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Remote Sensing-Based Comparative Study of Land Use and Land Cover in Pheowa and Thanesar Tehsils of District Kurukshetra, February 2020.

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Abstract: This study presents a comparative analysis of land use and land cover (LULC) in Pheowa and Thanesar Tehsils of the Kurukshetra District, Haryana, using data from the Landsat 8 Operational Land Imager (OLI). The research identifies significant differences in land utilization and environmental attributes between the two regions. Pheowa Tehsil exhibits a substantial agricultural focus, with a higher percentage of cropland compared to Thanesar, which shows more diverse land use with greater urban development and larger bare land areas. The analysis employs advanced remote sensing techniques and the Maximum Likelihood Algorithm for LULC classification. This comprehensive study underscores the importance of region-specific planning and policy-making to balance economic development with environmental sustainability. It provides critical insights for regional planning, aiding policymakers, urban planners, and environmentalists in the Kurukshetra District.

Keywords: Land Use and Land Cover, Remote Sensing, Agricultural Land, Urban Development, Environmental Sustainability

Introduction:

In the present day, acquiring comprehensive information about various complex and interconnected aspects of its functioning is crucial for effective decision-making. A critical element in this context is land use, which plays a pivotal role in addressing challenges related to uncontrolled and unplanned development, environmental degradation, the loss of prime agricultural lands, the destruction of wetlands, and the depletion of habitats for fish and wildlife. Accurate and real-time data on land use is paramount for the analysis and understanding of environmental processes and issues, which is essential for enhancing or maintaining living conditions and standards.

Land Cover is described as the observed physical features on the Earth's surface. When an economic function is incorporated, it is called Land Use (FAO, 2005). Mather (1986) stated, "Land is the basic natural resource; it is perhaps regarded more as a resource base than a resource itself." The term Land Use pertains to the segments of land that have been modified or utilized by humans, encompassing a variety of uses such as residential, agricultural, commercial, industrial, recreational, conservation, and infrastructural purposes

(e.g., roads and buildings). It involves strategic planning and decision-making related to allocating and arranging land for specific human activities.

In contrast, Land Cover relates to the physical and biological cover over the Earth's surface, including natural and man-made elements like vegetation, water bodies, bare soil, urban areas, and snow or ice. It essentially characterizes the surface's physical materials and features.

The classification scheme developed by NRSA in 1995 is utilized to identify land use and land cover classes. Based on this scheme, 8 land use and land cover classes are delineated. However, for the current study, five LULC classes have been adopted: Forest, Agricultural Land, Barren Land, Settlements, and Water Bodies (source: NRSC, LULC classification, 1995). The land use/land cover classification scheme at a 1:50,000 scale comprises Level I with 8 classes, Level II with 31, and Level III with 54 classes (NRSC, 2012).

The study and mapping of land use and land cover changes, often conducted through remote sensing and geographical information systems (GIS), are critical for environmental monitoring, urban planning, resource management, and assessing human environmental impact. While land use emphasizes human utilization of land, land cover focuses on the physical state of the surface.

The significance of studying land use is multi-faceted. It ensures optimal resource allocation, promotes economic development, supports environmental conservation, enhances social well-being, reduces disaster risks, mitigates climate change, and informs legal and policy frameworks. Effective land use management seeks a balance between human needs and environmental sustainability.

The land use and cover classification is inherently complex and subjective, often customized to meet specific user requirements. 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 includes broad categories at Level I (e.g., urban, agricultural, forest). It becomes increasingly detailed through Levels II to IV, with Level IV offering very specific classifications, such as crop-specific categories within agriculture.

This study is centred on exploring a comparative analysis of land use and land cover in the Thanesar and Pheowa tehsils of the Kurukshetra district in Haryana, utilizing hierarchical Level I classifications via remote sensing technology. Understanding these aspects is imperative in a world experiencing rapid changes. Modern technologies, particularly remote sensing, and GIS, have substantially improved our capability to accurately monitor and analyze these changes, providing in-depth insights into land use and cover dynamics.

Study Area:

The present study focuses on a comparative analysis of land use and land cover in the Pehowa and Thanesar Tehsils of the Kurukshetra district in Haryana, employing remote sensing techniques to elucidate the geographical and environmental characteristics of these regions.

