



Research Paper

Geospatial monitoring and change detection of land use land cover in west Kohima District Nagaland, India

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Abstract: Understanding land use and land cover (LULC) change is essential for monitoring how Earth's surface evolves over time. The increasing demand for urban expansion and resource consumption has made it critical to track LULC dynamics and identify the drivers behind these transformations. Regions like the West Kohima District, part of the geologically active Himalayan belt formed by the collision of the Indian and Eurasian plates approximately 55 million years ago are experiencing rapid surface alterations. Located at an elevation of 1,444 meters and still thrusting at 4.5-5 cm/year, the district presents a compelling case for geospatial analysis. Using Landsat satellite imagery across decades, five major land categories were identified: Vegetation, Built-up, Agriculture, Water Bodies, and Barren Land. Vegetation cover decreased from 28,593.01 to 24,082.71 hectares, while built-up areas nearly doubled, indicating accelerated urbanization. Agricultural land slightly decreased, and water bodies saw a marginal decline, while barren land increased. Vegetation and built-up zones experienced the most dramatic shifts. Effective land management and planning are essential for

a robust environment, necessitating implementation by policymakers and planners. LULC alterations primarily resulted from the marginalization of shifting cultivation, deforestation, infrastructure development, and urban migration. In Northeast India, where data is limited, this study provides policymakers with fundamental insights into LULC. It also proposes strategies to ensure sustainable land use planning amidst rapid growth.

Keywords: Land use Land cover, Landsat, West Kohima District, Geo-Spatial, Change Detection.

Aberrations: Understanding land use and land cover (LULC), Geographic Information System (GIS)

Introduction: Great changes have occurred in the Earth's crust due to agricultural and development activities. Depletion in the environmental quality has been observed over a span of time due to certain mismanagement activities. Land Use Land Cover is one of the techniques that help in the observation, specification and detection of

such changes in the Earth's surface. The development of remote sensing and GIS techniques has made land use/cover mapping possible, and this has improved the selection of regions intended for use as agricultural, urban, or industrial zones within a region in a practical and detailed manner. (Selcuk *et al.*, 2003). Detecting changes in land use and cover is crucial for improving our comprehension of the dynamics of the landscape over a certain amount of time and for implementing sustainable management. The transition to more regular and consistent monitoring and modelling of land use/land cover patterns has been brought about by the development of high spatial resolution satellite images as well as more sophisticated image processing and GIS technology. The influence of LULC alterations in the ecosystem has led to an increase in demand for LULC mapping utilizing remote sensing data (Macarringue *et al.*, (2022). The use of remote sensing has made a substantial contribution to our understanding of how the terrain has changed. Many ways have been used to highlight the land use land cover pattern using remote sensing and GIS methodologies. LULC mapping has provided fresh insights into the monthly land altering trend of estimated earth resources using continuous satellite-based multi-temporal data. selection of regions intended for use as industrial, urban, or agricultural areas (Roy and Inamdar 2019). For effective land management and better decision-making, it is crucial to comprehend landscape patterns, changes, and the interplay between human activity and natural phenomena (Rawat and Kumar 2015). The most popular source of data for LULC pattern detection, quantification, and mapping is remote sensing because of its excellent georeferencing, processing-friendly nature, and capacity for repetitive data collecting (Chen *et al.*, 2005). The quantitative study of spatial distribution on

area of interest has led to the gradual emergence of land use change detection as an important step in monitoring and managing natural resources and urban development (Hassan *et al.*, 2016). Changes in land use are a result of how land use patterns impact the subsurface area. However, land degradation is not always implied by changes in land cover brought about by land exploitation. The majority of LULC changes are brought about by human activities like land conversion to agriculture, tree cutting, and settlement, all of which have an effect on trace gas emissions, biodiversity, water and radiation budgets, and other processes that affect the biosphere and climate (Subba Rao, 2003). Utilizing contemporary satellites capable of collecting data akin to aerial platforms, there is enhanced usefulness in assessing changes at environmental scales. Similarly, advancements in image processing, database management, and spatial analysis tools have enhanced our ability to investigate this data for illustrating LULC change (Treitz and Rogan 2004). Certain research depends on land surface temperature data derived from satellite imagery, which is pertinent to studies on urban heat islands, land use classification, thermal ecosystems, and hydrological assessments in urban development (Ibrahim, 2017). Land use influences land cover, while alterations in land cover affect land usage. Alterations in land cover due to land use do not invariably indicate land degradation. Nonetheless, dynamic land use strategies advocated by various societal influences result in alterations to land cover that affect biodiversity, potable water, radiation budgets, trace gas emissions, and other processes that collectively influence local climate and the biosphere (Riebsame *et al.*, 1994). The GIS is an information technology that has been employed in community policymaking for environmental and forest

planning and decision-making over the past two decades (Bassole *et. al.*, 2001). Thus, this study uses geospatial techniques to map the land use and cover status of one of the districts of Nagaland i.e. Kohima under which the western part of Kohima district is considered, to determine the land consumption rate and changes that have occurred over the past three decades.

