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Comparative Analysis of Land Use and Land Cover (LULC) In Shahabad and Thanesar Tehsils of Kurukshetra District, Haryana, Using Landsat 8 OLI Imagery, February 2020.

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Abstract:

This study presents a comparative analysis of land use and land cover (LULC) in Shahabad and Thanesar Tehsils of Kurukshetra District, Haryana, using Landsat 8 OLI imagery as of February 2020. Emphasizing the ecological and socio-economic dynamics, the research categorizes land into five classes: water bodies, vegetation, cropland, bare land, and built-up areas. Shahabad is predominantly agricultural with a considerable extent of bare land, while Thanesar displays a balance between agriculture and urban development. The study highlights the significance of agriculture in both regions, alongside urbanization challenges and the need for sustainable land management. It underscores the importance of strategic planning for sustainable land use, addressing urban growth, ecological balance, and agricultural productivity. The findings are pivotal for future sustainable development and environmental conservation strategies in the region.

Keywords: Land Use and Land Cover (LULC), Shahabad Tehsil, Thanesar Tehsil, Agricultural Land Management, Remote Sensing, Sustainable Planning

Introduction:

This research paper delves into the critical examination of land use and land cover (LULC) within the context of contemporary society. Recognizing the importance of comprehensive data for effective decision-making, it emphasizes how land use is pivotal in addressing challenges such as unplanned development, environmental degradation, and the depletion of natural habitats. The acquisition of accurate, real-time land use data is deemed essential for understanding environmental processes and enhancing living conditions.

Land cover, as defined by the Food and Agriculture Organization (FAO) in 2005, refers to the Earth's surface's observed physical features. When an economic dimension is integrated, it translates into land use. Mather (1986) conceptualizes land as a fundamental natural resource, suggesting it should be considered more as a resource base than a resource itself.

Land Use, in this context, is understood as the human-modified or utilized segments of land. It encompasses a variety of applications including residential, agricultural, commercial, industrial,

and recreational uses, as well as conservation efforts and infrastructural developments like roads and buildings. The concept involves strategic planning and decision-making regarding land allocation for specific human activities.

In contrast, Land Cover pertains to the physical and biological materials covering the Earth's surface. This includes both natural and artificial elements such as vegetation, water bodies, bare soil, urban areas, and snow or ice, effectively describing the surface's physical materials and features.

The classification scheme developed by the National Remote Sensing Agency (NRSA) in 1995 is employed for identifying land use and land cover classes. Out of the eight classes delineated by this scheme, five have been adopted for this study: Forest, Agricultural Land, Barren Land, Settlements, and Water Bodies.

The land use/land cover classification scheme, as updated by the National Remote Sensing Centre (NRSC) in 2012, includes a hierarchy of three levels: Level I with 8 classes, Level II with 31 classes, and Level III with 54 classes. This study focuses on Level I classification, utilizing remote sensing technology for analysis.

The mapping and study of LULC changes, often conducted through remote sensing and geographical information systems (GIS), are fundamental for environmental monitoring, urban planning, resource management, and assessing human impacts on the environment. While land use underscores human utilization of land, land cover focuses on the physical state of the surface. Understanding land use is multifaceted in its importance. It ensures optimal resource allocation, supports economic development, aids environmental conservation, enhances social well-being, reduces disaster risks, mitigates climate change impacts, and informs legal and policy frameworks. Effective land use management seeks a balance between human needs and environmental sustainability.

The classification of land use and land cover is inherently complex and subjective, often tailored to specific user needs. The U.S. Geological Survey (USGS) employs the "Land Use and Land Cover Classification System" (LULC), a hierarchical system that provides detailed categorizations of land use and cover. This system, ranging from broad categories at Level I to more specific classifications at Level IV, enables a comprehensive understanding of land dynamics.

This study, therefore, aims to explore the Level I categorization of land use and land cover using advanced remote sensing technology. In a rapidly changing world, such an understanding is crucial, and modern technologies like remote sensing and GIS play a significant role in enhancing our ability to accurately monitor and analyze these changes, providing detailed insights into the dynamics of land use and cover.