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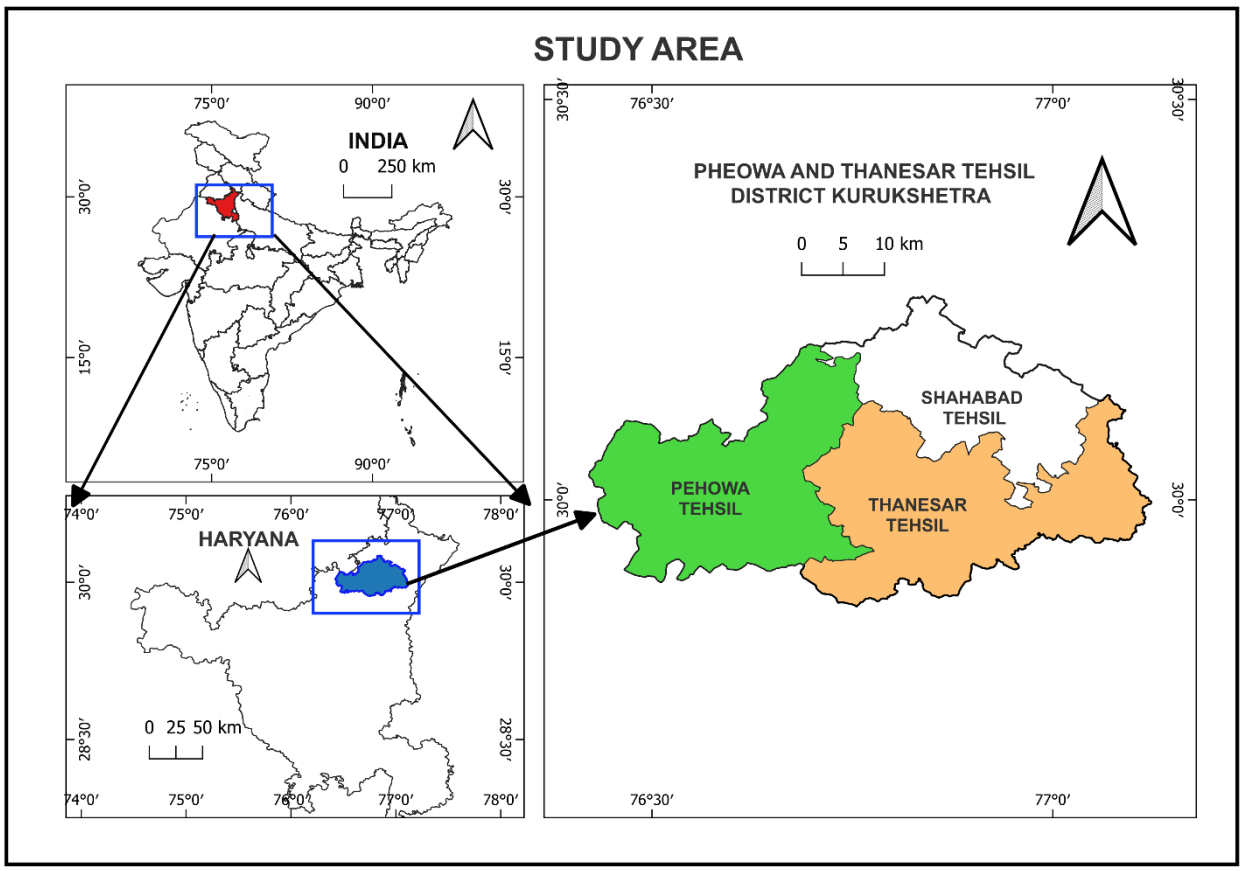

Pehowa Tehsil Located in the northern part of Haryana, Pehowa Tehsil is a crucial administrative and agricultural hub within the Kurukshetra district. Approximately 30 kilometers from Kurukshetra and about 160 kilometers from Chandigarh, the state capital, it encompasses both urban and rural areas, with a total area of 548 km² (528.08 km² rural and 19.50 km² urban).

Topographically, Pehowa is characterized by fertile plains as part of the Indo-Gangetic plain, renowned for its rich alluvial soil conducive to agriculture. The region is well-irrigated, primarily due to the Ghaggar-Hakra and Markanda rivers, which are integral for agricultural activities. The climate is typical of North India, with hot, dry summers, cold winters, and a monsoon season bringing necessary rainfall.

Agriculture is the predominant occupation, with wheat, rice, sugarcane, cotton, and various fruits and vegetables being the main crops. The area's vegetation is primarily agricultural, with limited natural cover due to extensive cultivation. Wildlife is not abundant, but the region supports diverse bird species, particularly migratory birds in winter.

Pehowa Tehsil has a mix of numerous villages and small towns, with Pehowa town being a significant commercial and administrative center. The economy revolves around agriculture and related businesses, with a burgeoning presence of small-scale industries and trade. The region has a population density of 466 inhabitants per square kilometer and a literacy rate of 62.82%.

