

P-ISSN: 2706-7483

E-ISSN: 2706-7491

NAAS Rating (2026): 4.5

IJGGE 2026; 8(3): 37-43

www.geojournal.net

Received: 11-12-2025

Accepted: 14-01-2026

Sentiakum Jamir

Research Scholar,

Department of Geography,

Nagaland University,

Lumami, Nagaland, India

Sangyu Yaden

Professor,

Department of Geography,

Nagaland University,

Lumami, Nagaland, India

Corresponding Author:

Sentiakum Jamir

Research Scholar,

Department of Geography,

Nagaland University,

Lumami, Nagaland, India

Population growth and its impact on land use land cover: Mokokchung District, Nagaland

Sentiakum Jamir and Sangyu Yaden

DOI: <https://doi.org/10.22271/27067483.2026.v8.i3a.492>

Abstract

Rapid population growth and increasing pressure over natural resources have characterised the 21st century. Population growth has led to increasing demand for food, settlement, and social infrastructure, which led to overexploitation of natural resources. The study of LULC change detection becomes vital in this context to understand the level of resource exploitation. The study area of Mokokchung district has experienced remarkable population growth over the past few decades, which has a far-reaching impact on the land use pattern of the district. The study area experiences a population growth of approximately 86.52% during 1991-2021, which indicates a rapid growth of population in the district. For the study purpose, Landsat satellite images for the years 1991, 2001, 2011, and 2021 were analysed, and along with that, population data for the same years were obtained from the census of India and other statistical sources. To analyse the relationship between the two variables, Pearson's correlation method was employed. The finding revealed a strong relationship between the two variables, which highlights the growing impact of anthropogenic activities on land.

Keywords: Land use, land cover, population growth, Landsat image, Pearson's coefficient

1. Introduction

Population growth emerges as one of the main drivers of environmental depletion in the present context, as it triggers demand for space, food production, settlement areas, and other necessary social infrastructure. This escalating pressure often leads to the conversion of natural landscape into man-made structures (agricultural land, settlements, and built-up areas). Such growing changes in land use and land cover illustrate the correlation between population growth and anthropogenic alteration of the environment, which makes population growth a key driver in comprehending spatial and environmental conversion. Alteration in LULC has significant consequences on ecological stability and sustainable development. The conversion of forest, agricultural land, and open space into urban and semi-urban areas has far-reaching impacts on the quality of soil, water availability, local climate, and biodiversity. Examining the relationship between these two variables elucidates the impact of anthropogenic activities on land systems over time. Human needs continue to expand over time, and to fulfil these needs, humans have to a great extent explored the inaccessible land, which has brought a drastic change to the land use and land cover classes. Throughout the years, built-up areas have undergone swift expansion, whereas, on the other hand, forest cover has consistently declined across the globe. The combined impact of population growth and economic development over the past few centuries has exacerbated human strain on land resources, and the prevailing trends indicate that such situations are likely to persist in the future. The present study aims to examine the correlation between population growth and LULC change in the Mokokchung district of Nagaland. To achieve the desired objective, satellite imagery for the years 1991, 2001, 2011, and 2021 was analysed to evaluate the spatial-temporal changes in different LULC classes over the decades. Population data for the same years were obtained from the Census of India and different statistical data sources. The finding discloses a significant decrease in dense vegetation cover alongside a considerable increase in built-up areas during the study period. This change reflects the influence of population growth and evolving socio-economic conditions, which collectively play a crucial role in transforming the land use pattern of the district.

2. Study area

The Naga Hills, a discontinuous continuation of the eastern Himalayan Mountains, encompass the hill ranges where the district of Mokokchung is situated. The hill ranges extend from northeast to southwest, running approximately parallel to one other. The average elevation of the hills above mean sea level varies from 1,000 to 1,200 meters. Mokokchung, situated at an elevation of 1,326 meters above mean sea level, functions as the district headquarters. The district is partitioned into six principal ranges. Asetkong, Jangpetkong, Japukong, Langpangkong, Ongpangkong, and Tsurangkong

are included. The trajectories of Jangpetkong and Japukong are almost parallel. The easternmost range is Langpangkong, the southernmost is Ongpangkong, and the central range is Asetkong. The hill ranges on the eastern side of the district are generally of higher elevation than those on the western side. The region is predominantly enveloped in dense jungles and deciduous trees, which yield substantial fuel and timber. The principal occupation of the residents is agriculture, with paddy being the predominant crop cultivated in the valley region. The primary food of the population consists of rice.

