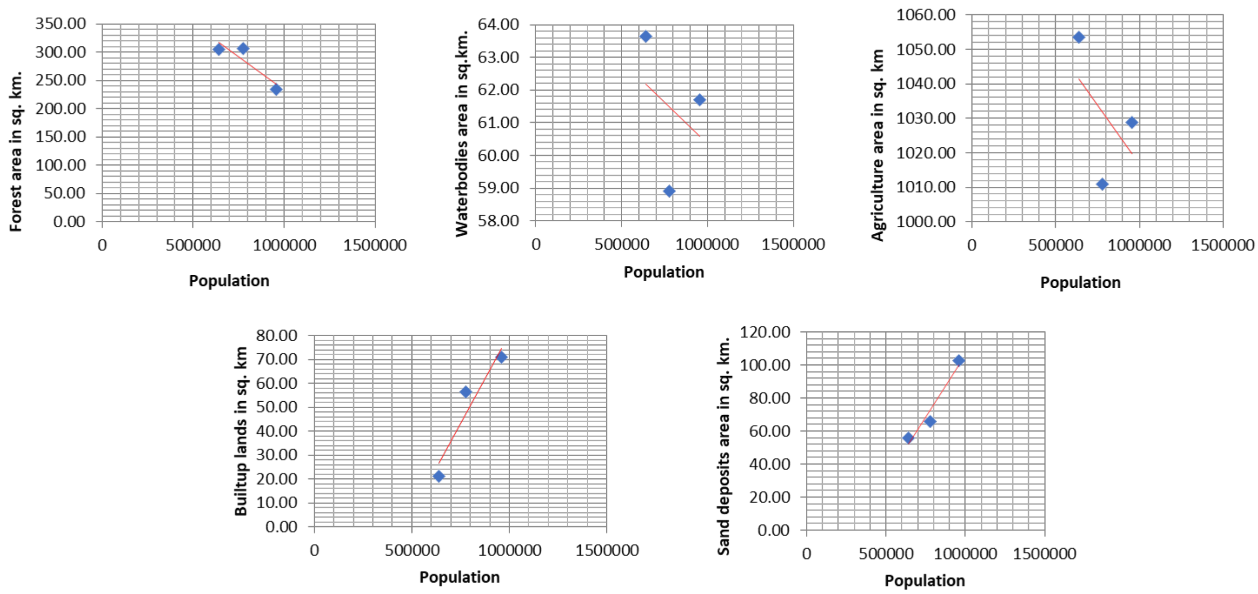

Fig 6. Correlation with population and different LULC parameters

4 Conclusion

In order to examine the effects of population pressure on LULC in Morigaon district, this research implies geospatial technology for more comprehensive and integrated study. The present study focuses on the human influence of LULC change in the studied area. In addition to explain current LULC, a thorough grasp of historical LULC is necessary to comprehend the ecological structures, processes, and functions that are based on it. The natural landscape has been converted to cultural landscape. There has been a noticeable change in the Land Use and Land Cover (LULC) between 1992 and 2022 in the Morigaon district. This shift indicates a steady decrease in the area covered by water bodies, forests, and farmland, with an increase in built-up areas and sand deposit areas. Positive correlation between population and built-up lands shows that there is an increased demand for housing, commercial spaces, infrastructure and which leads to reduced green spaces. There is a known negative relationship between water bodies, forests, and agriculture with population. A more harmonious coexistence of human activities and the natural world may become possible if planners embrace land use complexities by deploying creative and collaborative land management policy. On sustainable development and the welfare of future generations, effective planning and management of land resources has to be prioritized.