Study Area:

In this comparative study, we examine Shahabad and Thanesar Tehsils, both situated in the Kurukshetra District of Haryana, India, highlighting their geographical, demographic, and socio-economic characteristics.

Geographical Location and Area: Thanesar Tehsil, located about 150 kilometers northwest of Chandigarh, covers an extensive area of 801 km², including 762.13 km² of rural and 38.87 km²

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of urban zones. Shahabad Tehsil, positioned at approximately 29.97°N latitude and 76.15°E longitude, is relatively smaller, encompassing 181 km², with 165.43 km² rural and 16.00 km² urban areas.

Topography and Agriculture: Both tehsils are part of the fertile Gangetic alluvial plains, making them conducive to agriculture. Thanesar's flat landscape supports a range of crops including wheat, rice, sugarcane, cotton, and various fruits and vegetables. Similarly, Shahabad, sharing the same fertile alluvial soil, cultivates wheat, rice, sugarcane, and cotton, among other crops. The predominant use of land for agriculture in both regions underscores their agrarian economic base.

Climate and Vegetation: The climate in both tehsils is characteristic of North India, with hot, dry summers and cool, dry winters, complemented by a crucial monsoon season for agriculture. Thanesar boasts diverse vegetation, primarily agricultural crops and citrus fruit orchards, while Shahabad experiences similar climatic conditions, influencing its agricultural practices.

Water Resources: Thanesar benefits from the Saraswati and Yamuna rivers and a local canal system for irrigation. Shahabad, on the other hand, relies on the Western Yamuna and Bhakra Canals, and the Ghaggar-Hakra River, which are essential for its agrarian lifestyle and contribute to groundwater recharge.

Urbanization and Infrastructure: Thanesar's urban area, including the historic city of Thanesar, is noted for its significant growth and religious importance, housing numerous historical and religious sites. Shahabad, while smaller in urban size, also features essential infrastructure like roads, educational institutions, healthcare facilities, and markets.

Demographics and Literacy: As of the 2011 Census, Thanesar had a population of 5,79,172, with a higher density in urban areas (4735 persons/km²) compared to rural areas (518 persons/km²). Shahabad, with a total population of 1,30,176, shows a balanced distribution between its urban (42,607) and rural (87,569) residents. The literacy rate in Thanesar stands at 68.26%, with a gender disparity in education, whereas Shahabad has a slightly higher overall literacy rate of 70.01%, with male literacy at 75.41% and female literacy at 63.88%.

In summary, while both Shahabad and Thanesar Tehsils share similarities in their agrarian-based economies, fertile landscapes, and climatic conditions, they differ in terms of size, urbanization, demographic density, and literacy rates. These distinctions are crucial for understanding the unique challenges and opportunities in each tehsil, thereby informing targeted development and policy interventions.