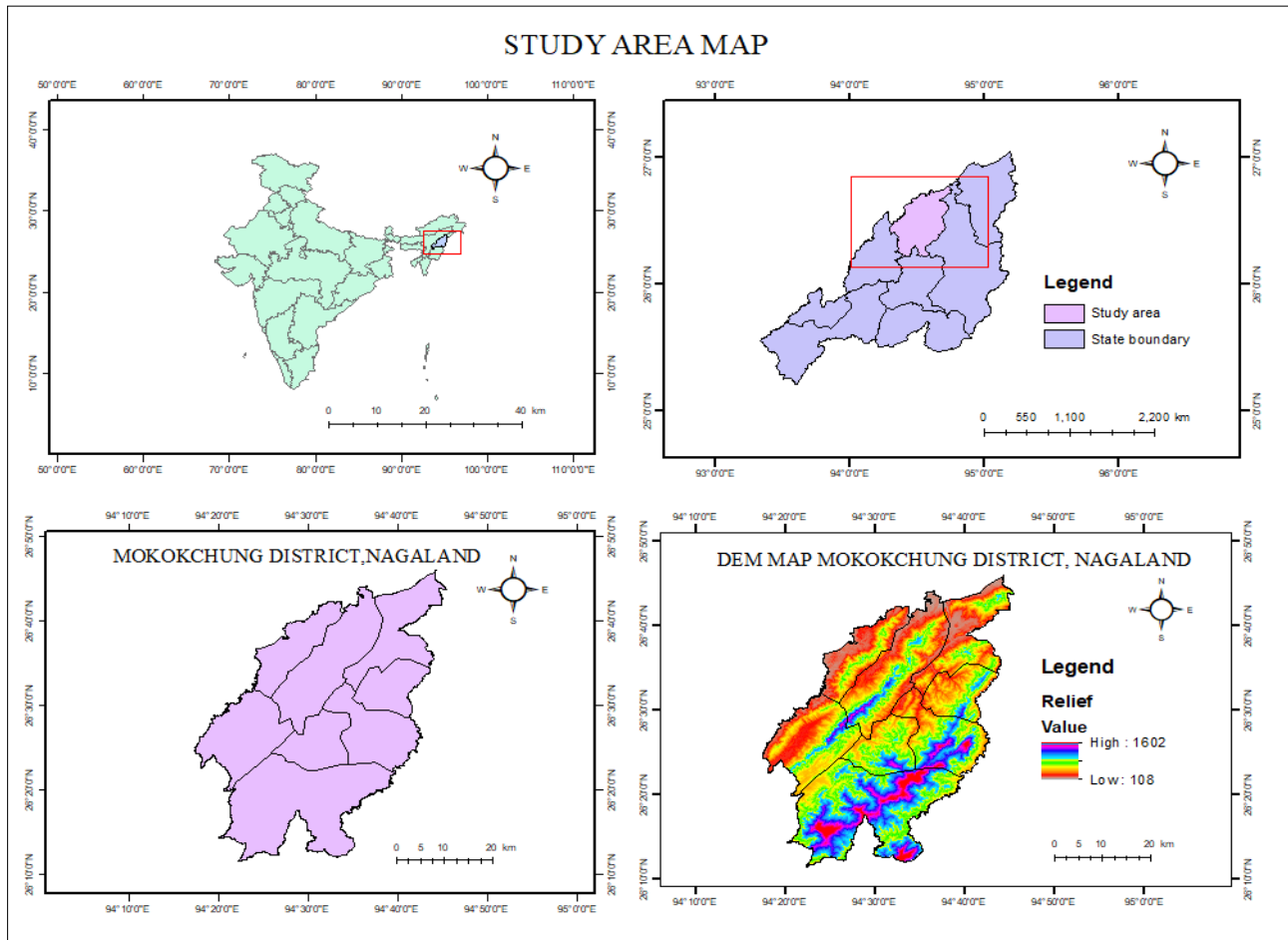


Fig 1: Study area Map

3. Methodology

Satellite imagery from the years 1991, 2001, 2011, and 2021 of Mokokchung district was utilised to identify land use and land cover changes in the study area. Landsat 4 (TM) imagery from 1991, Landsat 5 (TM) from 2001 and 2011, and Landsat 8 (OLI) imagery from 2021 were utilised, respectively. The Landsat image was acquired from the USGS Earth Explorer website.

