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Urban Sprawl Analysis of Hisar City by using Geospatial techniques

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ABSTRACT
Urban sprawl refers to the uncontrolled expansion of urban areas into peripheral rural lands, resulting in environmental degradation, resource mismanagement, and inefficient infrastructure. The current study employs geospatial techniques to investigate the spatial and temporal urban sprawl pattern of Hisar city, Haryana, using multi-temporal Landsat satellite images for the years 2000, 2010, and 2020. Using supervised classification, change detection analysis, and Shannon's entropy index, the study reveals a significant increase in built-up area at the cost of agricultural and vegetation lands. The analysis provides a framework for sustainable urban planning and growth regulation.

KEYWORDS: Tempral Changes, urban sprawl, Ground Truth, Georeferencing, Classification and GIS

I. INTRODUCTION

Urban sprawl has become a critical issue in urban studies, particularly in rapidly urbanizing countries like India. It leads to the loss of agricultural land, increased travel time, higher infrastructure costs, and ecological imbalances (Brueckner, 2000; Bhatta, 2010).

Geospatial technologies, including GIS and remote sensing, provide effective tools to monitor and analyze the spatio-temporal dynamics of urban growth (Herold et al., 2003; Sudhira et al., 2004; Jat et al., 2008). Several studies (Dewan & Yamaguchi, 2009; Schneider et al., 2005) have highlighted the usefulness of satellite imagery for change detection and sprawl analysis.

This paper focuses on Hisar, an emerging Tier-II city in Haryana, which has witnessed rapid transformation due to infrastructural, economic, and institutional developments.

Urbanization is generally defined as the growth of a country's urban population relative to its rural population. The growth of a nation's cities and municipalities depends on its natural, economic, and social developments. Due to the growth of economic specialization and technological advancements, urbanization and contemporary civilization are closely linked to the stage of development. In actuality, industry is the main force behind urbanization. This has accelerated the rural-to-urban migration process, the development of new urban centers, and the expansion of existing ones. In a country like India, the degree of industrialization is correlated with the level of urbanization.

When compared to developing nations, such as those in Asia, the world's rapid urbanization is particularly concerning in industrialized nations. The development of urbanization is causing the irreversible loss of surface water bodies, forests, and productive agricultural regions (Pathan, 1991). In 2001, the proportion of Indians residing in cities and urban areas nearly doubled to 27.78%, which was low in comparison to affluent nations. Together with traditional ground data, satellite data can be used to reliably assess, monitor, and map the spatial patterns of urban sprawl over various time periods. The pattern and growth rate can be determined with the aid of modern geoinformatics and remote sensing technology.

II. OBECTIVES

- To map the land use/land cover (LULC) changes in Hisar from 2000 to 2020.
- To detect and quantify urban sprawl using remote sensing and GIS tools.
- To assess urban expansion trends through Shannon's entropy index.
- To suggest planning interventions based on spatial analysis.

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III. STUDY AREA

The current study of Hisar and its surroundings was selected based on an initial analysis of the areas where urban development has occurred. The study area's selection criteria are predicated on

availability of several time periods, precise location data of metropolitan built-up areas, and, lastly, a real critical scenario that requires scientific approach. This is situated between latitudes 29°11'50" and 29°5'50" north and longitudes 75°51'10" and 75°41'10" east. On N.H. No. 10, it is located 164 kilometers to the northwest of Delhi. It is bordered by the districts of Fatehabad in the north, Jind in the east, Rohtak in the south-east, Bhiwani in the south, and Rajasthan state in the west. There are currently four tehsils and three sub-tehsils in the Hisar district. These sub-tehsils are Barwala, Uklana, and Bass, while the tehsils are Hisar, Hansi, Narnaund, and Adampur. Hisar serves as both the Divisional Commissioner's and the Police Range's divisional headquarters. Additionally, it serves as the commando force's and B.S.F. 3rd Bn. H.A.P. unit headquarters. A five-story District Administrative Complex building was finished, and offices were moved in 1980 to house all the departments under one roof. It is next to the newly constructed Judiciary Complex, which is also operationalized. Figure 1 shows the location map of the study region. In 1980, offices were moved to a five-story facility called the District Administrative Complex, which housed all the departments. It is next to the newly constructed Judiciary Complex, which is also operationalized. Study area location map shown in figure .1