References

1) Chen H, Chen C, Zhang Z, Lu C, Wang L, He X, et al. Changes of the spatial and temporal characteristics of land-use landscape patterns using multi-temporal Landsat satellite data: A case study of Zhoushan Island. *China Ocean & Coastal Management*. 2021;213. Available from: https://doi.org/10.1016/j.ocecoaman.2021.105842.
2) Abebe G, Getachew D, Ewunetu A. Analysing land use/land cover changes and its dynamics using remote sensing and GIS in Gubalafito district, Northeastern Ethiopia. *SN Applied Sciences*. 2022;4(1):1–15. Available from: https://doi.org/10.1007/s42452-021-04915-8.
3) Borah D, Bora AK. Integrated Approach of Morphometric and LULC Parameters for Watershed Prioritization in Pachnoi River Basin. *Indian Journal Of Science And Technology*. 2023;16(44):4002–4015. Available from: http://dx.doi.org/10.17485/IJST/v16i44.1113.
4) Singh RK, Sinha VSP, Joshi PK, Kumar M. A multinomial logistic model-based land use and land cover classification for the South Asian Association for Regional Cooperation nations using Moderate Resolution Imaging Spectroradiometer product. *Environment, Development and Sustainability*. 2021;23:6106–6127. Available from: https://doi.org/10.1007/s10668-020-00864-1.
5) Darem AA, Alhashmi AA, Almadani AM, Alanazi AK, Sutantra GA. Development of a map for land use and land cover classification of the Northern Border Region using remote sensing and GIS. *The Egyptian Journal of Remote Sensing and Space Science*. 2023;26(2):341–350. Available from: https://doi.org/10.1016/j.ejrs.2023.04.005.
6) Rafiq M, Mishra AK, Meer MS. On land-use and land-cover changes over Lidder Valley in changing environment. *Annals of GIS*. 2018;24(4):275–285. Available from: https://doi.org/10.1080/19475683.2018.1520300.
7) Chamling M, Bera B. Spatio-temporal Patterns of Land Use/Land Cover Change in the Bhutan–Bengal Foothill Region Between 1987 and 2019: Study Towards Geospatial Applications and Policy Making. *Earth Systems and Environment* . 2020;4:117–130. Available from: https://doi.org/10.1007/s41748-020-00150-0.

8) Mohamed MA, Anders J, Schneider C. Monitoring of Changes in Land Use/Land Cover in Syria from 2010 to 2018 Using Multitemporal Landsat Imagery and GIS. *Land*. 2020;9(7):1–30. Available from: https://doi.org/10.3390/land9070226.
9) Bunyangha J, Majaliwa MJG, Muthumbi AW, Gichuki NN, Egeru A. Past and future land use/land cover changes from multi-temporal Landsat imagery in Mpologoma catchment, eastern Uganda. *The Egyptian Journal of Remote Sensing and Space Science*. 2021;24(3, Part 2):675–685. Available from: https://doi.org/10.1016/j.ejrs.2021.02.003.
10) Kafy AA, Md N, Nh, Subramanyam G, Faisal AA, Ahmed NU, et al. Cellular Automata approach in dynamic modelling of land cover changes using RapidEye images in Dhaka, Bangladesh. *Environmental Challenges*. 2021;4:1–15. Available from: https://doi.org/10.1016/j.envc.2021.100084.
11) Dhaloiya A, Hooda R, Kumar D, Malik A, Kumar A. Geoinformatics-based assessment of gross irrigation requirement of different crops grown in the south-western region of Haryana, India. In: Current Directions in Water Scarcity Research;vol. 7. 2022;p. 299–316. Available from: https://doi.org/10.1016/B978-0-323-91910-4.00018-2.
12) Seyam MMH, Haque MR, Rahman MM. Identifying the land use land cover (LULC) changes using remote sensing and GIS approach: A case study at Bhaluka in Mymensingh, Bangladesh. *Case Studies in Chemical and Environmental Engineering*. 2023;7:1–12. Available from: https://doi.org/10.1016/j.cscee.2022.100293.
13) Khan N, Raza M, Shakoor MS, Biswas F, Rahaman M. Dynamic of population growth and its effect on land use/land cover of Bahraich district in Uttar Pradesh. *Journal of Environmental Studies and Sciences*. 2023;13(1):124–140. Available from: https://doi.org/10.1007/s13412-022-00805-6.
14) Nath T. Population Pressure On Natural Resources Of Morigaon District, Assam. *International Journal Of Scientific & Technology Research*. 2019;8(12):2589–2591. Available from: https://www.ijstr.org/final-print/dec2019/Population-Pressure-On-Natural-Resources-Of-Morigaon-District-Assam.pdf.