Table 1: Satellite Image Source

Year	Sensor	Date of acquisition	Spatial resolution (m)
1991	Landsat - 4 TM	December 14 1991	30 M
2001	Landsat - 5 TM	October 15 2001	30 M
2011	Landsat - 5 TM	November 20 2011	30 M
2021	Landsat - 8 OIL	December 21 2021	30 M

Source: USGS Earth Explorer

3.1 Processing of satellite data

Satellite images for the years 1991, 2001, 2011, and 2021 of the Mokokchung district were used to detect LULC change in the study area. Landsat 4 (TM) images for the year 1991, Landsat 5 (TM) for 2001 and 2011, and Landsat 8 (OLI) images for the years 2021 were used, respectively. Landsat images were obtained from the USGS Earth Explorer website.

3.2 Classification of satellite image

Satellite image categorisation follows a systematic and structured pipeline which aims to convert raw satellite images into relevant LULC data. Supervised image classification was employed to classify the satellite images. The Maximum Likelihood Classification (MLC) algorithm has been applied for all the study years.

Firstly, the sample data which represents each of the LULC classes were selected after which the image processing software was assigned to learn the samples and label all the

pixels based on the spectral characteristics. The study employs six LULC classes, which are classified below.

Table 2: Description of LULC class

LULC class	Class description
Agriculture land	plantation, shifting cultivation area
Dense vegetation cover	Reserved and conserved area, semi evergreen and deciduous forest
Low vegetation cover	Sparse vegetation, ground cover percentage, scrub forest
Built - up areas	Settlement area (rural and urban), road, different social infrastructure
Water bodies	Rivers, ponds, fisheries, wetlands etc.
Barren land	Fallow land, extremely low vegetation cover.

Classified by researcher

3.3. Accuracy assessment

To assess the accuracy of the LULC map derived from the Landsat image, 30 reference points were chosen using stratified random sampling techniques. The chosen reference points were substantiated the image Kappa coefficient statistic was employed to examine the reliability between User Accuracy (UA), Producer Accuracy (PA), and Overall Accuracy (OA).

For accuracy assessment the following equations were used

$$\text{Overall Accuracy} = \frac{1}{N} \sum_k^r = 1^{ni}$$

$$\text{Kappa coefficient} = \frac{n \sum_i^r = 1^{xii} - \sum_i^r = 1(x_i + x_{+i})}{n^2 - \sum_i^r = 1(x_i + x_{+i})}$$

Table 3: Accuracy Assessment Using Kappa Coefficient for LULC maps (1991, 2001, 2011 & 2021)

