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Analysis Of Urban Growth Dynamics Of Lucknow City:A Gis Approach

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Abstract

The outburst growth of metropolitan areas, commonly known as fringe or periurban areas, has been the primary challenge for the comprehensive development of a city. The main objective of this research paper is to analyze the growth dynamics of India's tries II metro cities using GIS as a tool. The study revolves around modifications in the LULC, identified concerning Lucknow from 2005-2020 using Geographical Information Systems (GIS). The research area was divided into five categories based on comparative analysis, geographic conditions, and remote sensing data. Comparing LULC data between 2005, 2010, 2015, and 2020 showed a substantial variation in land use classifications in the study area. The data was obtained from the analysis of topo-sheet and satellite images. The result also shows the dynamics and patterns of emerging urban agglomerations concerning peri-urban areas and development plan strategies for future development. The study shows that remote sensing and GIS tools are successful in urban studies and management. It was examined during the analysis, large quantities of agricultural land, water bodies, and dense vegetation areas were transformed due to the rapid urbanization of the urban agglomeration of Lucknow.

Keywords—Growth Direction, GIS, Remote sensing, Peri-urban, Urban management, Urban agglomeration, Vegetation.

1. Introduction

Currently, 55% of the world's population lives in urban areas. It is assessed that the figure will increase to 68% by 2050. Urbanization can be related to a gradual transition between rural and urban populations. Presently, the biggest challenge is 2.25 billion people living in urban areas, with the urban population in China and Asia rising to 90% in 50 more years[1]. Environmental developments cannot be accomplished without significant changes in how we structure and maintain our urban environments. Because of the demand for a better quality of life, urbanization has become a sustainable process with rapid population growth in India [1].

Cities in developed countries are rapidly growing because of population growth and increased migration[18]. Cities have become a significant part of people's lives. Sustainable cities provide job and business opportunities, safe and affordable housing for sustainable communities. This applies to public transport investments, building green public spaces, and promoting fair and diverse urban planning and management commitments [2]. In classifying and separating urban or rural areas, the density of communities and economic activity influence play a key role. These factors are essential in characterizing urban areas like towns, cities, and metropolitan towns. The three sustainable development parameters are strictly connected with urbanization: economic, social, and environmental development [3]. Agglomeration are enhanced through linked urbanization (including factors), influenced by a long-term understanding of population dynamics. [4].

Recognizing economic, social, and environmental interdependence, the relationship between small towns and rural areas must be strengthened. Strengthening services and infrastructure and creating more non-agricultural rural can promote sustainable development in urban and rural areas [5]. The urban and rural population service delivery strategy should consider potential cities and

multiple opportunities for rural settlements in the vicinity, together with public and private investment in constructed forms, associated infrastructures, urban and space planning impact on urbanization. A growing share of economic activity and innovation in cities is concentrated as a center for traffic, commerce, and information flow. High-quality government and private services are often available in the cities, where public services are also more affordable than rural ones.

The increasing urban activity in city areas beyond the current municipal borders generally leads to peri-urban areas. Peri-urbanization can be characterized by increasingly spatial, economic, and social activity in rural suburbs, often based on circumstances. It is characterized by local economic and employment trends, rapid population growth, and agricultural migration. This leads to higher land values and mixed land utilization [6]. Peri-urbanization process around the world tends to be complicated at first glance.

Geoinformation Technology and Remote Sensing is a powerful tool to track and analyze information on other social/cultural variables, natural resources, and environmental changes in recent years. It provides a continuous and reliable record of spatial trends [7]. In comparison to others, remote sensing can provide reliable, predictive surface information at broad spatial coverage at frequent intervals is one of the most essential and distinguishing features. Due to its multi-spectral, multi-resolution, and periodic monitoring capabilities, remote sensing is ideal for inventorying land usage/land cover trends and dynamics in vast areas [8]. The properties of Remote Sensing allow researchers and urban planning professionals to predict the growth pattern of the metropolitan regions and is a significant tool for growth management.

Spectacular advances in the GIS analysis have become an instrument for achieving sustainable growth strategies in land and water resources management to synthesize different knowledge with collateral information. In the analysis and modeling of integrated data, GIS is well known for its utility. GIS was used to develop electronic databases, evaluate the resource status and use patterns in regions, and promote and analyze different resource management alternatives [9].