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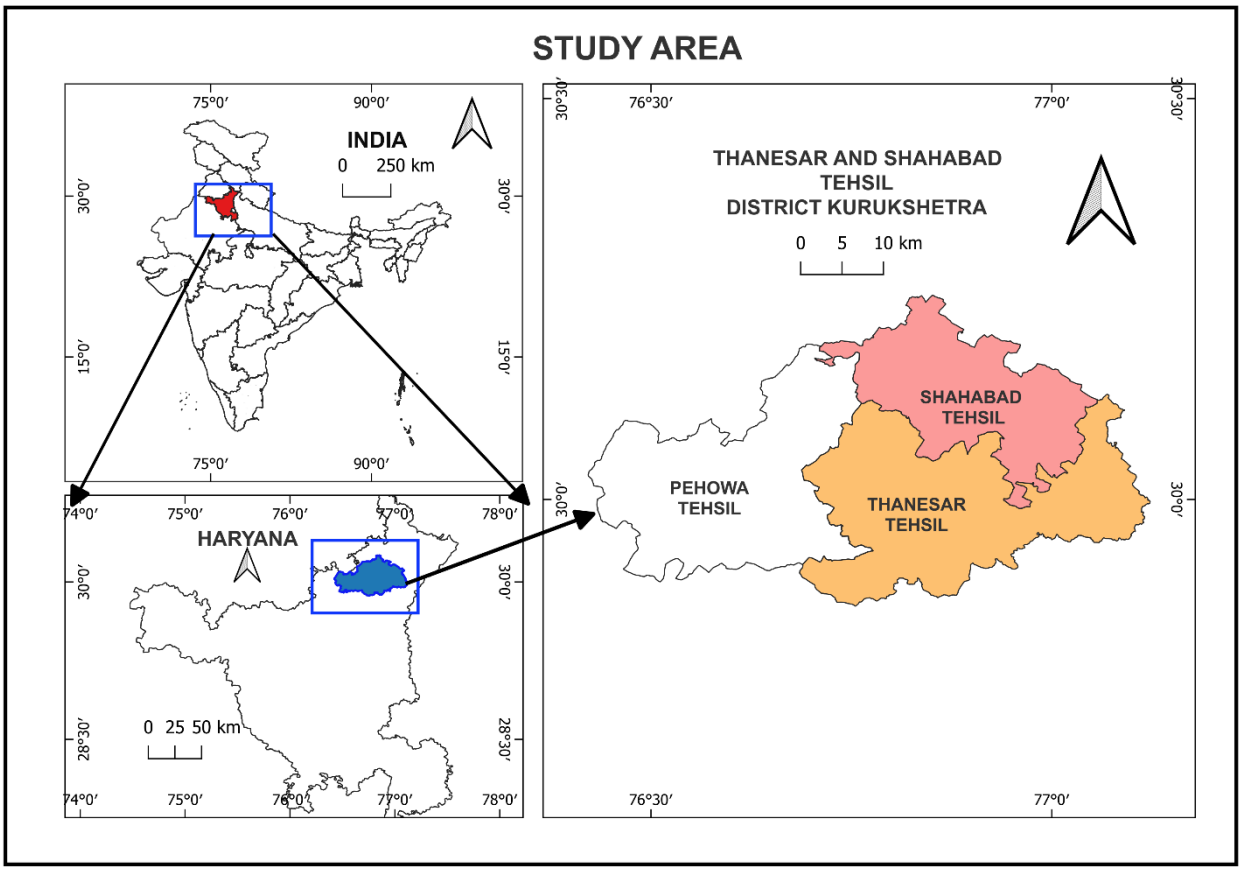

Data Used:

The study utilized data obtained from the Landsat 8 Operational Land Imager (OLI), available through the Earth Explorer portal (https://earthexplorer.usgs.gov). Landsat 8 OLI offers a range of spectral bands, each distinguished by unique wavelength ranges and spatial resolutions. The bands used in this research, with their specific characteristics, are:

- Band 2 (Blue): Has a wavelength range between 0.450 and 0.51 micrometers (µm) and a spatial resolution of 30 meters.
- Band 3 (Green): Features a wavelength range from 0.53 to 0.59 µm and a spatial resolution of 30 meters.
- Band 4 (Red): Its wavelength range spans from 0.64 to 0.67 µm, with a spatial resolution of 30 meters.
- Band 5 (Near-Infrared): This band covers a wavelength range of 0.85 to 0.88 µm and maintains a spatial resolution of 30 meters.
- Band 6 (SWIR 1): Wavelengths range from 1.57 to 1.65 µm, and it has a spatial resolution of 30 meters.
- Band 7 (SWIR 2): Encompasses wavelengths between 2.11 and 2.29 µm, with a spatial resolution of 30 meters.

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Data Selection and Curation: The study emphasized a meticulous selection process to ensure the dataset's robustness and relevance. Focus was placed on cloud-free images from February 2020, aligning with the end of the Rabi agricultural season. This timing was crucial for maximizing data relevance and accuracy, underscoring the significance of specific temporal framing and clear imagery in satellite-based environmental studies. The criteria aimed to secure the most representative and unaltered images, thereby bolstering the analysis's reliability and validity.