Study Area:

The study area is under Kohima district under the state of Nagaland on the North-East of India with an area of 352.7 sq. km. This area is located on the foothills of Mt. Japfü range situated on the southern part of Nagaland. The geographical location of Kohima is between 25°6' and 27°4' latitude, North of Equator and between the longitudinal lines 93°20' E and 95°15' E. the study area comprises of western

Angami region with places like Khonoma, Jotsoma, and Sechu Zubza, Mezoma, Sechuma, Kiruphema, Peducha, Dzuleke, Dzudza Village. The study area is important since it holds vast scope for developmental activities chiefly due to ongoing rail head connectivity and 4 lane road connecting Kohima and Dimapur. The impact of globalization and modernity will have immense impact in the form of urban heat island, lesser NDVI values, higher rate of settlement and lesser moisture content etc. Thus, this study aims to understand the environmental quality, factors and indicators of environmental assessment, and impact of its deterioration in parts of West Kohima District using Geo-spatial techniques.

Material and Methods:

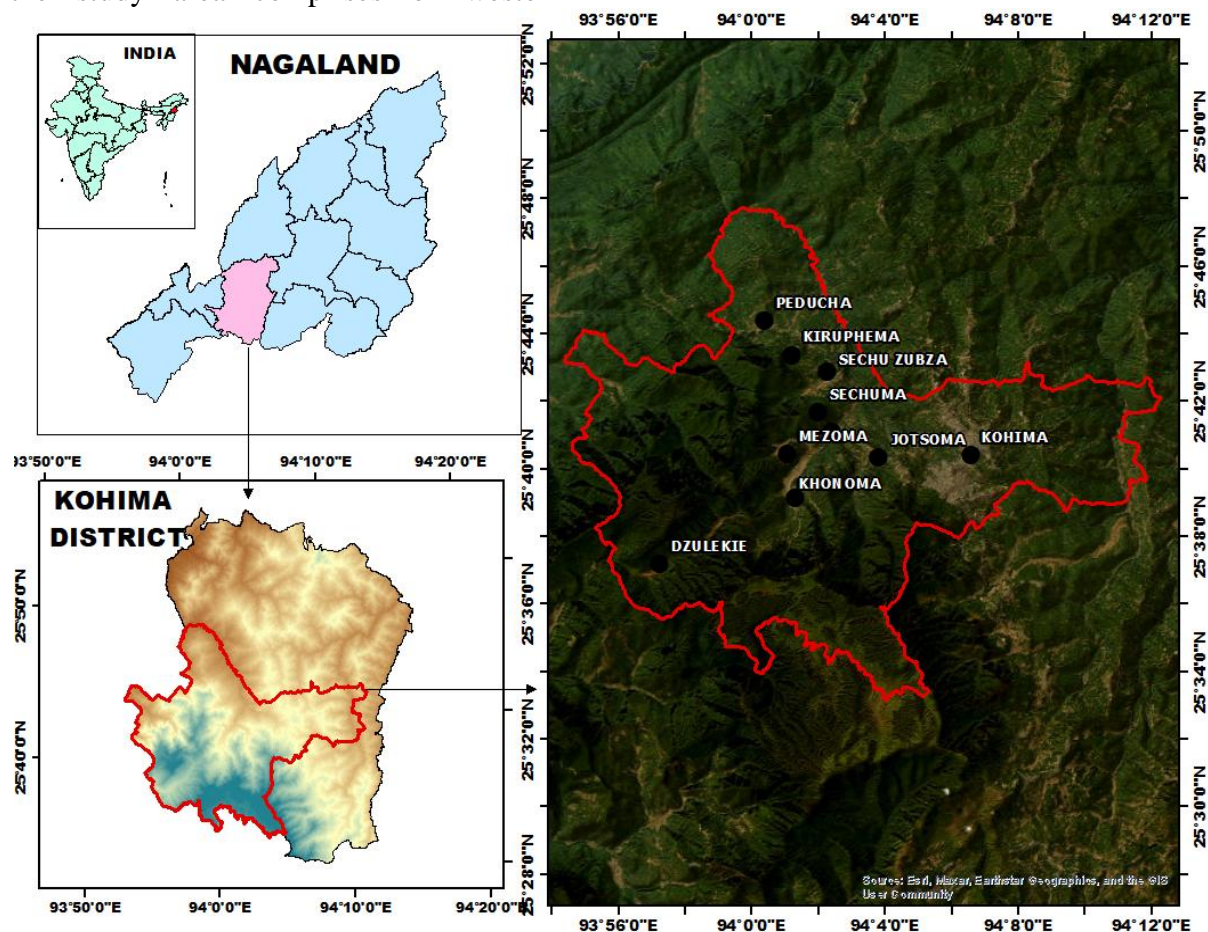


Figure: 1a. Study area map

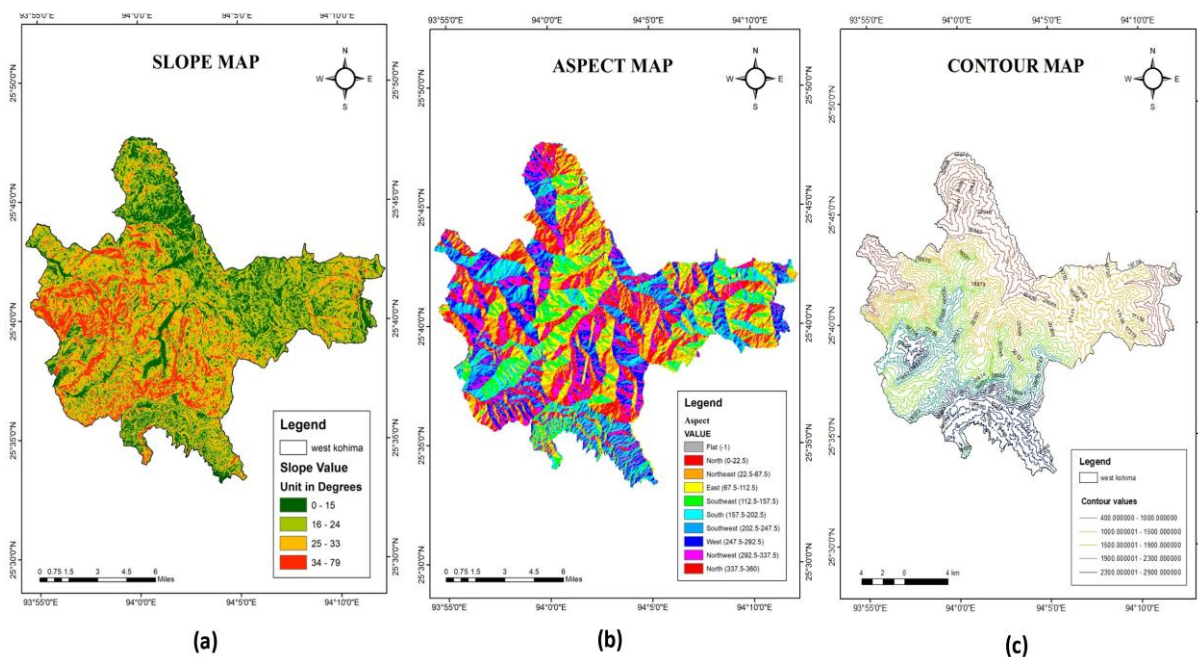


Figure: 1b. (a) Slope map, (b) Aspect map, (c) Contour Map of West Kohima District (study area)

Dataset: 1) The study used DEM, Landsat 7 ETM+ and Landsat 8 OLI level 1 satellite imaging data. Multispectral imagery is captured by the Landsat image sensor, which is located on the Landsat satellite space platform. The first crucial step in a successful categorization is choosing appropriate sensor data (Ward *et al.*, 2000). A study area's size and characteristics, the needs of the user, the availability of different picture data and