Thanesar Tehsil Thanesar Tehsil, also situated in the Kurukshetra district, is approximately 150 kilometers northwest of Chandigarh. Encompassing the historical city of Thanesar, it covers an area of 801 km² (762.13 km² rural and 38.87 km² urban).

The tehsil's topography is marked by the Gangetic alluvial plains, providing fertile ground for agriculture, which is a vital part of the local economy. The presence of the Saraswati and Yamuna rivers, along with a network of canals, supports extensive irrigation. The climate mirrors that of Pehowa, with hot summers, cool winters, and a significant monsoon season.

Agriculturally, the region is known for crops like wheat, rice, sugarcane, and cotton, alongside fruit orchards. Urbanization in Thanesar is more pronounced compared to Pehowa, with the city undergoing significant expansion in infrastructure and residential areas. The historical and cultural importance of Thanesar, particularly its connection to the Mahabharata, adds to its significance.

With a population density of 723 persons per square kilometer and a literacy rate of 68.26%, Thanesar Tehsil plays a vital role in the region's development and administration.

Data Used:

In this research, data acquisition for the study area was conducted using the Landsat 8 Operational Land Imager (OLI), a vital instrument accessible through the Earth Explorer portal (https://earthexplorer.usgs.gov). The Landsat 8 OLI offers a spectrum of spectral bands, each distinguished by unique wavelengths and spatial resolutions. The specific bands employed in this analysis, along with their attributes, are as follows:

Band 2 (Blue): Exhibits a wavelength range of 0.450 - 0.51 µm and a spatial resolution of 30 meters.

Band 3 (Green): Has a wavelength range of 0.53 - 0.59 µm and a spatial resolution of 30 meters.

Band 4 (Red): Features a wavelength range of 0.64 - 0.67 µm and a spatial resolution of 30 meters.

Band 5 (Near-Infrared): Encompasses a wavelength range of 0.85 - 0.88 µm and a spatial resolution of 30 meters.

Band 6 (SWIR 1): Possesses a wavelength range of 1.57 - 1.65 µm and a spatial resolution of 30 meters.

Band 7 (SWIR 2): Contains a wavelength range of 2.11 - 2.29 µm and a spatial resolution of 30 meters.

Regarding Data Selection and Curation: A meticulous selection process ensured the dataset's robustness and relevance. The dataset was confined to cloud-free images, specifically captured in February 2020, aligning with the culmination of the Rabi agricultural season. This strategic timing was chosen to enhance the data's relevance and precision, underscoring the criticality of temporal specificity and clarity in satellite-based environmental studies. The criteria for selection focused on securing the most representative and unobscured images that align with the study's objectives, thereby bolstering the reliability and validity of the ensuing analytical processes.

Methodology:

This research's methodology encompasses several critical stages, essential for the accurate analysis of satellite imagery data. These stages are detailed below:

Preprocessing of Satellite Imagery: The reliability and precision of satellite imagery analysis significantly hinge on meticulous preprocessing. The preprocessing steps undertaken in this study are as follows:

a. Radiometric Calibration: The satellite sensors detect radiation from Earth as digital numbers (DNs). These DNs are converted into actual radiance values using calibration

coefficients from the satellite sensor's metadata, thereby ensuring a more accurate representation of the radiative intensity.

b. Atmospheric Correction: As electromagnetic radiation travels through the Earth's atmosphere, it is subject to scattering and absorption. These interactions can alter the spectral signatures captured by satellites. To mitigate these atmospheric effects and attain true surface reflectance values, specialized algorithms tailored to the satellite sensor type and atmospheric conditions were applied.

c. Spatial Subsetting: The study concentrated on Pheowa and Thanesar Tehsil within Kurukshetra District, Haryana. To ensure geographical relevance and computational efficiency, spatial subsetting of the satellite imagery was conducted to focus exclusively on this area.

These preprocessing measures are vital as they lay the groundwork for the accuracy and relevance of the land use and land cover (LULC) classifications derived from the satellite imagery.

Supervised Classification Methodology: Fundamental to this research is the identification and categorization of LULC using satellite imagery, a key aspect in fields like urban planning and environmental conservation. The methodology employed is supervised classification, leveraging existing knowledge about the study area.

The primary technique used is the Maximum Likelihood Algorithm (MLA). This algorithm, based on probabilistic theory, calculates the likelihood of a pixel belonging to a specific class by analyzing its spectral values. The process involves examining the mean and variance of each band for every class, with pixels being assigned to the class that they most likely belong to, under the assumption that pixel spectral values in each class follow a normal distribution across the bands.

The MLA facilitated the segmentation of satellite imagery into basic LULC categories, including water bodies, vegetation, cropland, bare land, and built-up land. The success of this supervised classification, especially the MLA, is intrinsically linked to the judicious selection of training samples, crucial for the accurate interpretation of the spectral data into meaningful LULC categories.