Methodology:

1. **Preprocessing of Satellite Imagery**: The precision and accuracy in analyzing satellite imagery hinge on comprehensive preprocessing. Given the challenges inherent in satellite data acquisition, we implemented several key preprocessing steps:

a. **Radiometric Calibration**: Satellite sensors record Earth's radiation as digital numbers (DNs). To accurately represent radiative intensity, these DNs are converted into actual radiance values using calibration coefficients from the satellite sensor's metadata.

b. **Atmospheric Correction**: As electromagnetic radiation traverses the Earth's atmosphere, it undergoes scattering and absorption, altering the spectral signatures detected by satellites. To correct these atmospheric distortions and achieve true surface reflectance values, specialized algorithms tailored to the satellite sensor type and atmospheric conditions were used.

c. **Spatial Subsetting**: Our focus area was Thanesar Tehsil in Kurukshetra District, Haryana. We conducted a spatial subsetting of the extensive satellite imagery to ensure geographical relevance and computational efficiency.

These preprocessing measures are crucial for ensuring the accuracy and applicability of the land use and land cover (LULC) classifications derived from the satellite imagery.

2. **Supervised Classification Methodology**: Key to applications ranging from urban planning to environmental conservation, this study employed a supervised classification approach for identifying and categorizing LULC from satellite imagery, leveraging existing regional knowledge.

The foundation of this approach is the Maximum Likelihood Algorithm (MLA). Using probabilistic theory, the MLA calculates the likelihood of each pixel belonging to a particular class based on its spectral values. This involves analyzing the mean and variance of each band for each class, assigning pixels to the class with the highest probability, under the assumption of normal distribution of spectral values within each class.

Using the MLA, the satellite imagery was segmented into fundamental LULC categories:

- Water Bodies: Lakes, rivers, reservoirs.
- Vegetation: Forests, grasslands.
- Cropland: Agricultural areas.
- Bare Land: Areas with little or no vegetation.
- Built-up Land: Urban and rural developments.

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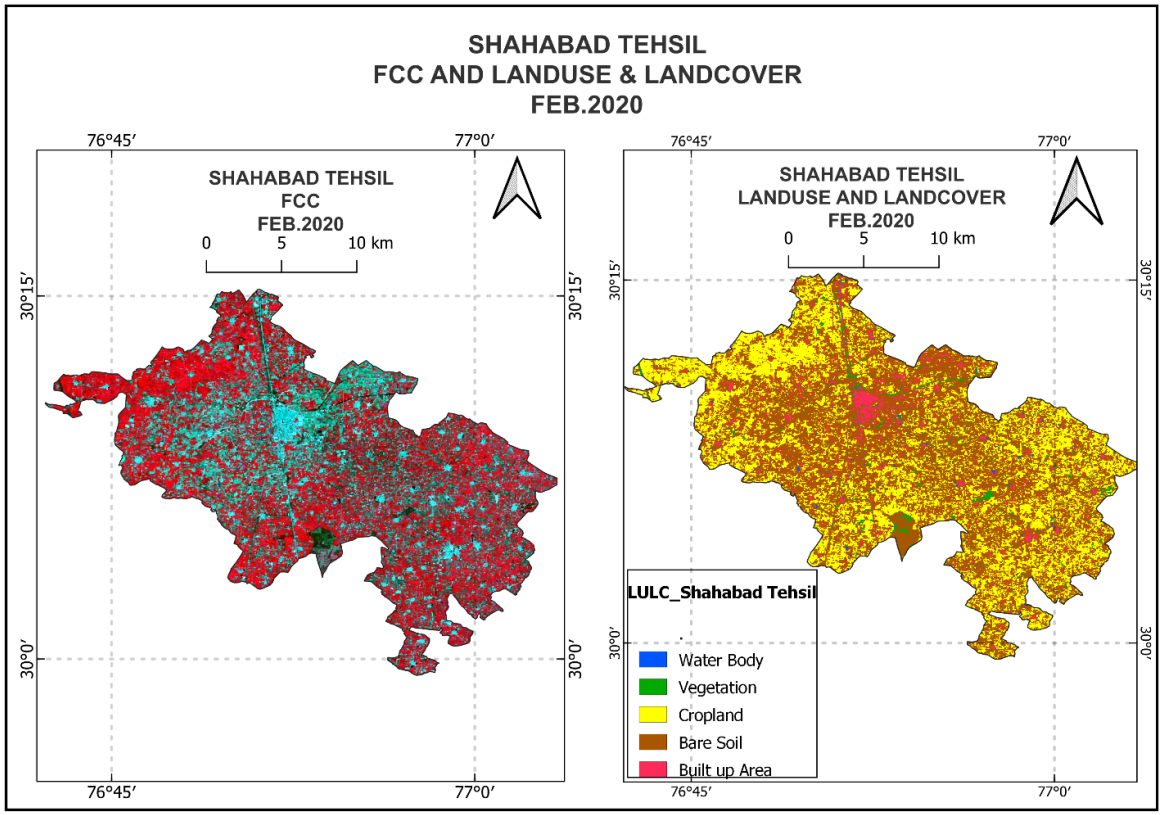
The success of supervised classification, especially using MLA, hinges on the accurate selection of training samples, which significantly improves the interpretation of spectral data into LULC categories.