their attributes, financial and scheduling restrictions, and the analyst's prior experience with the chosen image are just a few of the variables that must be taken into account (Lu and Weng, 2007). The USGS Earth Explorer website provided the data that was downloaded. Since the research area is in a tropical region, cloud cover was avoided by choosing the winter, or dry season, when the most prominent land cover elements are displayed.

Table: 1. Dataset details

S.N.	Satellite Image	Date	Spatial resolution
1	Landsat 7 ETM+	21-07-2003	30m
2	Landsat 8 OLI/TIR	24-11-2013	30m
3	Landsat 8 OLI/TIR	20-01-2023	30m

Pre-processing:

The semi-automated classification technique was used to adjust the datasets for atmospheric factors. For the LULC mapping, five classes were considered. The class and its categories were shown in

table 2. Following the classes recognition, maximum likelihood classification based supervised classification procedure was used. Figure 2 displays the flowchart of the methodology.

Table: 2. LULC classification class.

S.N.	LULC class	Description
1	Vegetation	Forest, Grass, Shrubs.
2	Built-up Area	Human settlements, Residential area, Roads, artificial infrastructure.
3	Agriculture	Irrigated agricultural area, crop fields,
4	Water Body	River, Stream, Ponds, Reservoirs.
5	Barren Land	Degraded forest area, exposed rocks, landslide zones, sediments, deserted and fallow areas.

By choosing ROI using stratified random points and using them as a reference for the evaluation, an accuracy assessment was carried out to improve the classification and the findings. To

emphasize the shift in land use and landcover, a pixel-based change detection technique was used after categorization.