Software Used: The analysis and interpretation of LULC data, derived from Landsat 8 satellite imagery, were conducted using the QGIS software suite. QGIS, an open-source geospatial platform, is renowned for its comprehensive capabilities in data visualization, modification, and in-depth geospatial analyses. The open-source nature of QGIS, free from licensing restrictions, makes it a valuable tool for broad application in diverse geospatial research and analysis projects.

Results and Discussion:

The study areas of Pehowa and Thanesar Tehsils, located within the Kurukshetra District of Haryana, exhibit a diverse array of land use and land cover (LULC) types. An exhaustive investigation into these patterns reveals nuanced insights into the socio-economic dynamics, environmental conditions, and developmental trajectory of the region. Utilizing Landsat 8 satellite imagery, this detailed analysis aims to elucidate the agricultural focus of the district and the spatial dynamics between its urban and rural areas.

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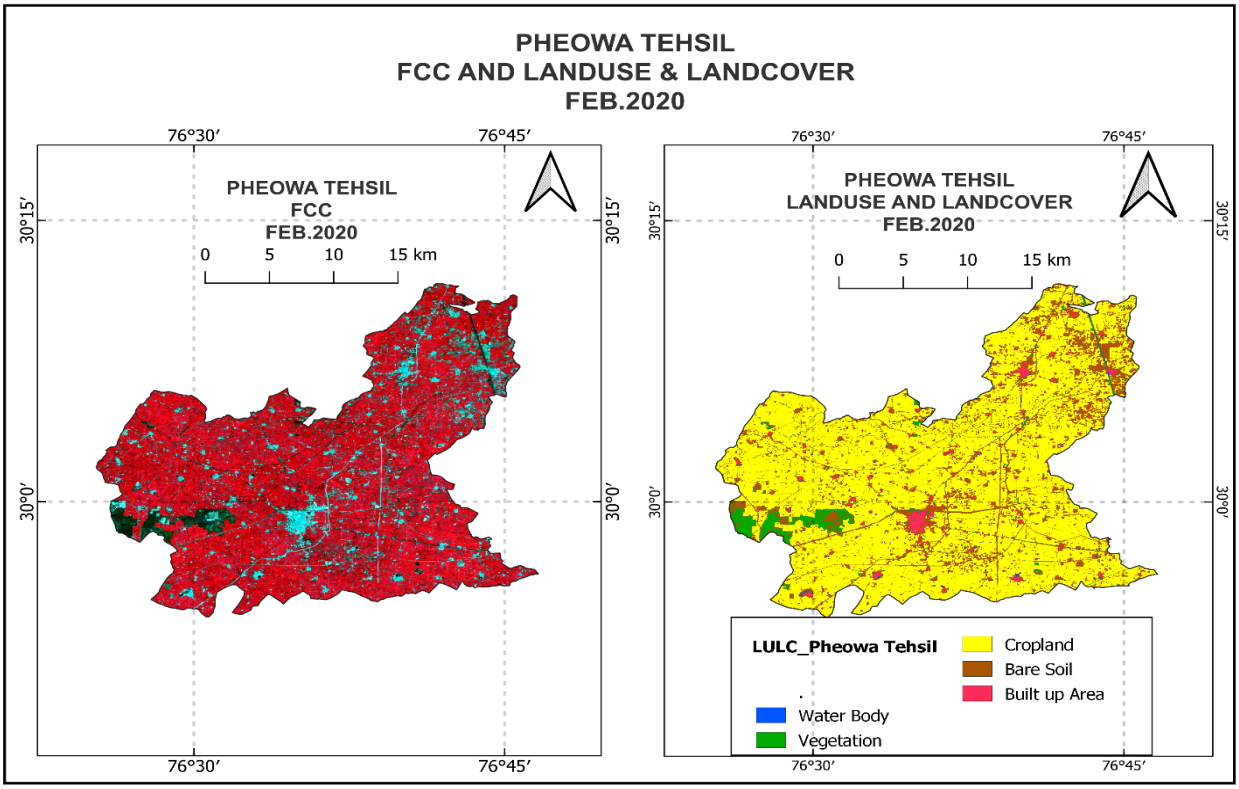