Because of the above advancements in GIS technology and the challenges faced by urban planners for assessment and projection growth dynamics of urban areas, in this paper, the researchers have tried to solve the same by analyzing the timeline LULC change derived from GIS maps to predict the growth pattern and direction of the city of Lucknow, Uttar Pradesh, India

2. SELECTION OF THE STUDY AREA

Lucknow is the capital of Uttar Pradesh, India's most populous state. It lies in the northern hemisphere between latitude 26.83 ° North and longitude 80.92 ° South. It is situated in the core area of the Gangetic plain. The NH-25 (Kanpur road towards Jhnasi / Bhopal) NH-28 (Faizabad road) is limited to five NH-24 national roads (Sitapur road to New Delhi). Sultanpur (LDA,2031.) NH-24(B)- Raibarelly and Allahabad NH-(56) give excellent inter and intra-state connectivity. There are also two state highways. Both the Northern Railway (N.R.) and the Northeastern Railway (NER) corridors cut old and newly developed parts. Administratively it is the district headquarter in addition to the state capital.

Lucknow district has the 5th largest population in Uttar Pradesh (45.8 lakhs), the second-most populous urban area (29.02 lakhs) of Uttar Pradesh, and the 11th largest city of India The population density in Lucknow ranges from 600 PPH to 1000 PPH in existing residential areas (according to Lucknow Development Authority Vision Report, 2031). Recently, the population of Lucknow has been growing fast in its peri-urban areas.

There are three main consequences of this expansion:

i) Peri-urban areas with smaller physical areas have
both positive and negative impacts
ii) The peri-urban population has increased with forced transfers or "free agents."
iii) A disparity exists between the residential preferences of the different age groups.

Within the inhabited areas, the positive aspect is a new infrastructure for industrial and other urban services and more open spaces for both pleasure and sports activities. It also facilitates increasing municipal income contributing to local economies in the long run, in other words, the value of land and the effectiveness of urban services has risen over the years. Another critical factor is that living in peri-urban areas can be cheap and inexpensive.

This research paper's principal objective is to evaluate the growth pattern of the city of Lucknow with the interpretation of land use with of modern geo-informatics Remote Sensing and GIS techniques. In this research paper, the allied issues like the management of agro-ecological, urban growth patterns, and other planning and policy-related problems shall also be explained while looking at the growth dynamics of the city. In the Northwest and Southeastern Metropolitan Regions, Lucknow has seen considerable growth, increasing land demand, increased use of urban services,

moving from agriculture to non-farming, greenhouse emissions rates, increased pollution, and the creation of urban heat islands in areas where greenhouse emissions are high has been a pertinent issue in the developed regions of the city [10]. This study uses the following data:

2.1 Satellite data

- By using different Landsat (4-5 and 8) thematic mapper data obtained from earth explorer.usgs.gov

2.2 Maps and reports

Lucknow Development Authority Master Plan-2021 -2031 and Census of India, Map Data, Census 2021, India), District Census Handbook, Lucknow-2011, (Census of India, 2011).

- Lucknow municipal corporation CDP (2040) and other respective secondary published reports and documents.
- The mango belt gazette-1985 and other norms.

2.3 Software

Geographic information system software of Arc GIS 10.4 (ESRI), Autocad-2019, Ms. Excel -2016, Ms. Word, etc.

Due to rapid population growth and for a better quality of life, India is going through unprecedented urbanization. Indian cities are developing outside their demarcated boundaries due to this urbanization[12]. As a result, the cities' fringe areas, also known as peri-urban areas, are experiencing inadequate urban planning, poor environmental management, and crisis in land control and investment factors in immobilization. (UN-Habitate, 2010).

3. METHOD

The following methodological steps were used for this study

3.1 Source of data for Imaginary

Facts and figures taken from the United States Geological Survey of the Earth Explorer were extracted by Landsat TM Fig.1-3 i.e 2005, 2010 and 2015 respectively and OLI Fig. 4 (2020). All Landsat data sets were referenced earlier. The entire research is focused on the review of Arc data GIS 10.4 applications.

3.2 Imaginary advanced Landsat processing (TM/OLI)

Figures 1–3 used Landsat TM data as thermal bands for land use, while Landsat OLI (Operational Land Images Indicators) data from Figures 4 were used for 2020 [13]. Bands 1–7 were only used to map land use. Controlled image classification techniques with a highly probable approach were used to demonstrate land use/landscape changes over a decadal period and different types of land use. 1700 signatures are composed and combined from all images to detect any land use adequately. The maps were created after reclassifying the LULC raster data, converting it to vector data, and calculating each classified polygon area.