Methodology:

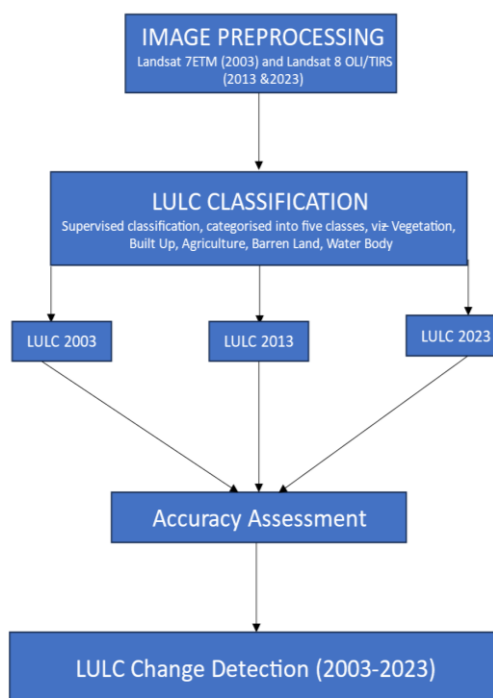


Figure: 2. Flowchart of the methodology incorporated

Result and Discussion:

Land use Land cover Status

The accuracy assessment for LULC 2003 was 86% in the overall accuracy while the accuracy assessment for LULC 2013 was 84% and the accuracy assessment for LULC 2023 was 87% in the overall accuracy respectively.

Figure 3 and Table 3 shows the LULC map and classification of the study area.

The built-up area in 2003 covered 9.02 % with an area of 4,329.45 hectares of the total geographic area. Vegetated area under 2003 was 28,593.01 hectares covering an area of 86.02 % of the total area. Water body was 0.9 hectares (0.02%) of the total area and other classes such as

Agriculture consist of 1,046.597 hectares (1.27 %) and Barren Land with 1,300.64 hectares (3.68 %) of the total area. In 2013, the total classes are as follows, built-up area covered 12.28 % with an area of 5,297.06 hectares of the total geographic area. Vegetated area was 27,405.28 hectares covering an area of 78.47 % of the total area. Water body was 0.5 hectares (0.01%) of the total area and other class which includes Agriculture covering an area of 948.65 hectares (2.68%) and Barren land with an area of 1,619.15 hectares (6.56%) of the total area. Lastly, the vegetative area covered in the year 2023 was 24,082.71 hectares (69.84 %) of the total area. Built up constitute about 8,493.11 hectares (19.27%) and Agriculture was 879.86 hectares (2.49%) of the total area. 0.3 hectares (0.001 %) under water body and 1,814.13 hectares

(8.44%) was covered under barren land respectively.

Kappa Coefficient Accuracy:

The Kappa coefficient quantifies the comparison between classification results after ground-truthing and values assigned randomly during sample training. It may assume values ranging from 0 to 1. A kappa coefficient of 0 indicates a complete lack of agreement between the categorized image and the reference image.

$$Ka = (p_o - p_e) / (1 - p_e)$$

Where, Ka = Kappa coefficient; 0 = agreement like random chance. 0.1 - 0.20 indicates minimal concordance. 0.21 - 0.40 signifies a moderate concordance. 0.41 - 0.60 signifies moderate agreement. 0.61 - 0.80 indicates strong agreement. 0.81 - 0.99 indicates near-perfect concordance. 1 signifies complete concordance.