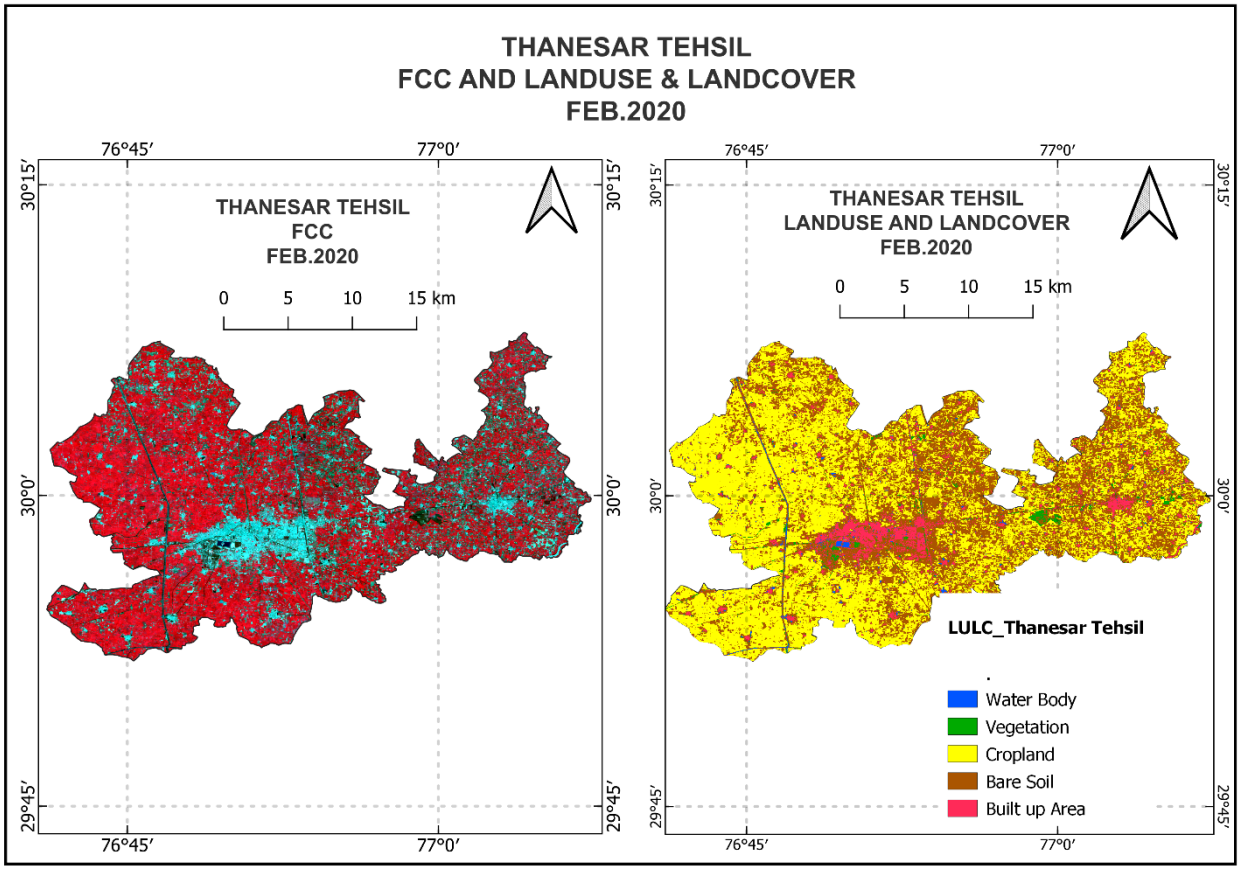

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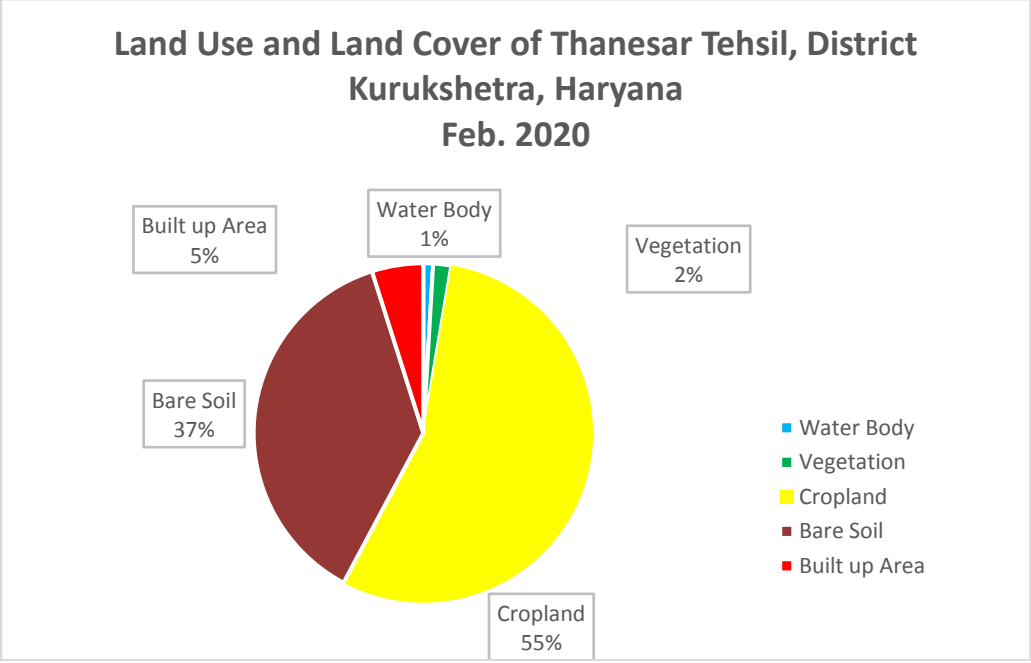
Land Use and Land Cover Analysis of Pheowa and Thanesar Tehsil:

Land Use and Land Cover of Pheowa Tehsil, District Kurukshetra, Haryana Feb. 2020			
Class Code	**Class Name**	**Area in sq. km**	**Percentage**
1	Water Body	4.0797	0.67
2	Vegetation	17.4942	2.88
3	Cropland	469.0368	77.23
4	Bare land	104.9886	17.29
5	Built-up Area	11.7522	1.93
	Total Area	**607.3515**	

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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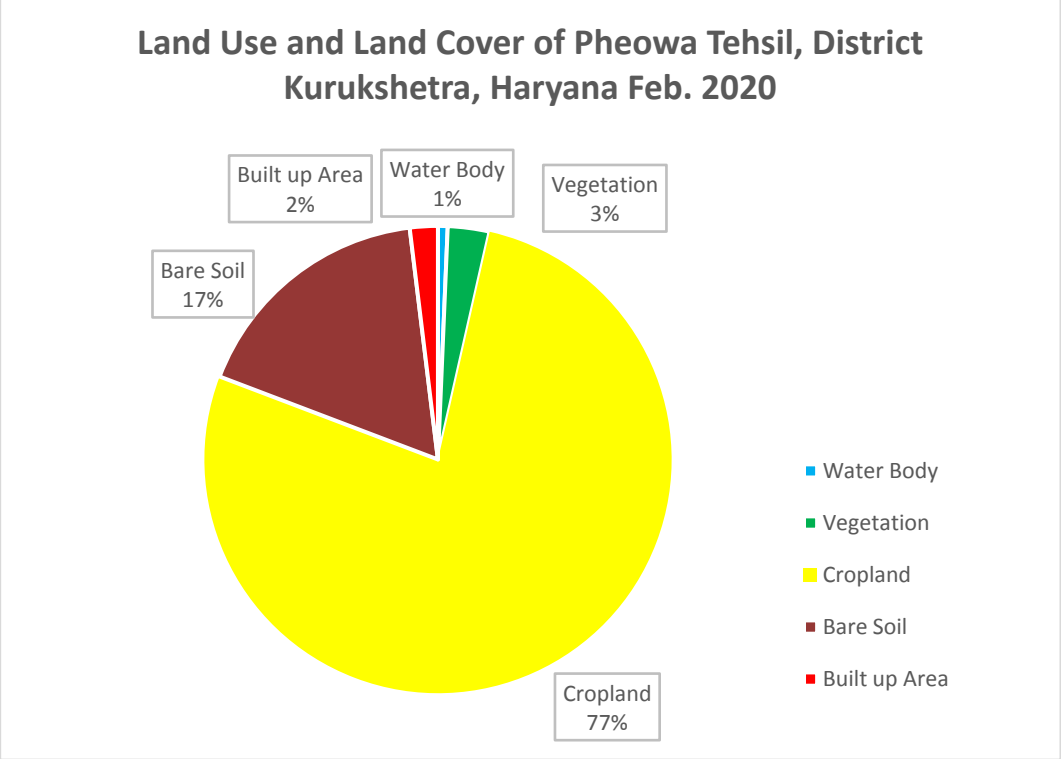

In a comparative analysis of land use and land cover (LULC) between Pheowa and Thanesar Tehsils of Kurukshetra District, Haryana, distinct differences emerge in land utilization and environmental characteristics.

Cropland: The significant variation in cropland proportions between Pheowa Tehsil and Thanesar Tehsil indicates a notable contrast in their agricultural emphasis. Pheowa stands out with a substantial 77.23% of its total area dedicated to croplands, suggesting a robust focus on agriculture in this region. In contrast, Thanesar Tehsil, while still maintaining a considerable agricultural area, allocates a relatively lower proportion of 55.15% to cropland. However, it is essential to recognize that this difference in cropland distribution is not solely indicative of a disparity in agricultural intensity. Rather, it is primarily influenced by the distinct types of crops cultivated in each tehsil.