Software Utilized: The LULC data analysis from Landsat 8 imagery was conducted using the Quantum GIS (QGIS) software suite. QGIS, an open-source geospatial platform, is renowned for its comprehensive features, allowing effective visualization, modification, and detailed analysis of geospatial data. The open-source nature of QGIS enhances its accessibility, eliminating licensing fee restrictions and making it valuable for various geospatial research and analysis projects

Results and Discussion:

Shahabad Tehsil and Thanesar Tehsil, integral components of Kurukshetra District in Haryana, exhibit a diverse array of land use and land cover (LULC) patterns. A detailed examination of these LULC variations provides nuanced insights into the socio-economic dynamics, environmental conditions, and developmental trajectory of the district. Utilizing Landsat 8 satellite imagery, this comprehensive study aims to delve into the agricultural focus of the district and analyze the spatial relationship between its urban and rural areas.



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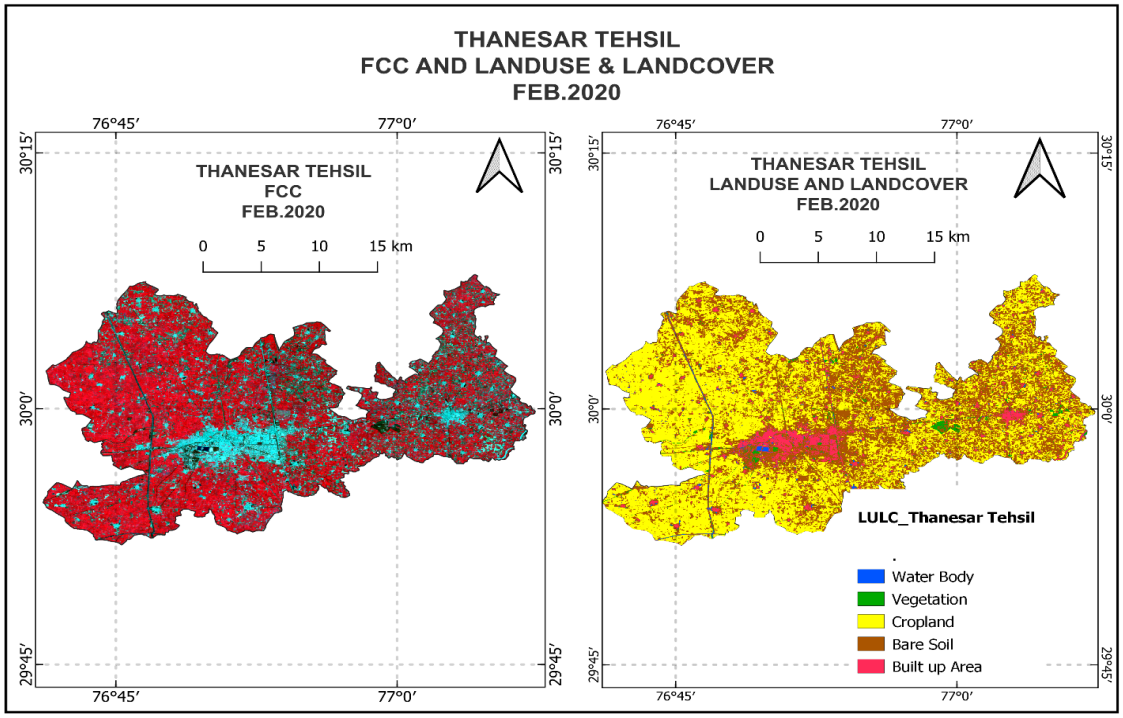