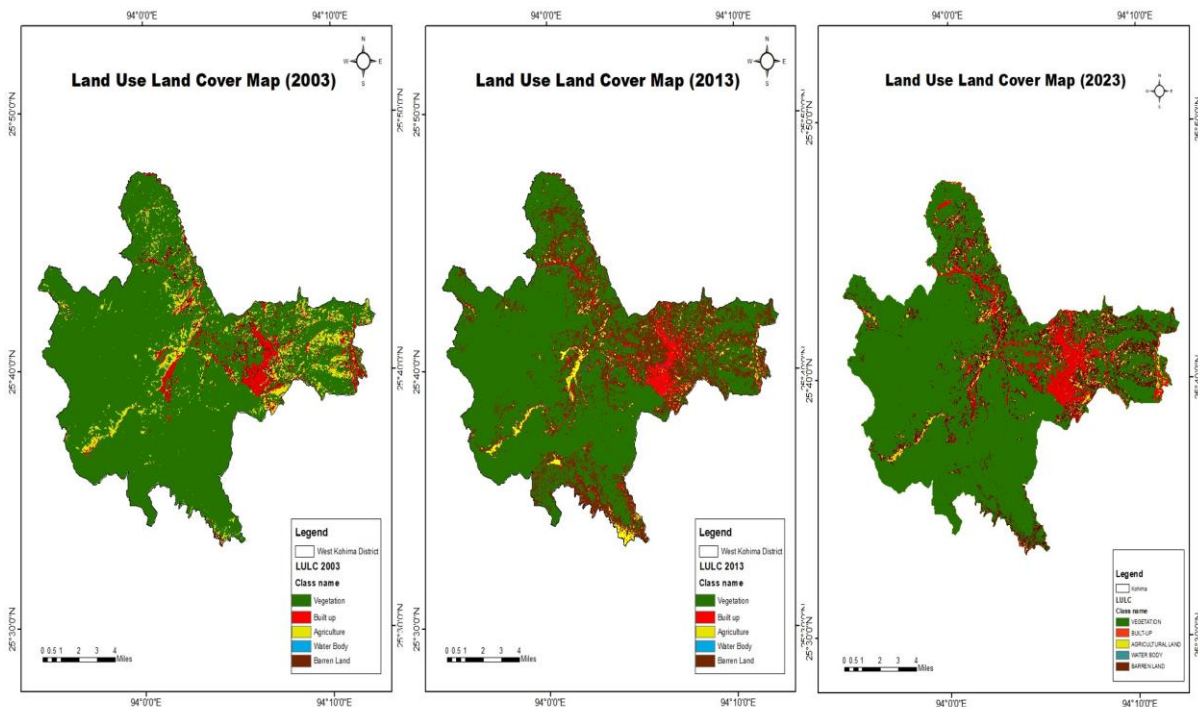


Figure: 3. LULC map of study Area showing classes distribution in 2003, 2013 and 2023

Table: 3. LULC geographical distribution in 2003, 2013 and 2023

S.N.	Class	2003		2013		2023	
		Area (Hectares)	Percentage (%)	Area (Hectares)	Percentage (%)	Area (Hectares)	Percentage (%)
1	Vegetation	28,593.01	86.02	27,405.28	78.47	24,082.71	69.84
2	Built-up	4329.45	9.02	5297.06	12.28	8493.11	19.27
3	Agriculture	1046.597	1.27	948.65	2.68	879.86	2.49
4	Water Body	0.9	0.02	0.5	0.01	0.3	0.001
5	Barren Land	1300.64	3.68	1619.15	6.56	1814.13	8.44
	Total	35,270	100	35,270	100	35,270	100

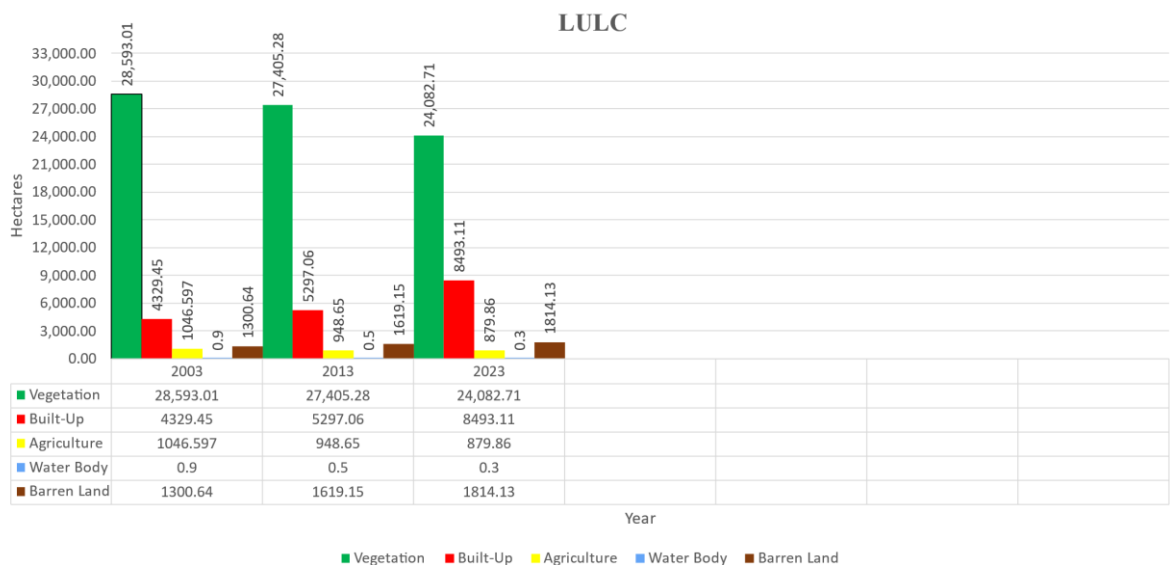


Figure: 3a. LULC graphical distribution in 2003, 2013 and 2023

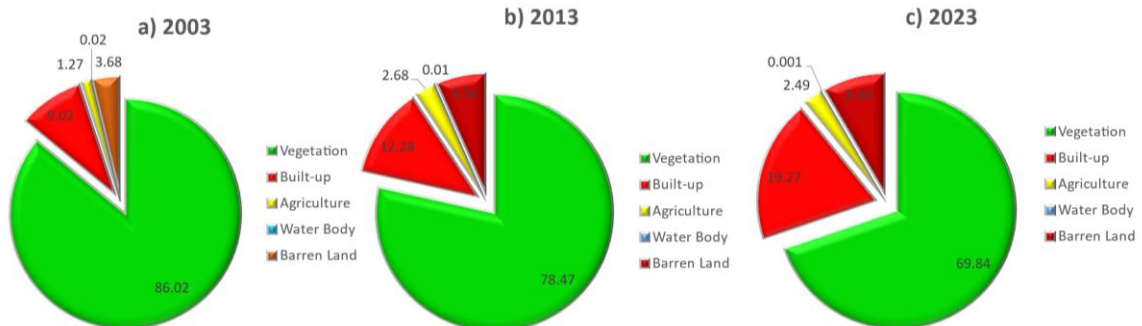


Figure: 3b. Percentage area composition of the five LULC classes in West Kohima district during 2003, 2013, and 2023