The diverse crops grown in Pheowa and Thanesar Tehsils contribute to variations in the reflectance of energy from the land. As different crops reach maturity and ripen in different seasons and months, their unique growth cycles result in varied reflectance patterns. This discrepancy in reflectance is manifested in the diverse colors exhibited by the crops, contributing to distinct Land Use and Land Cover (LULC) characteristics. The interplay of seasonal agricultural practices, coupled with the changing tones associated with different crop types, ultimately leads to the portrayal of varying LULC categories in satellite imagery. Therefore, the disparity in cropland proportions is not merely a reflection of agricultural intensity but is intricately linked to the temporal dynamics of crop growth and ripening, which in turn influence the visual representation of the landscape in different colors and LULC categories.

Bare land: When analyzing the expanse of bare land, Thanesar emerges with a significantly larger portion, encompassing 37.31% of its total area, in stark contrast to

Pheowa's 17.29%. The primary contributor to this substantial proportion of bare land in the Thanesar tehsil can be attributed to the annual harvest and cutting of sugarcane crops during the month of February. Consequently, the fields that have undergone sugarcane harvesting display similarities with bare land, contributing to this statistical disparity. Another factor influencing the elevated bare land percentage in Thanesar may be a higher degree of urbanization compared to Pehowa tehsil within the district. While other factors such as kiln bricks and various forms of wasteland may also play a role, their impact is likely limited in comparison. This observed difference suggests potential variations in land management strategies, soil fertility, or specific land use policies between the two tehsils, underscoring the complex interplay of agricultural practices, urban development, and land utilization in the region.

Built-up Area: In terms of built-up area and settlement especially urbanization, Thanesar Tehsil exhibits a notably higher built-up area, constituting 4.89% of its total land, in contrast to Pheowa's 1.93%. This disparity implies a more advanced level of infrastructure development and potentially greater commercial activities in and around Thanesar. Notably, Thanesar Tehsil encompasses two closely situated urban areas that contribute significantly to its higher built-up percentage. Firstly, the town of Thanesar itself stands out as a congested and densely populated urban center. Secondly, the well-planned Kurukshetra city adds to the urban landscape of the tehsil. The presence of these two urban centers, along with urban sprawl around these twin cities, plays a pivotal role in elevating the built-up areas within Thanesar Tehsil as compared to Pheowa Tehsil. This suggests a nuanced urbanization pattern, highlighting the coexistence of both densely populated traditional urban settings and strategically planned urban expanses, contributing to the overall built-up landscape in Thanesar Tehsil.

Water Bodies: In the context of water bodies, both Thanesar and Pheowa Tehsils present relatively modest proportions, each accounting for less than one percent of their respective total areas. However, Thanesar slightly edges ahead with a marginally more significant percentage of water bodies. This discrepancy may be attributed to the presence of cultural and tourist sites in Thanesar that are absent or less prominent in Pheowa Tehsil. In Thanesar Tehsil, notable pilgrimage sites such as Jyotisar and Brahm Sarovar contribute to the higher percentage of water bodies. These sacred locations not only hold cultural and religious significance but also attract tourists, potentially influencing the local agricultural practices and microclimatic conditions in Thanesar differently than in Pheowa. The presence of such water bodies can have multifaceted effects on the surrounding environment, impacting soil moisture, local temperatures, and potentially fostering unique agricultural practices in the Thanesar region compared to Pheowa.

Vegetation cover: The vegetation cover in Pehowa and Thanesar Tehsils stands at 2.88 percent and 1.74 percent, respectively, with Pehowa exhibiting a slightly higher proportion of vegetation compared to its Thanesar counterpart. This variance can be primarily attributed to the lower extent of urban areas in Pehowa Tehsil as opposed to Thanesar Tehsil. Urbanization tends to replace natural vegetation with built-up structures, leading to a reduction in overall green cover. However, despite the slight advantage in vegetation cover in Pehowa, both tehsils fall considerably below the recommended threshold of 10 percent, which is often considered essential for sustaining a local ecosystem and effective management of natural resources.

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The deficiency in vegetation cover raises concerns about the ecological balance and environmental sustainability in both regions. Inadequate vegetation cover can result in soil erosion, reduced biodiversity, and hindered water retention capacity. The disparity in vegetation cover between the two tehsils underscores the impact of urbanization on the landscape and emphasizes the need for strategic land-use planning to strike a balance between urban development and environmental preservation. Efforts to enhance green cover through afforestation initiatives and sustainable land management practices could contribute to fostering a healthier local ecosystem in both Pehowa and Thanesar Tehsils.