Year	1991	2001	2011	2021
Kappa coefficient value	0.82	0.676	0.672	0.706

Source: Calculated by researcher

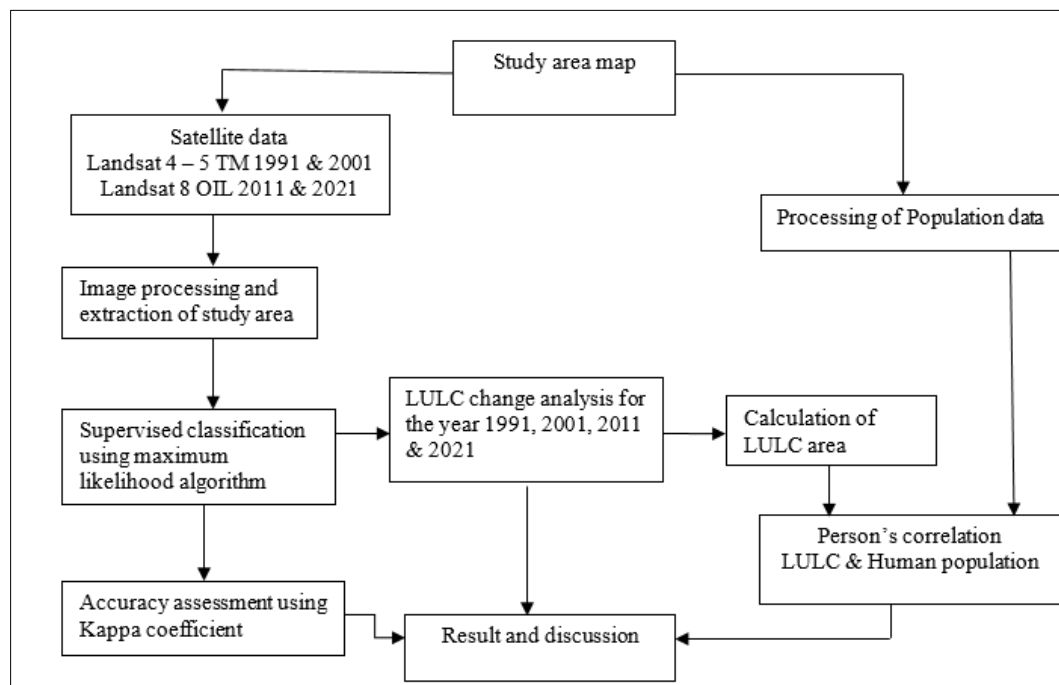


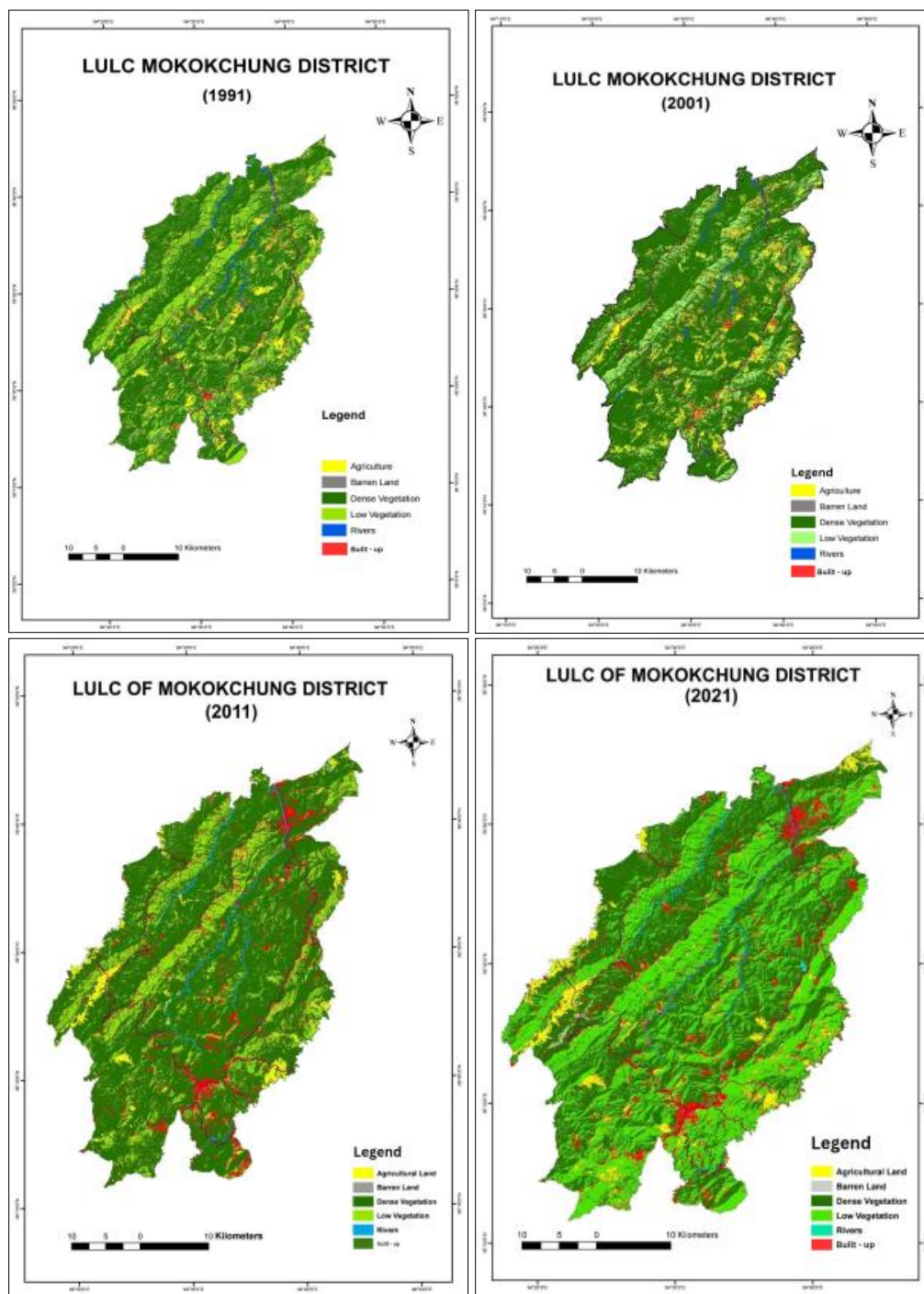
Fig 2: Methodological flowchart

4. Results and Discussion

4.1. Land use and land cover dynamic (1991 - 2021)

Land use and land cover in the study area were examined using multi-temporal data sets, revealing substantial variation over time. For the study purpose six LULC classes were identified namely dense vegetation cover, low vegetation

cover, agricultural land, built-up areas, barren land, and water bodies. Forest cover was the dominant class over the study area with forest cover dominating all through the study period with notable change observed within the vegetation types. Dense vegetation cover experienced a marked decline while low vegetation cover showed an overall increase.