Lan duse Land cover Status:

The vegetation class with an area of 6.45% showed the most major change. It was noticed that the type of change went from vegetation to built-up in due point of time. Secondly, the agricultural class to barren land class was determined the most with 4.06 % due to mainly practice of shifting cultivation in parts of the district where major lands are shifted for cultivation from different time periods and thus leading to various vegetation growth in terms of

shrubs in such post cultivated area. The change in land area from barren land to vegetation recorded an area of 1.1 %. Barren Land to settlements showed a changed of 1.2 % and 0.7 % hectares from vegetation to agriculture due to displacements of the land use area under human interventions. Lastly, different classes depicted different changes in minimum numbers with undergone changes observed from Table 4 and Figure 5.

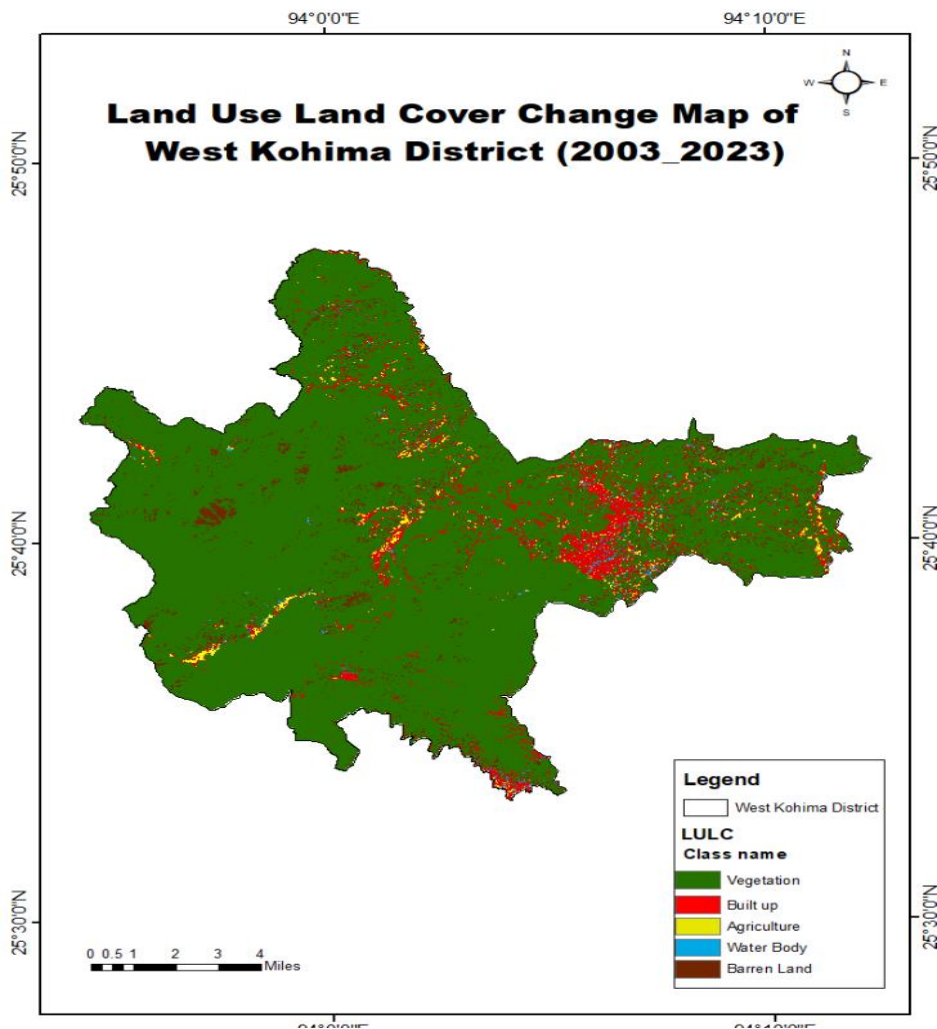


Figure: 4a. Land Use Land Cover Change Map of the Study Area

Table: 4. LULC Change Class 2003-2013

Classes	Changes (%)
Agriculture - Agriculture	0.00200791000
Agriculture - Barren Land	4.06709000000
Agriculture -Vegetation	1.54700000000
Agriculture -Water Body	0.05854330000
Barren Land - Agriculture	0.17870000000
Barren Land -Barren Land	2.76815000000
Barren Land -Built up	1.20370000000
Barren Land -Vegetation	1.11400000000
Barren Land -Water body	0.00306497000
Built up -Barren Land	0.15091100000
Built up- Build ups	2.45103000000
Built up -Vegetation	0.75500000000
Built up -Water Body	0.08728590000
Vegetation - Agriculture	0.70069700000
Vegetation - Barren Land	0.33915500000
Vegetation - Built up	6.45136000000
Vegetation -Vegetation	0.38450000000
Vegetation -Water Body	0.17910500000