3.3 Visual interpretation and validation of Imaginary from ground authenticity.

• To identify land use/land cover classes and land degradation, standard picture interpretations such as tone, texture, size, pattern, match, ancillary, and legacy data were used [14]. Preliminary screen visual image interpretation was done based on image interpretation keys. Digital images were also classified to identify features using supervised and unattended methods.

• Drought areas in the interpreted photos have been identified and classified for ground confirmation and field-transverse verification [15].

There are three main criteria for selecting peri-urban areas (i) Within a 30 km radius of the city nucleus since, as per the skeletal infrastructure, it is the maximum daily commutable distance. (ii) Land cover density open versus the constructed areas. (iii) The scope of the master plan is set to the 2031 administrative boundary of the ULB as Nagar Panchayats. Actual boundaries between urban and rural areas are 10 to 25 km.

4. RESULTS AND DISCUSSION

It is becoming increasingly important to address the issue of biogeochemical cycles sustainably by addressing habitat decline, biodiversity loss, environmental quality loss, agricultural land loss, and degradation of wetlands, aquatic life, and wildlife habitats. Rapid population growth has resulted in rural-to-urban migration and the reclassification of rural areas as metropolitan areas, one of the primary reasons for the LULC reforms. Other factors include a lack of understanding of biophysical limitations and environmentally unsustainable technologies. Trends in the city's urban agglomeration as a whole are also depicted.

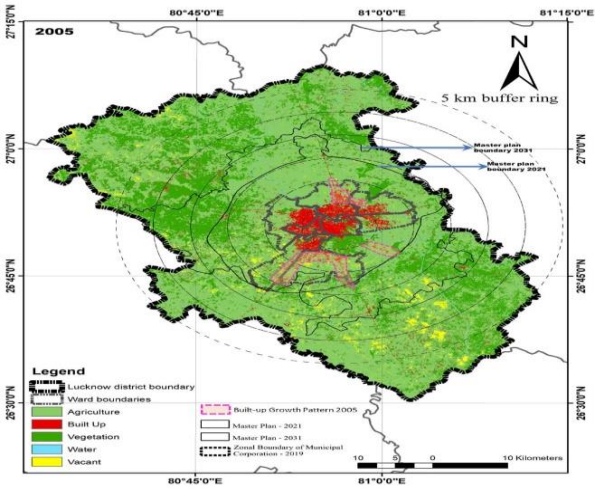

Figure 1: LULC 2005 Lucknow District, Uttar Pradesh
Source: Author's interpretation, Sep-2020

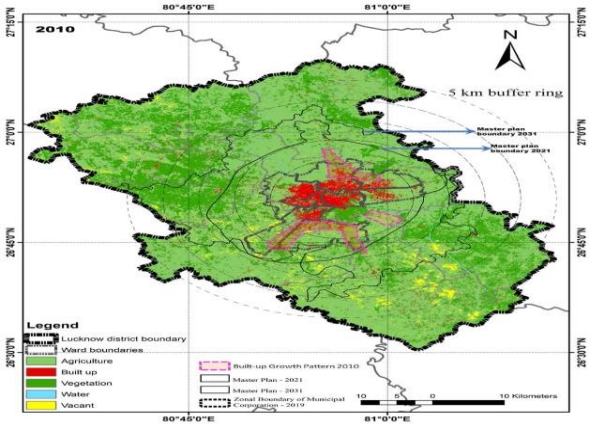

Figure 2: LULC 2010 Lucknow District, Uttar Pradesh
Source: Author's interpretation, Sep-2020

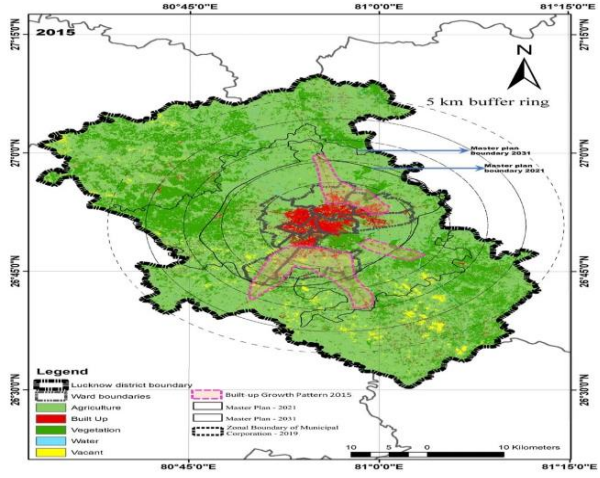

Figure 3: LULC 2015 Lucknow District, Uttar Pradesh
Source: Author's interpretation, Sep-2020