Source: Created by researcher (USGS earth explorer)

Fig 3: Land use and land cover Map of Mokokchung district (1991, 2001, 2011 & 2021)

Dense vegetation covers an area of 946 km² in 1991 and 897 km² in 2001, which increases to 1054 km² in 2011 before it sharply declines to 503 km² in 2021. On the other hand, low vegetation covers an area of 474 km² in 1991 and 501 km² in 2001, which declines to 268 km² in 2011 and later increases to 824 km² in 2021. This trend reflects a gradual conversion of dense vegetation cover into low vegetation cover. Agricultural land use and built-up area share a significant portion of the district. Agricultural land use increases from 97 km² in 1991 to 109 km² in 2001, and further it increases to 132 km² in 2011 before declining to 91 km² in 2021. Built-up areas, on the other hand, had shown the most consistent expansion over the decades, increasing from 32 km² in 1991 to 42 km² in 2001, 85 km² in 2011, and further to 129 km² in 2021, representing 75% growth in built-up areas over the

decades. Barren land and water bodies occupy a substantial portion of the study area. In 1991 barren land covered 21 km², which increased to 32 km² in 2001 and to 45 km² in 2011, followed by a slight decline to 41 km² in 2021. Water bodies showed comparatively minor fluctuations, covering 39 km² in 1991, 34 km² in 2001, 25 km² in 2011, and 27 km² in 2021. Over the study period, built-up area demonstrates the most consistent growth, with over 75% growth in built-up areas over the past decades. Low vegetation cover also exhibits expansion in area by over 42.47% during the same period. Dense vegetation cover records a decline of approximately 88.07% during the same period. This showcases the combined influence of population growth and growing anthropogenic activities on the LULC dynamics of the study area.