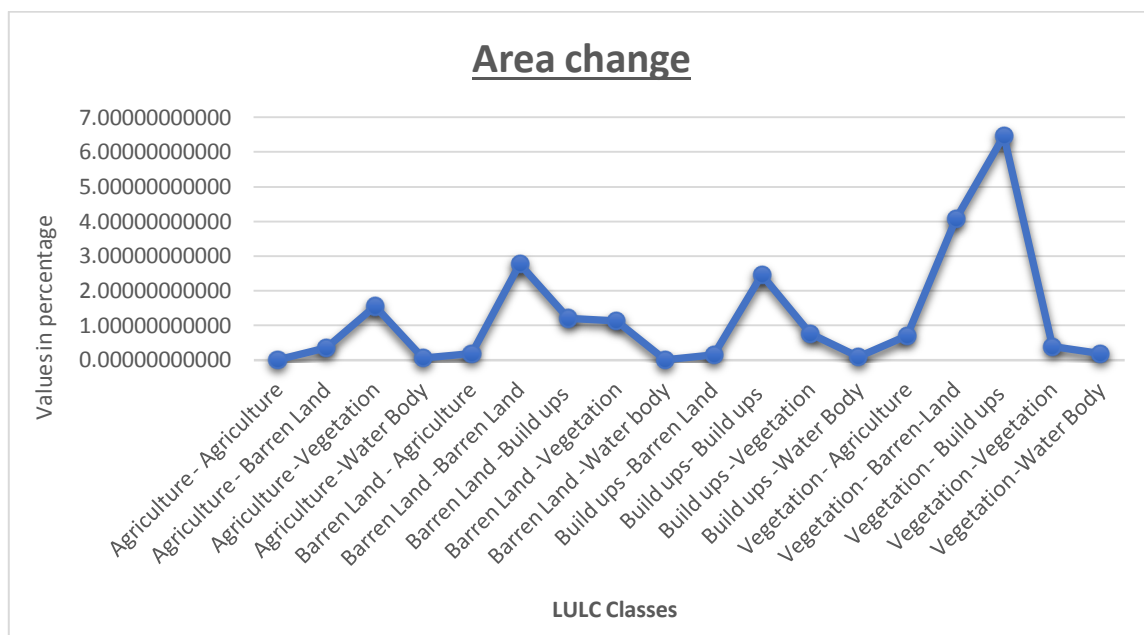


Figure: 5. LULC change from 2003-2023.

Table: 5. LULC Change Class 2003-2023

S.N.	Class	2003 Area (Hectares)	2023 Area (Hectares)	LULC Change Area
1	Vegetation	28,593.01	24,082.71	- 4510.30
2	Built-up	4329.45	8493.11	4163.66
3	Agriculture	1046.59	879.86	- 166.73
4	Water Body	0.9	0.3	- 0.6
5	Barren Land	1300.64	1814.13	514.13

The above table encapsulates the alterations in land use and land cover over a two-decade span. It underscores a substantial decrease in vegetation cover by 4,510.30 hectares and a fall in agricultural area by 166.73 hectares, suggesting potential urban expansion and environmental damage. In contrast, developed regions have had a significant expansion of 4,163.66 hectares, indicative

of urbanization and infrastructure advancement. The expanse of barren land has risen by 514.13 hectares, indicating potential land deterioration or conversion from other usage. Water bodies have undergone a reduction of 0.6 hectares. The data demonstrates a distinct tendency of urban expansion at the cost of natural and agricultural areas.