Comparative Analysis of Land Use and Land Cover of Thanesar Tehsil and Shahabad Tehsil:

Land Use and Land Cover of Shahabad Tehsil, District Kurukshetra, Haryana Feb. 2020			
Class Code	**Class Name**	**Area in sq. km**	**Percentage**
1	Water Body	1.5939	0.38
2	Vegetation	8.4897	2.04
3	Cropland	157.6863	37.97
4	Bare land	230.1651	55.42
5	Built-up Area	17.3529	4.18
	Total Area	**415.2879**	

Land Use and Land Cover of Thanesar Tehsil, District Kurukshetra, Haryana Feb. 2020			
Class Code	**Class Name**	**Area in sq. km**	**Percentage**
1	Water Body	6.0309	0.92
2	Vegetation	11.2626	1.72
3	Cropland	360.3879	55.15
4	Bare land	243.8316	37.31
5	Built-up Area	31.9707	4.89
	Total Area	**653.4837**	

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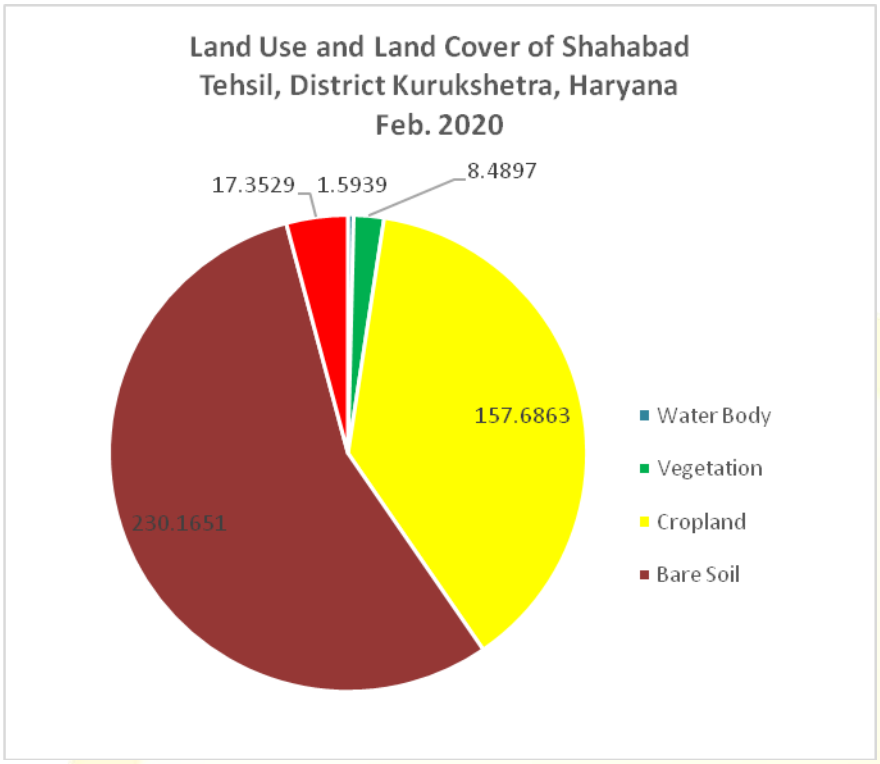