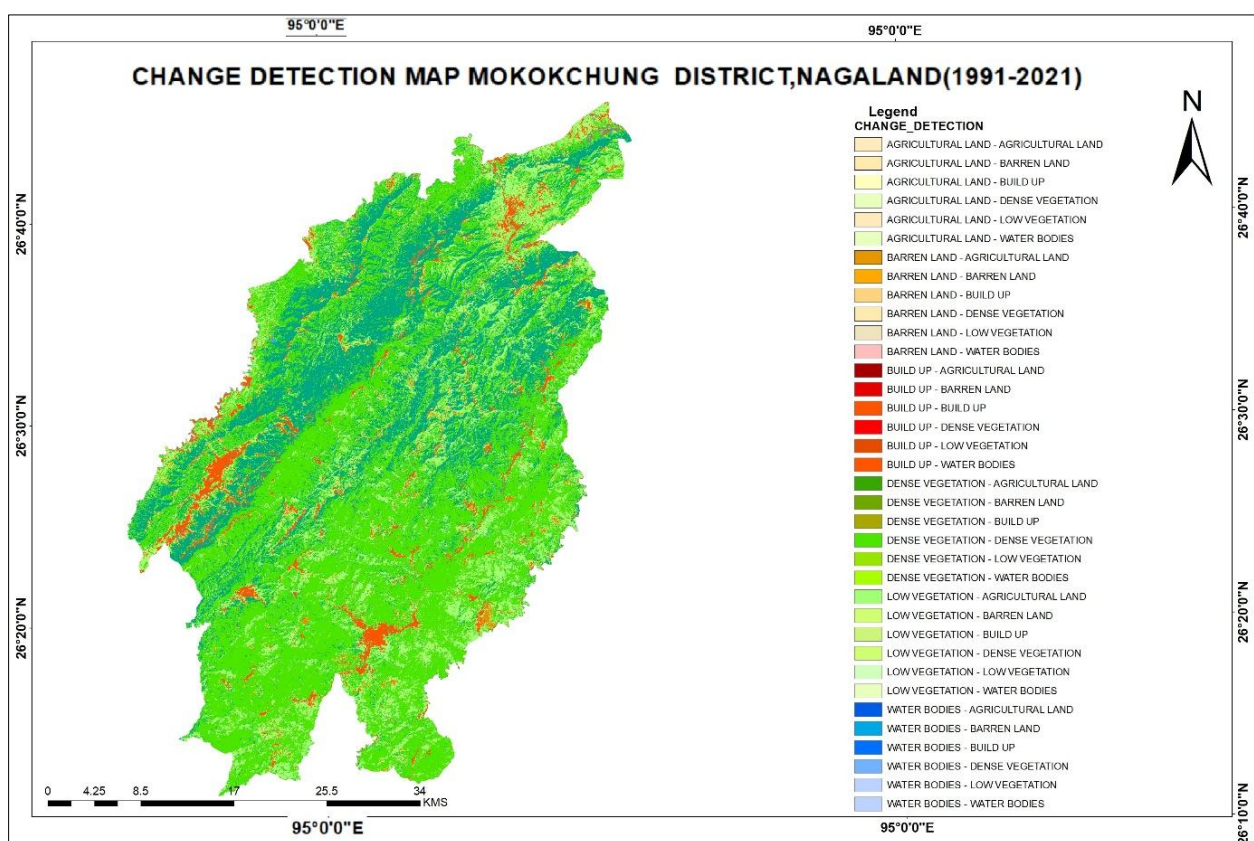
4.2 Change detection

The objective of change detection is to compare spatial representation of two points in time by controlling all variances caused by differences in variables that are not of interest and to measure change caused by differences in the variable of interest (Green *et al.* 1994) [5]. Change detection is essential as it helps in analysing spatial and temporal variation of LULC pattern of a region.

The change detection study for the years 1991-2001 indicates a reduction in dense vegetation area from 946 km² in 1991 to 897 km² in 2001, reflecting a decadal decline of -5.46% in area. The agricultural area expanded from 97 km² in 1991 to 109 km² in 2001, reflecting an 11% increase in total agricultural land. From 1991 to 2001, low vegetation cover increased by 5.38%, rising from 474 km² in 1991 to 501 km² in 2001. The developed area has markedly expanded from 32 km² in 1991 to 42 km² in 2001, reflecting a gain of 26.17%. The area of barren land expanded from 21 km² in 1991 to 32 km² in 2001, reflecting an increase of 11 km² (34.37%). Water bodies decreased in area by 5 km², indicating a decadal reduction of -14.7% from 1991 to 2001. From 2001 to 2011, the area of dense cover expanded from 897 km² to 1059 km², representing a gain of 15.29% in dense vegetation cover. Conversely, throughout the same study period, low vegetation cover diminished by 233 km² (-86.94%), representing a notable change. The constructed area has experienced a substantial rise from 42 km² in 2001 to 85 km² in 2011, indicating a growth of 50.58%. Agricultural land included 109 km² in 2001 and 132 km² in 2011, indicating a rise of 17.42% in agricultural land area. The area of water bodies decreased from 34 km² in 2001 to 25 km² in 2011, indicating a reduction of 9 km², or -26.47%. From 2001 to 2011, barren land increased by 13 km². The period from 2011

to 2021 exhibits a notable transformation in the land use and land cover pattern. The area of dense vegetation covers significantly decreased from 1059 km² in 2011 to 503 km² in 2021, whereas low vegetation cover expanded from 268 km² in 2011 to 824 km² in 2021, representing a 67.47% increase in low vegetation cover. The alteration in built-up land use from 2011 to 2021 was significant, rising by 34.1% (44 km²). Agricultural and barren land experienced a decline in area from 2011 to 2021. The agricultural sector experienced a decline of -45.05%, while barren land exhibited a decrease of -9.75%.

The LULC change detection analysis reveals specific modifications in land use and land cover types. From 1991 to 2001, agricultural land was transformed into thick vegetation by 7.17 km², low vegetation by 11.75 km², water bodies by 6.43 km², and built-up areas by 9.18 km². Between 1991 and 2001, the area under dense vegetation cover was transformed into agricultural land by 26.32 km², low vegetation by 114.42 km², aquatic bodies by 1.23 km², and built-up areas by 4.8 km². Low vegetation cover has been transformed into agricultural land by 10.12 km², dense vegetation covers by 29.89 km², water bodies by 1.09 km², and built-up areas by 4.47 km². Additionally, built-up space has been transformed into agricultural land by 5.39 km², dense vegetation by 0.77 km², low vegetation by 5.36 km², and water bodies by 0.18 km². The area of water bodies has been transformed into agricultural land by 2.93 km², dense vegetation covers by 3.16 km², low vegetation by 1.67 km², built-up area by 6.97 km², and barren land by 0.56 km². In the same research period (1991-2001), bare land was transformed to agricultural land by 3.2 km², dense vegetation by 3.45 km², low vegetation by 2.39 km², water bodies by 0.41 km², and built-up areas by 1.48 km².



