Remote Sensing and GIS based Land Use Land Cover Analysis in Chandel District, Manipur, India

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Abstract: Rapid urbanization has dramatically altered land use and land cover (LULC). The focus of this research is on the examination of the last two decades. The research was conducted in the Chandel district of Manipur, India. The LULC of Chandel (encompassing a 3313 km² geographical area) was mapped using remotely sensed images from LANDSAT4-5, LANDSAT 7 ETM+, and LANDSAT 8 (OLI) to focus on spatial and temporal trends between years 2000 and 2021. The LULC maps with six major classifications viz., Thickly Vegetated Area (TVA), Sparsely Vegetated Area (SVA), Agriculture Area (AA), Population Area (PA), Water Bodies (WB), and Barren Area (BA) of the were generated using supervised classification approach. For the image classification procedure, interactive supervised classification is adopted to calculate the area percentage. The results interpreted that the TVA covers approximately 65% of the total mapped area in year 2002, which has been decreased up to 60% in 2007, 56% in 2011, 55% in 2017, and 52% in 2021. The populated area also increases significantly in these two decades. The change and increase in the PA has been observed from year 2000 (8%) to 2021 (11%). Water Bodies remain same throughout the study period. Deforestation occurs as a result of the rapid rise of the population and the extension of the territory.

Keywords: LULC, LANDSAT, ARCGIS, Interactive supervised classification.

1. INTRODUCTION

The importance of mapping and observation of LULC at a regional scale is enormous in the sector of urban development and land degradation. The landscape of Asia's Northeastern Region (NER), which is experiencing rapid LULC change as a result of massive deforestation, conversion to settlements and temporary agricultures (slash and burn practices where the settlement growth, poses a threat to agricultural production and environmental security in the region. Physical factors such as topography, soil, and climate, as well as human factors such as population density influence the land usage. Because of the ongoing interaction of physical and human forces, there are substantial geographic and temporal variations in land utilization. LULC changes are important drivers of water, soil, and pollution. The land cover gets affected due to clearance of land for agriculture. Vegetation clearance exposes [1–3] soils to a
greater risk of being eaten away by wind and water, especially on steep terrain, and once among the clouds, releases toxins into the atmosphere. Land use/cover changes must be detected in order to have a better knowledge of landscape dynamics during the property management period. Land use/cover change leads to changes that may have an impact on natural. The remote sensing and Geographical Information System (GIS) [4–6] technology is very useful tool for betterment of the selection of regions planned for Agricultural, Urban, Industrial purpose. The LULC changes are being influenced by urbanization which is difficult to prevent due to rapid growth in the development. Deforestation, pollution, and other issues arise as a result of population growth. Most of the terrestrial biosphere has been changed into anthropogenic biomass as a result of human populations and land use. Such change has resulted in the emergence of a number of new ecological patterns and processes, and it has been significant for over 8000 years [7–9]. investigated the LULC changes that have occurred in metropolitan over the last two decades as a result of rapid urbanization using a post classification technique. The behavior of changes in land use and land cover is largely influenced by phylogenies and environmental influences. Land cover refers to changes on the Earth's surface such as forests, grass, water etc. using RS & GIS. Land cover refers to the biophysical status of the earth's surface differences in order to appropriately employ them in land and immediate subsurface investigations. The environmental elements such as soil quality, climate, topography, and vegetation influence land usage. It also recognizes the value of land as a limited resource for a variety of human activities, including agriculture, industry, forestry, energy generation, settlement, recreation, and construction and storage for water. Researchers and policymakers all around the world are working to monitor and mitigate the negative effects of land use/land cover change while maintaining the production of key resources. When it comes to monitoring and maintaining natural resources, change detection is very important because it provide quantitative analysis of the spatial distribution of the population of interest [10–12].

The current study aims at temporal variation in LULC for the year 2002, 2007, 2011, 2017, and 2021 to assess the transformation in LULC between years 2002 and 2021. The analysis additionally aims to supply modification detection map of Thickly Vegetated Area, Sparsely Vegetated Area, Barren Area, Populated area, Agriculture Area, and Water Bodies. The whole process of this study has been done on ArcGIS 10 software. There are a number of software extensions that can be added to ArcGIS that provide additional functionality, including 3D Analyst, Spatial Analyst, Network Analyst, Survey Analyst, Tracking Analyst, and Geostatistical Analyst [13–15].

2. STUDY AREA

Chandel is located in the state called Manipur which is situated in the North-Eastern part of India. It is bounded by the Indian states of Nagaland to the north, Mizoram to the south and Assam to the west. Chandel is one of sixteenth districts of the Manipur state of India which is founded on May 13th, 1974. It is the state's second least populated district, behind Tamenglong. The study area is located in the southeastern region of the state at 24°40’ N latitude and 93°50’ E Longitude. The vegetation and hills of Chandel are covering 3313km² area. As per 2011 census, the Chandel district has a population of 144,182. The district has a population density of 43 people per square kilometer which encompasses a sex ratio of 932 females to 1000 males, and a literacy rate of 70.85% [16–18], see figure 1.
3. METHOD

The satellite imagery has been collected from USGS (United States Geological Survey) platform for 5 different years (2002, 2007, 2011, 2017, and 2021). The satellite bands were analyzed after band composition followed by Supervised classification. The satellite bands LANDSAT4-5, LANDSAT 7 ETM+, LANDSAT 8 (OLI) were utilized for the year 2002, 2007, 2011, 2017, and 2021 as given in Table 1. To analyze the changes [19–21] in LULC classes of 5 years, an Interactive Supervised classification was adopted [22–25]. The methodology adopted for analyzing LULC pattern is mentioned in the flowchart as shown in Figure 2.
**Figure 2**: Methodology adopted for analyzing LULC pattern.