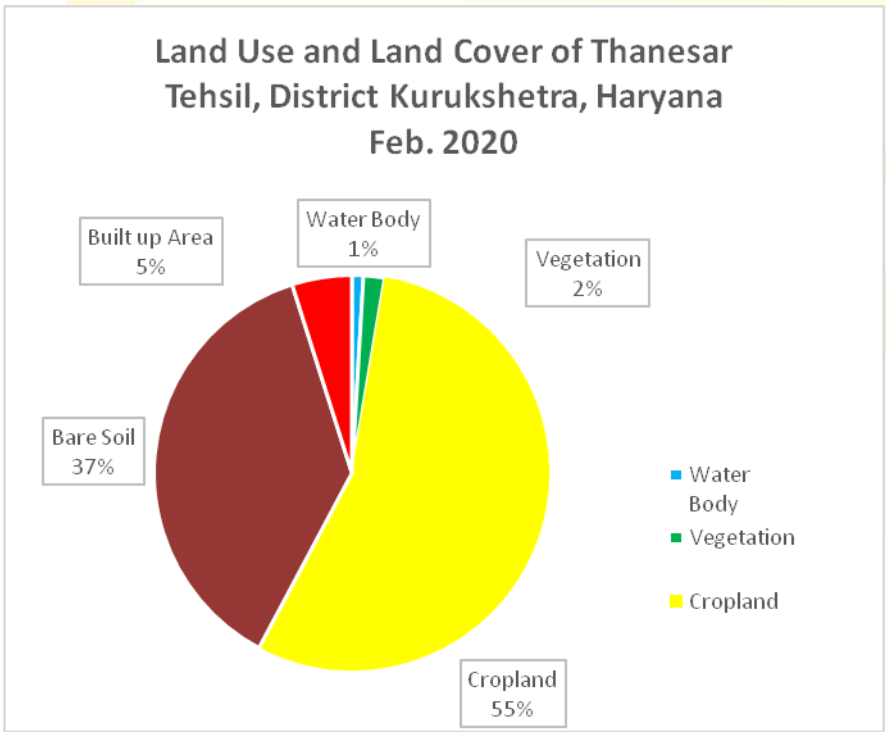

This comparative study explores the land use and land cover (LULC) patterns in Shahabad Tehsil and Thanesar Tehsil of Kurukshetra District, utilizing data of February 2020. Both regions are categorized into five main classes: water bodies, vegetation, cropland, bare land, and built-up areas, revealing distinct ecological and socio-economic characteristics.

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Cropland: In Shahabad Tehsil, croplands constitute 37.97% of the area, totaling 157.6863 sq. km, positioning it as the second most prevalent LULC feature after bare land. Conversely, Thanesar Tehsil exhibits a more substantial proportion of cropland, covering 55.15% of the area, equivalent to 360.3879 sq. km. This discrepancy highlights Thanesar Tehsil's dominance in cropland percentage compared to Shahabad Tehsil, indicative of a more extensive agrarian landscape. The observed variation in cropland distribution underscores the heterogeneity in agricultural influence across Shahabad and Thanesar tehsils. Thanesar Tehsil's higher percentage of cropland is indicative of a robust agrarian economy, potentially shaped by historical land use practices and economic factors. Furthermore, the prevalence of bare land in Shahabad Tehsil, despite significant cropland coverage, is attributed to shifts in satellite reflectance resulting from the conversion of sugarcane cultivation areas to bare land.

BareLand:

Shahabad has the largest proportion of bare land, accounting for 55.42% of its total area, which is approximately 230.1651 square kilometers. This bare land includes fallow areas and sections less suitable for agriculture. Notably, this coverage exceeds half of the total Land Use and Land Cover (LULC) in Shahabad. In Thanesar, there is also a significant amount of bare land, constituting 37.31% of the area, equivalent to 243.8316 square kilometers.

The substantial presence of bare land in Shahabad tehsil can be primarily attributed to post-harvest sugarcane fields. After the sugarcane harvest, the fields are left fallow, contributing to the overall bare land coverage. Additionally, other factors contribute to the high bare land in Shahabad, including the presence of kiln bricks, deserted areas, and unused plots. These factors collectively contribute to the landscape composition, with sugarcane farming practices and other human activities playing a significant role in shaping the land use patterns in Shahabad tehsil.

Built-upArea:

The settlement areas in Shahabad and Thanesar are distinctly characterized by their respective proportions of built-up areas, offering insights into the urban development patterns within these tehsils. In Shahabad, the built-up area constitutes 4.18% of the total, covering 17.3529 square kilometers. This area encapsulates a mix of residential, commercial, and industrial zones, illustrating a balanced urban fabric. Shahabad's settlement landscape indicates a well-distributed integration of various land uses, reflecting a harmonious blend of living, economic, and industrial activities. On the other hand, Thanesar boasts a slightly higher proportion of built-up areas, accounting for 4.89% and encompassing 31.9707 square kilometers. This disparity suggests that Thanesar has experienced a more pronounced urban development compared to Shahabad, likely due to factors such as higher population density, economic activities, and infrastructural advancements. The greater extent of built-up areas in Thanesar signifies a more concentrated and intensified urban environment, showcasing a higher degree of urbanization and development in this tehsil.