Source: Created by researcher (USGS earth explorer)

Fig 4: Land use and land cover change detection map of Mokokchung district (1991 - 2021)

The examination of Land Use and Land Cover (LULC) changes from 2001 to 2011 and from 2011 to 2021 indicates a substantial transformation of LULC classes. The conversion of agricultural land to dense vegetation cover was 11.7 km² from 2001 to 2011 and 18 km² from 2011 to 2021. The conversion of agricultural land to low vegetation cover was 12.6 km² from 2001 to 2011 and 6.1 km² from 2011 to 2021. Conversion of agricultural land to developed area amounted to 8.1 km² from 2001 to 2011 and 17 km² from 2011 to 2021. The region under dense vegetation has been transformed into agricultural land by 14.84 km² and 5.6 km² during the periods of 2001-2011 and 2011-2021, respectively. The transformation of deep forest to sparse vegetation was 34 km² from 2001 to 2011 and 367 km² from 2011 to 2021. The amount of thick vegetation adjacent to water bodies was 0.56 km² from 2001 to 2011 and increased to 2.1 km² from 2011 to 2021. Additionally, the area from dense vegetation to built-up regions expanded from 10.3 km² in 2001-2011 to 25 km² in 2011-2021. Low vegetation cover transitioned to agricultural land by 25 km² from 2001 to 2011 and by 7 km² from 2011 to 2021. The transition from low vegetation to high vegetation cover was 197 km² from 2001 to 2011 and 12 km² from 2011 to 2021. The conversion of low vegetation cover to aquatic bodies was 0.51 km² from 2001 to 2011 and 0.12 km² from 2011 to 2021, while the conversion of low vegetation to built-up areas was 19 km² from 2001 to 2011 and 4.1 km² from 2011 to 2021. The conversion of water bodies to agricultural land was 2.2 km² from 2001 to 2011 and 1.3 km² from 2011 to 2021.

Between 2001 and 2011, water bodies transformed into dense vegetation by 1.26 km², and from 2011 to 2021, by 1.06 km². Conversely, the conversion from water bodies to low vegetation cover was 0.61 km² from 2001 to 2011 and 1.2 km² from 2011 to 2021. The area of water bodies converted to built-up space was 1.7 km² from 2001 to 2011 and 0.96 km² from 2011 to 2021. The change of water bodies to barren land is 0.67 km² from 2001 to 2011 and 1.04 km² from 2011 to 2021. From 2001 to 2011, 8 km² of built-up area was turned to agricultural land, and from 2011 to 2021, 5 km² underwent the same transformation. The area transitioning from built-up to intense vegetation cover was 5 km² from 2001 to 2011 and 1.29 km² from 2011 to 2021. The built-up area to low vegetation cover was 4 km² from 2001 to 2011 and 3.65 km² from 2011 to 2021. Additionally, the area converted from built-up land to aquatic bodies was 0.19 km² and 1.37 km² during the periods of 2001-2011 and 2011-2021, respectively, while the transition from built-up land to barren land amounted to 2.76 km² in 2001-2011 and 3.1 km² in 2011-2021. Additionally, barren land was transformed into agricultural land by 1.1 km² and 2.5 km² for the periods of 2001-2011 and 2011-2021, respectively, whereas the conversion of barren land to low vegetation cover occurred at rates of 2.69 km² and 3.2 km² during the same periods. The transformation of barren land into developed areas was 3.45 km² from 2001 to 2011 and 4.93 km² from 2011 to 2021, while the conversion from barren land to water bodies amounted to 0.59 km² from 2001 to 2011 and 1.23 km² from 2011 to 2021.

4.3 Correlation between population growth and land use and land cover change

Population growth remains as one of the main drivers for LULC change as growing population creates increasing demand for resources, which significantly impacts the

environment and socio-economic structure of a given place.

Table 4: Total population of Mokokchung District (1991 - 2021)

Year	Population
1991	158374
2001	232085
2011	194622
2021*	227989

Source: Census of India, Estimated Population*

Mokokchung district witnesses considerable fluctuation in population growth during the study period (1991-2021). The district records a population of 158,374 in 1991, 232,085 in 2001 which shows a decadal growth of 46.5%. A notable change in population structure occurs during 2001-2011 census period as the district experiences a decline in population. In 2011, the district records a population of 194,622, which shows a decline of 16.14% as compared to the 2001 population. Estimated population of 2021 reflects a recovery trend, with population estimated at approximately 227,989 showing a growth by 17.14%. To examine the relationship between population growth and LULC change, Pearson's correlation coefficient, rho (ρ), was employed. The correlation matrix reflects a strong relationship between population growth and different LULC classes. Built-up area exhibits a strong positive correlation with population growth with rho (ρ) = 0.514, which highlights a close relation between increasing population and urban sprawling. A positive correlation was observed between population and barren land with rho (ρ) = 0.705. This correlation is attributed to deforestation, which is driven by the practice of Jhum cultivation, road construction, fuel wood extraction, and social infrastructural expansion. Similarly, low vegetation cover shows positive correlation with rho (ρ) = 0.416, which is mainly due to decrease in Jhum cycle, deforestation, and settlement expansion.