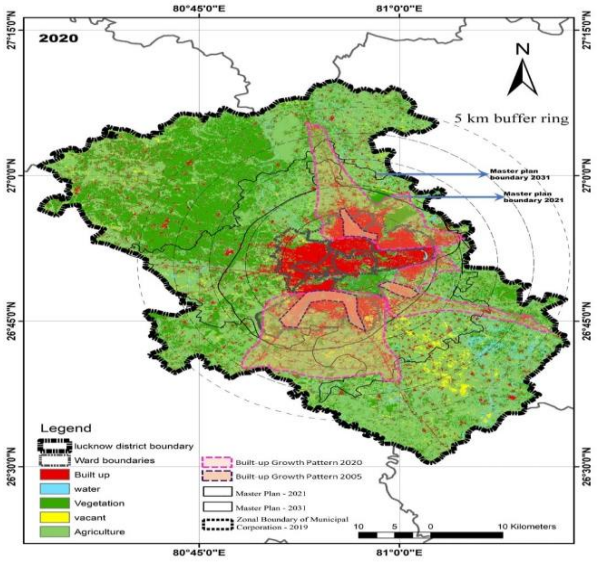

Figure 4: LULC 2020 Lucknow District, Uttar Pradesh
Source: Author's interpretation, Sep-2020

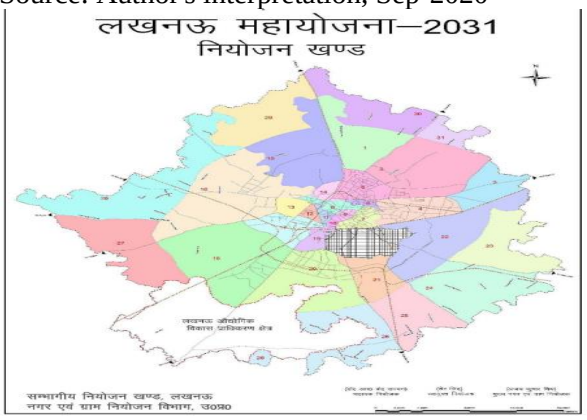

Figure 5: Map showing Zonal area for planning, Source: LDA master plan 2031

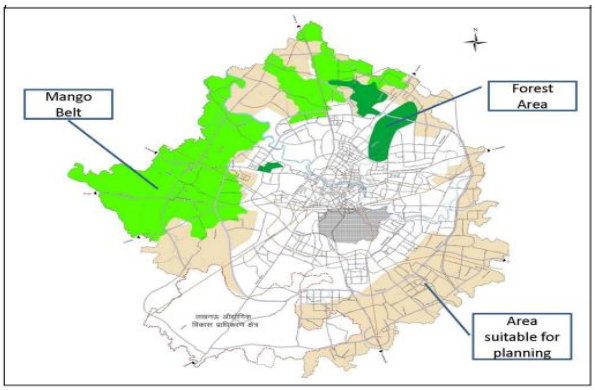

Figure 5A: Map showing area suitable for future planning Source: LDA master plan 2031

According to Lucknow Master Plan-2031, the Lucknow Master Plan-2031 is divided into 31 zones (see Fig.5). The primary goal of the Zonal Development Plan is to provide and maintain facilities/services/roads/parks, etc., due to the risks of permanent construction. Rapid and preliminary action is required in zones 01,02,03,15,16,22,24, and 25 based on the urban pattern of development

(see figure 5A). The study area has been distributed into five groups: based on the analysis of remote sensing images, field surveys, and current research conditions—agriculture, vegetation, built-up area, water bodies, and vacant land (see Fig. 6). The area of study is 2528 sq. Km and the LULC measured and analyzed the gap between the five years: 2005, 2010, 2015, and 2020.

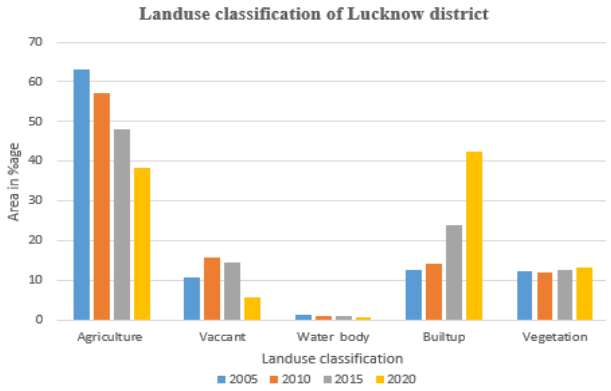

Figure 6: Assessment of LULC of Lucknow (in %)
Source: Computed by author, Sept- 2020