**Table 1**: Temporal information of the satellite bands

| S.NO. | DATA             | SOURCE                  | YEAR       |
|-------|------------------|-------------------------|------------|
| 1.    | LANDSAT 7 ETM+   | USGS Earth Explorer     | 07/03/2002 |
| 2.    | LANDSAT 4-5      | USGS Earth Explorer     | 20/04/2007 |
| 3.    | LANDSAT 4-5      | USGS Earth Explorer     | 09/04/2011 |
| 4.    | LANDSAT 8(OLI)   | USGS Earth Explorer     | 09/04/2017 |
| 5.    | LANDSAT 8(OLI)   | USGS Earth Explorer     | 20/04/2021 |
4. RESULTS AND DISCUSSION

The Interactive Supervised Classification approach was used to detect LULC classes from the satellite Imagery. Figures 3, 5, 7, and 9 depict spectral satellite images, whereas Figures 4, 6, 8, and 10 demonstrate the nature of the trend of change in LULC categories as shown in pie chart for the corresponding study years.

![Image of satellite imagery and pie charts showing LULC changes between 2002 and 2007.](image)

**Figure 3:** LULC change between 2002 and 2007.

**Figure 4:** Trend of Land changes between 2002 and 2007.

Figures 3 and 4 indicate that the Thickly Vegetated Area (TVA) is reduced from 65% in year 2002 to 60% in the year 2007 whereas Sparsely Vegetated Area (SVA) increased from 15% to 17% respectively. Populated Area (PA) remains same as 8% while Barren Area (BA) increased from 8% to 9%. Agriculture Area (AA) increased 2% to 3% while Water Bodies (WB) remains same as 3%.
Figures 5 and 6 indicate that the Thickly Vegetated Area (TVA) is reduced from 60% in year 2007 to 56% in the year 2011 whereas Sparsely Vegetated Area (SVA) increased from 17% to 18% respectively. Populated Area (PA) increases from 8% to 9% while Barren Area (BA) increased from 9% to 11%. Agriculture Area (AA) and Water Bodies (WB) remain same as 3%.
Figures 7 and 8 indicate that the Thickly Vegetated Area (TVA) is reduced from 56% in year 2011 to 55% in the year 2017 whereas Sparsely Vegetated Area (SVA) increased from 18% to 19% respectively. Populated Area (PA), Barren Area (BA), Agriculture Area (AA) and Water Bodies (WB) remain same as 9%, 11%, 3% and 3% respectively.

**Figure 7:** LULC change between 2011 and 2017.

**Figure 8:** Trend of Land changes between 2011 and 2017.
Figures 9 and 10 reveal that the Thickly Vegetated Area (TVA) has fallen from 55% in 2017 to 52% in 2021 and the Sparsely Vegetated Area (SVA) has declined from 19% to 18%. Populated Area (PA) climbed from 9% to 11%, while the percentage of Barren Areas (BA) increased from 11% to 12%. Agriculture Area (AA) increased from 3% to 4% while Water Bodies (WB) remains same as 3%, see Table 2 and Figure – 11.

Table 2: LULC areas in 2017 and 2021.

| AREA | 2017 Area (%) | 2021 Area (%) |
|------|---------------|---------------|
| TVA  | 55            | 52            |
| SVA  | 19            | 18            |
| PA   | 9             | 11            |
| AA   | 3             | 4             |
| WB   | 3             | 3             |
| BA   | 11            | 12            |
Table 2: LULC Classification of area between 2002 and 2021.

| LULC Types          | 2002 | 2007 | 2011 | 2017 | 2021 |
|---------------------|------|------|------|------|------|
|                     | %    | %    | %    | %    | %    |
| Thickly Vegetated Area | 65   | 60   | 56   | 55   | 52   |
| Sparsely Vegetated Area | 15   | 17   | 18   | 19   | 18   |
| Populated Area      | 8    | 8    | 9    | 9    | 11   |
| Agriculture Area    | 2    | 3    | 3    | 3    | 4    |
| Water Bodies        | 3    | 3    | 3    | 3    | 3    |
| Barren Area         | 8    | 9    | 11   | 11   | 12   |

Figure 11: Comparison of trends of land changes since Years 2002-2021.

5. CONCLUSION

In township planning, watershed design, and other applications, RS and GIS have been proved as useful tools. This research demonstrates the geographical and temporal alterations in the LULC pattern, which are difficult to achieve using traditional methods. Major Land Use Changes in Thickly Vegetated Area, Sparsely Vegetated Area, Populated Area, Barren Area, Agricultural Area, and Water Bodies were discovered in the study. Between 2002 and 2021, the Thickly Vegetated Area got reduced 65% to 52% while the Sparsely Vegetated Area increases from 15% to 18%. The TVA and SVA underwent significant changes, while little changes were identified in the Agricultural Area and Barren Area over the years. Agriculture Area increases from 2% to 4% whereas Barren Area increases from 8% to 12%. Populated Area was also changed from 8% to 11%. Water Bodies cannot be traceable any changes during this period. The LULC mapping informs the working plan for managing natural resources and environmental...
concerns. The unplanned Urban Land may result in higher temperature, less water purification, and air pollution etc. The current study will aid in a better understanding of the growth patterns of various LULC classes which will help planners on how to design an eco-friendly management approach.

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