IV. MATERIAL AND METHODS

- **DATA SOURCES**

Dataset	Source	Year
Landsat 7 ETM+	USGS Earth Explorer	2000
Landsat 5 TM	USGS Earth Explorer	2010
Landsat 8 OLI	USGS Earth Explorer	2020
SOI Toposheets	Survey of India	1:50,000
City Boundary	Census of India	2001, 2011

SOFTWARE USED

- ArcGIS 10.8
- QGIS 3.22
- ERDAS Imagine 2014
- Excel, R (for statistical analysis)

METHODOLOGY

1. Preprocessing:Georeferencing, radiometric and atmospheric correction of satellite images.
2.LULC Classification:Supervised classification using Maximum Likelihood Algorithm.
3.Change Detection: Cross-tabulation and post-classification comparison.
4.Urban Sprawl Analysis:

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- Shannon's Entropy Index (Yeh & Li, 2001)
- Buffer Analysis and Directional Growth Assessment
- Landscape metrics (FRAGSTATS)

V. RESULT AND DISCUSSION

- **LULC Classification and Change Detection**

Class	Area (2000)	Area (2010)	Area (2020)	Change (2000–2020)
Built-up	18.2 km²	27.5 km²	38.4 km²	+110.98%
Agriculture	60.1 km²	50.6 km²	42.3 km²	-29.6%
Vegetation	5.4 km²	4.1 km²	3.8 km²	-29.6%
Barren Land	10.3 km²	12.2 km²	11.5 km²	+11.6%
Water Bodies	1.1 km²	1.1 km²	1.2 km²	+9.1%

Built-up area shows steady increase while agricultural land shrinks consistently.

Shannon's Entropy Index
Entropy increased from **0.72 in 2000** to **0.88 in 2020**, indicating higher dispersion and sprawl, consistent with results reported by Bhatta (2010) and Jat et al. (2008).

Spatial Pattern Analysis
- Growth corridors identified along NH-9 and university areas.
- Leapfrog development and ribbon sprawl are dominant.
- Core saturation has led to radial expansion.

VI. CONCLUSION

This study confirms significant urban sprawl in Hisar city over two decades, with a marked increase in built-up land at the cost of agriculture and vegetation. Geospatial analysis reveals a highly dispersed and unplanned urban structure.

The information for the specific years 2000 and 2020 is not explicitly stated, but the growth from 1991 to 2022 indicates a significant urban sprawl. Geospatial techniques show a 41.51% increase in built-up area over 31 years. Urban sprawl is the direction in which the city changes and flows. NH 10 has seen it spread out. It has spread along other transportation routes in both north and south directions in addition to NH 10. Numerous roads and a few railroad lines connect the city to its environs. The most significant factor in the city's evolving layout has been the road system. It interacts with smaller urban areas quite a bit. Urban sprawl in the future can be predicted using this study. The urban planning authority in underdeveloped nations, where data is not consistently available, can benefit from this.

The current study found a direct link between LULC surrounding cities and UHI, biodiversity loss, and ecological deterioration. The urban thermal environment is directly impacted by factors like the decrease in plant cover and the rise in minimum and maximum temperatures.

determined. Rapid urbanization has a negative impact on biodiversity and natural habitats [74]. The land use of Hisar city has changed dramatically due to the city's enormous industrial and commercial expansion as well as its exponential population rise. Hisar City's territory was mostly agricultural, arid, and covered in vegetation before 1991. After that year, these areas were transformed into residential and commercial districts.Its solar radiance and longwave radiation (LST) were significantly impacted by its fast population growth as well as residential, commercial, and industrial expansion. Between 1991 and 2022, the temperature in the populated areas rose noticeably. The city is home to a number of well developed commercial and residential districts, including as the ancient Hisar neighborhood, the airport, the court complex, Mil Gate, Azad Nagar, the bus stop, the automobile market, and the Jindal industrial sector. Heat islands and higher LST values are currently common in this area because there aren't many water bodies or vegetation.

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Recommendations

- Smart Zoning Laws: Enforce land-use regulations based on GIS-based master plans.
- Transit-Oriented Development (TOD): Encourage compact growth near transit lines.
- Agricultural Land Protection: Establish urban growth boundaries.
- Green Infrastructure: Develop urban green belts and ecological corridors.

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