Table 5: Decadal population growth Rate of Mokokchung District (1991 - 2021)

Year	1991 - 2001	2001 - 2011	2011 - 2021*
Population growth (in%)	46.5	-16.14	17.14

Source: Census of India, Estimated Population*

Table 6: Pearson's correlation analysis of population and LULC classes

Population Rho (ρ) value	Agriculture	Dense Vegetation	Low Vegetation	Built-Up	Barren Land	Water Bodies
	0.056	-0.53	0.47	0.48	0.55	-0.48

Source: Calculated by researcher

Conversely, dense vegetation cover, agricultural land, and water bodies shows a negative correlation with population growth with correlation rho (ρ) = -0.533, -0.464, and -0.273 respectively. This inverse correlation shows that increasing pressure of population growth contributes to decline in dense vegetation cover and degradation or encroachment of water bodies within the study area. Decline in agricultural land is driven by factors such as urban expansion, social infrastructural growth, and shift in socio-economic preferences.

5. Conclusion

The study was conducted in Mokokchung district of Nagaland, which is one of the rapidly developing districts of the state. The study employs Geospatial techniques to examine the dynamics of LULC along with population data to evaluate the inter-relationship between the two variables. The finding reveals a substantial and measurable change in LULC during the study period (1991-2021).

The analysis reflects that population growth positively correlates with built-up areas, barren land, and low vegetation cover whereas dense vegetation, agricultural land, and water bodies exhibit a negative correlation. Built-up and barren land exhibit a stronger association with population growth, with a correlation coefficient ρ of 0.514 and 0.705 respectively suggesting increasing demand for housing, infrastructure, and related development activities with growing population, which led to environmental degradation and expansion in barren land.

Population growth is dynamic in nature and despite efforts being made to regulate this, it becomes impossible to completely control population growth. Therefore, it becomes important that a proper balance between population growth and LULC transformation is essential. A periodic and systematic LULC assessment along with accurate data is crucial for informed decision making. Such analysis will help policymakers and resource planners in formulating effective strategies for resource management.

References

- Barana B, Toma S, Bajigo A. Population growth and environmental changes: conclusions drawn from the contradictory experiences of developing countries. *International Journal of Environmental Monitoring and Analysis*. 2020;8(5):161-169. DOI:10.11648/j.ijema.20200805.15
- Bora R, Bora AK. Population pressure and changing land use land cover in Morigaon district, Assam, India: a geospatial analysis. *Indian Journal of Science and Technology*. 2024;17(24):2547-2556. DOI:10.17485/IJST/v17i24.899
- Brown DG, Walker R, Manson S, Seto K. Modeling land use and land cover change. In: *Land change science*. Dordrecht: Springer; c2012. p. 395-409.
- Gogoi PP, Vinoj V, Swain D, Roberts G, Dash J, Tripathy S. Land use and land cover change effect on surface temperature over Eastern India. *Scientific Reports*. 2019;9(1):1-10.
- Green K, Kempka D, Lackey L. Using remote sensing to detect and monitor land cover and land use change. *Photogrammetric Engineering and Remote Sensing*. 1994;60:331-337.
- Islam K, Jashimuddin M, Nath B, Nath TK. Land use classification and change detection by using multi-temporal remotely sensed imagery: the case of Chunati Wildlife Sanctuary, Bangladesh. *Egyptian Journal of Remote Sensing and Space Science*. 2018;21(1):37-47.
- Jamir S, Zulumanen, Yaden S. A study of population growth in Mokokchung district, Nagaland. *Gradiva*. 2025;11:278-284.
- Khan N, Raza M, Shakoor MSA, *et al*. 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;13:124-140. DOI:10.1007/s13412-022-00805-6
- Lillesand TM, Kiefer RW. Remote sensing and image interpretation. New York: Wiley; 1994.
- Long H, Tang G, Li X, Heilig GK. Socio-economic driving forces of land-use change in Kunshan, the Yangtze River Delta economic area of China. *Journal of Environmental Management*. 2007;83(3):351-364.
- Pongen L, Jamir S, Rawat MS, Yaden S. Analyzing land use and land cover changes and its dynamics in Mokokchung district, Nagaland. *International Journal of Scientific Research in Science, Engineering and Technology*. 2025;12:214-220. DOI:10.32628/IJSRSET2512111