Overall, the comparison between Pheowa and Thanesar Tehsils reveals significant variances in land-use patterns. Pheowa's landscape is predominantly agricultural, while Thanesar, despite a solid agricultural base, shows greater urban development and more extensive bare land areas. These insights are critical for the Kurukshetra District's regional planning and sustainable development strategies.

Conclusion:

In conclusion, the contrasting proportions of cropland, bare land, built-up areas, water bodies, and vegetation cover between Pheowa Tehsil and Thanesar Tehsil in the district of Kurukshetra unveil a complex interplay of agricultural practices, urbanization, and natural resource management. Pheowa Tehsil distinguishes itself with a substantial focus on agriculture, dedicating 77.23% of its total area to croplands. However, this stark difference in cropland distribution is not solely indicative of agricultural intensity but is intricately linked to the temporal dynamics of crop growth and ripening, influencing the visual representation of the landscape in satellite imagery.

Thanesar Tehsil, on the other hand, stands out with a significantly larger portion of bare land, comprising 37.31% of its total area. This disparity is largely attributed to the annual harvest and cutting of sugarcane crops, as well as potential urbanization factors, suggesting variations in land management strategies and soil fertility between the two tehsils.

Urbanization is notably more advanced in Thanesar Tehsil, constituting 4.89% of its total land compared to Pheowa's 1.93%. This disparity implies a higher level of infrastructure development and commercial activities, with the presence of densely populated traditional urban settings and well-planned urban expanses contributing to the overall built-up landscape.

In terms of water bodies, both tehsils present modest proportions, with Thanesar slightly edging ahead due to the presence of cultural and tourist sites. These sites, such as Jyotisar and Brahm Sarovar, not only hold religious significance but also impact local agricultural practices and microclimatic conditions, potentially fostering unique conditions in Thanesar compared to Pheowa.

The vegetation cover in Pheowa and Thanesar Tehsils remains below the recommended threshold of 10%, with Pheowa exhibiting a slightly higher proportion. This variance is primarily attributed to the lower extent of urban areas in Pheowa, emphasizing the impact of urbanization on natural green cover.

In essence, the disparities in land use and land cover between Pheowa and Thanesar Tehsils underscore the intricate balance between agricultural practices, urban development, and environmental factors in shaping the landscape of the Kurukshetra district.

Bibliography and References:

1. Kurukshetra District Census Handbook, 2011
2. Kurukshetra District Statistical Abstract, 2013
3. State Statistical Abstract of Haryana 2019-20
4. Economic Survey, Haryana, 2019-20
5. Chauhan A, Kumar Pawan, Dimple & Deswal S. K, (20210 Comparative Analysis of LanD Use and Land Cover (LULC) in Shahbad and Thanesar Tehsils of Kurukshetra district, Haryana, Usin Landsat 8 OLI Imagery, February, 2020. *International Journal of Research in Social Sciences, Vol 11 Issue 10, October 2021, pp 238-348.*
6. Dimple & Singh, R. (2013). Land Use and Land Cover Change along Shivaliks between River Ghaggar and Yamuna. *Advances in Geographical and Environmental Sciences, Climate Change and Biodiversity, Proceedings of IGU, Rohtak Conference, Vol-I, pp 139-155.*
7. Mathur, A. S. (1986). Land Uses. *Longman Group (FE) Limited, Hong Kong.*
8. Peterson, J. H. (2006). Land Work and Resources: An Introduction to Economic Geography. *Edward Arnold, London.*
9. NRSC. (2014). Land Use/Land Cover Database on 1:50,000 scale. *Natural Resources Census Project, LUCMD, LRUMG, RSAA, National Remote Sensing Centre, ISRO, Hyderabad.*
10. NRSC. (2012). The land use/land cover classification scheme of 1:50,000 scale consists of Level-I: 8 classes, Level-II: 31 classes and Level-III: 54 classes.
11. NRSC. (1995). LULC Classes - Land Use and Land Cover Classes: 1. Forest 2. Agricultural Land 3. Barren Land 4. Settlements 5. Water Bodies. *Source: NRSC, LULC Classification.*
12. NRSC. (2019). Land Use/Land Cover Database for Dissemination through Bhuvan, June 2019.
13. Central Ground Water Board, Ministry of Water Resources, Government of India. (2013). North Western Region, Chandigarh.
14. Sudhakar, S., & Rao, S. V. C. K. (n.d.). Land Use and Land Cover Analysis. *Remote Sensing Applications. National Remote Sensing Centre.*
15. Personal observations, ground verification, peer group discussion of the study area, etc.