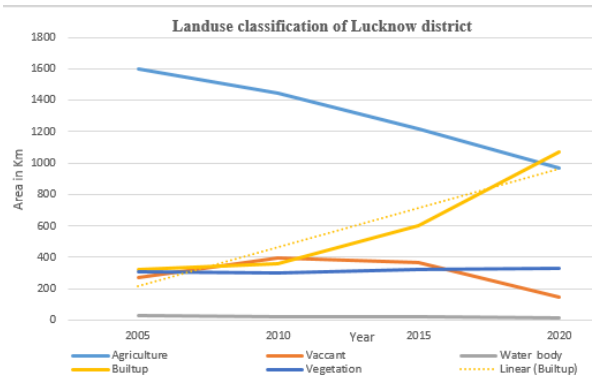

Figure 7: Assessment of LULC of Lucknow (in K.M.)
Source: Computed by author, Sep- 2020

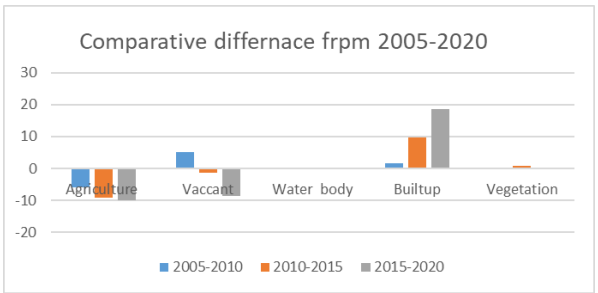

Figure 7A: Assessment of LULC of Lucknow from 2005 to 2020 (in %)
Source: Computed by author, Sept- 2020

OBSERVATIONS, RESULTS, AND FINDINGS

The above (see Fig.7) provides a statistical analysis of the LULC transition; it also shows that LULC decreases in agriculture while built-up increases rapidly between 2005 and 2020. According to topographical and satellite imagery interpretations, the built-up areas comprise housing built structures to meet their need for basic infrastructure requirements such as schools, hospitals, transportation facilities, etc.

The built-up area increased from 321.06 square kilometers in 2005 to 1071.87 sq. km in 2020, accounting for 233.58 percent of the total net area effective in 2005. Agriculture land area decreases from 1596.43 sq. km (2005) to 968.2 sq. km (2020), accounting for a loss of 39.35 percent of the total net area effective from 2005. Vegetation area increased from 310.94 sq. km in 2005 to 331.17 sq. km in 2020, accounting for 6.5 percent of the total net area effective in 2005. Waterbody area decreases from 30.34 sq. km (2005) to 12.64 sq. km (2020), accounting for a loss of 58.33 percent of the total net area effective from 2005.

This is due to rapid urbanization with unplanned growth. It has been observed that large amounts of farmland have been converted into settlements and other urban development activities in the study area. At the same time, the number of bodies of water has decreased significantly.

Because Malihabad is a notified area, the LULC map shows that urban growth is not occurring. The area was declared a notified area under State regulations, enacted in a gazette for the mango belt' on April 23, 1985 [14]. This 22.428-square-kilometer area is also depicted as a mango orchard in the Master Plan 2031. As a result, the impact of urbanization is significantly reduced in this area. At the same time, the number of bodies of water has decreased significantly. The area marked in green colour in Map is denoted as fig.no. 5A [16]]. shows green since the area has already been notified as a Mango Belt, justifies low rate of urbanization.

In contrast to Malihabad, Lucknow's Metropolitan Area's north and southeast corridors have seen rapid conversion from agricultural to non-agricultural land use, resulting in loss of agricultural land and vacant land. Vegetation coverage has remained nearly constant. Waterbodies have shrunk by 58.33% as a result of encroachment.

5. CONCLUSIONS

This paper assesses LU / LC changes in Lucknow urban agglomeration area using remote sensing data and GIS tools . Our findings show that there have been significant changes in LU / LC between 2005 and 2020. The built-up sectors have experienced a significant increase. On the other hand, agriculture and water bodies have decreased, while vacant land has increased in the first decade

and decreased over the next ten years [17]. This study demonstrates the significant impact of rapid urbanization on the city's existing natural resources. As a result, the outskirts of today's Indian cities are constantly changing[18]. Peri-urban areas in India are distinguished by mixed and uncontrolled land use, unregulated urban development, and inadequate delivery of necessary infrastructure and services [19].

In other words, the future urban areas of Indian cities are experiencing unprecedented spatial growth, which must be addressed adequately.

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