Vegetation: The vegetation in Shahabad is characterized by a modest coverage of 2.04%, encompassing various elements such as forests, tree cover, and grasslands, totaling 8.4897 square kilometers. Despite the inclusion of these green spaces, the overall percentage suggests a relatively limited presence of vegetation in the area. Thanesar, another tehsil in the region,

exhibits a slightly lower vegetation cover at 1.72%, spanning 11.2626 square kilometers. This lower percentage is indicative of a scarcity of greenery, particularly notable in the context of an agricultural setting. Notably, both Shahabad and Thanesar fall short of the recommended 10% vegetation cover suggested by the national forest commission for maintaining a healthy ecosystem in the region. The shortfall in vegetation cover raises concerns about the ecological balance and sustainability of the environment in these tehsils, emphasizing the need for conservation efforts and strategies to enhance green cover for the well-being of the local ecosystem.

Water Bodies: Water bodies in Shahabad constitute a mere 0.38% (1.5939 sq. km) of its area, relying mainly on rivers and canals. Thanesar has a higher proportion of water bodies at 0.92% (6.0309 sq. km), including lakes, reservoirs, and canals, crucial for local livelihood and sustainability.

Overall, the total area studied is 415.2879 sq. km for Shahabad and 653.4837 sq. km for Thanesar. The LULC data highlights Shahabad's landscape predominantly dedicated to agriculture with potential for expansion, while Thanesar shows a balance between agricultural dominance and urban development. Both regions reflect the intricacies of balancing human development with environmental conservation, crucial for future planning and resource management.

Conclusion:

In conclusion, the comparative analysis of land use and land cover (LULC) patterns in Shahabad and Thanesar Tehsils of Kurukshetra District provides insightful revelations about the region's ecological and socio-economic dynamics. The study, grounded in data as of February 2020, categorizes the land into five distinct classes: water bodies, vegetation, cropland, bare land, and built-up areas, each offering a unique perspective on regional land utilization and management.

Shahabad Tehsil, with its significant agricultural emphasis, exhibits a landscape predominantly covered by cropland, constituting 37.97% of its area. This agricultural dominance is slightly overshadowed by a larger extent of bare land, accounting for 55.42%, which includes fallow lands and post-harvest fields. The presence of 4.18% built-up area reflects moderate urbanization, whereas the limited coverage of water bodies (0.38%) and vegetation (2.04%) highlights the need for enhanced water resource management and ecological conservation.

In contrast, Thanesar Tehsil presents a more balanced interplay of land uses. The predominance of cropland at 55.15% underscores its strong agrarian base. The substantial 37.31% bare land area, similar to Shahabad, includes harvested fields and uncultivated lands. However, Thanesar exhibits a higher degree of urbanization, evidenced by a 4.89% built-up area, indicative of more advanced infrastructural development. The region's ecological aspect, represented by 1.72% vegetation and 0.92% water bodies, though modest, plays a crucial role in maintaining local ecosystem health and supporting sustainable livelihoods.

The overarching theme emerging from this comparative analysis is the prominent role of agriculture in both regions, coupled with the challenges and opportunities in urban development, land management, and ecological conservation. Shahabad, with its extensive agricultural and bare land areas, shows potential for agricultural expansion and land management strategies.

Thanesar, balancing agricultural dominance with significant urbanization, highlights the challenges of sustainable development and resource management in a rapidly changing landscape.

This study underscores the importance of strategic planning and management to ensure sustainable land use, addressing the needs of growing urbanization while preserving ecological balance and agricultural productivity. The findings contribute significantly to the understanding of land use dynamics in the Kurukshetra District, offering a foundation for future research and policy-making aimed at fostering sustainable development and environmental stewardship in the region.

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