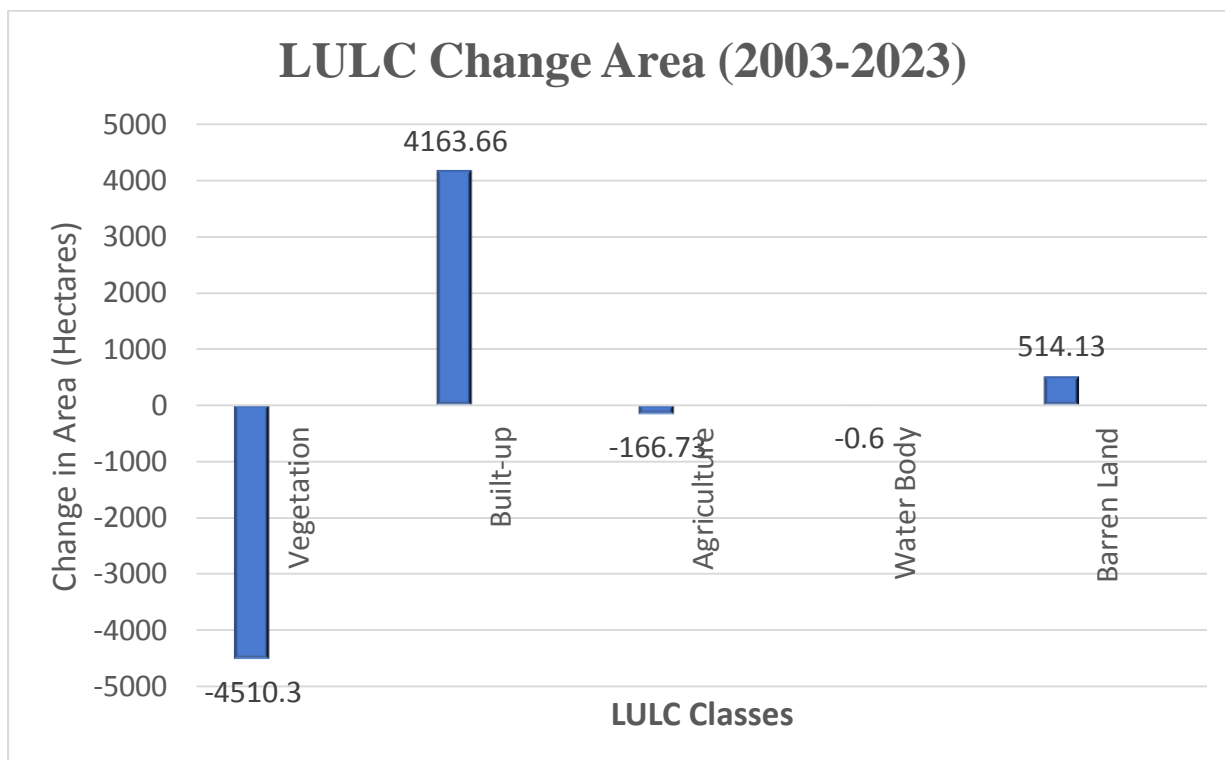


Figure: 6. Diagrammatic illustration of land use land cover change in percent in Kohima District, Nagaland

Conclusion:

The study elucidates the evolving topographical characteristics and land use/land cover (LULC) dynamics in the mountainous areas of Nagaland, particularly in West Kohima District. This is significantly pertinent within the larger framework of India, a developing economy experiencing swift infrastructural development, urban proliferation, and escalating population demands. Alterations in land use and land cover are significant indications of the interaction between human activity and the environment, especially in environmentally sensitive areas like North-East India. In regions such as West Kohima, where systematic and long-term spatial data are limited, the study underscores the necessity of ongoing geographic evaluations of land use and land cover changes and associated spatiotemporal dynamics.

The results indicate that substantial land use and land cover changes have occurred in Kohima District over the last twenty years. Urbanization, agricultural practices, and developmental initiatives, including road construction, institutional infrastructure, and other settlement-related activities, have been consistently increasing. These forces have progressively encroached upon regions that were formerly characterized by lush vegetation and forest cover. Notwithstanding this, the survey indicates that vegetation remains the predominant land cover category, with significant areas of the district still exhibiting a vibrant green cover. This demonstrates the resilience of natural systems and the endurance of forested landscapes in the area. The temporal analysis from 2003 to 2023 reveals a distinct rising trajectory in the built-up category. This increase is attributable to population growth, settlement expansion, and land conversion for human requirements and development. In contrast, vegetation, agricultural land,

and aquatic bodies have seen falling tendencies during the same timeframe. Agriculture, historically a predominant land use, is declining due to escalating urbanization and shifts in livelihood patterns. Water sources, already scarce in the mountainous region, have diminished more, indicating prospective issues in water availability in the future. Simultaneously, the expansion of barren land indicates both land degradation and the transformation of arable land into less viable forms. These trends have immediate consequences for environmental sustainability and planning. The depletion of vegetation and agriculture adversely impacts biodiversity and ecosystem services, while simultaneously heightening susceptibility to soil erosion, landslides, and climatic stressors. The expansion of urban areas signifies socio-economic advancement but also presents issues such as resource strain, habitat destruction, and ecological disruption.

The study illustrates the efficacy of geospatial technologies—specifically GIS and remote sensing—in documenting and examining such transformations. The capacity to observe long-term trends using satellite imagery and spatial analysis provides planners, policymakers, environmentalists, and lawmakers with a cost-effective and time-efficient instrument for decision-making. The delineated effect regions identified in this study can facilitate evidence-based discourse on sustainable land management, ensuring a balance between developmental requirements and ecological conservation. The land use and land cover shift in West Kohima District exemplifies the concurrent problems of development and conservation in North-East India. The results underscore the necessity of implementing integrated land management policies that prioritize development alongside sustainability.

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