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Comparative Land use and Landcover Analysis: Remote Sensing Insights from Shahabad and Pheowa Tehsils of District Kurukshetra, Haryana, February 2020.

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Abstract: This study conducts a comparative analysis of land use and land cover (LULC) in Shahabad and Pehowa Tehsils of Kurukshetra District, Haryana, using February 2020 data from the Landsat 8 Operational Land Imager (OLI). The analysis reveals significant contrasts in the land utilization and environmental characteristics of these two tehsils. Shahabad is predominantly characterized by bare land, indicating different land management strategies or agricultural expansion opportunities. In contrast, Pehowa exhibits a strong agricultural focus, with a higher percentage of its land dedicated to cropland. The study also notes variations in built-up areas, water bodies, and vegetation between the two tehsils, influencing local agricultural practices, biodiversity, and microclimatic conditions. These insights are crucial for region-specific planning and sustainable development in the Kurukshetra District, addressing the unique needs of Shahabad and Pehowa.

Keywords: Land Use and Land Cover, Comparative Analysis, Landsat 8 OLI, Agricultural Land, Environmental Sustainability

Introduction:

In the current era, acquiring detailed and interconnected information regarding various facets of societal functioning is essential for effective decision-making. A crucial aspect in this regard is land use, which significantly contributes to addressing numerous challenges such as unchecked and unplanned development, environmental degradation, the loss of essential agricultural lands, the destruction of wetlands, and the depletion of habitats crucial for fish and wildlife. The necessity for precise and contemporaneous land use data cannot be overstated, as it is critical for the analysis and comprehension of environmental processes and challenges, thereby playing a vital role in improving or sustaining the standards and conditions of living.

"Land Cover" is the observable physical attributes on the Earth's surface. This concept transitions to "Land Use" when an economic function is integrated into it, as stated by the Food and Agriculture Organization (FAO, 2005).

Mather (1986) posited, "Land is the fundamental natural resource; it is perhaps more accurately described as a resource base than a resource in itself." The term "Land Use" refers to those portions of land that have been altered or employed by human activities, covering a diverse range of uses, including residential, agricultural, commercial, industrial, recreational, conservation, and infrastructure-related activities (for instance, roads and buildings). This concept involves strategic planning and decision-making regarding the distribution and organization of land for specific human purposes.

In contrast, "Land Cover" pertains to the physical and biological coverage on the Earth's surface, encompassing both natural and anthropogenic elements such as vegetation, bodies of water, bare soil, urban areas, and formations of snow or ice. Essentially, it describes the surface's physical components and characteristics.

The classification scheme developed by the National Remote Sensing Agency (NRSA) in 1995 categorises land use and cover. According to this framework, eight land use and land cover classes have been established. However, for the purposes of the current research, only five Land Use and Land Cover (LULC) classes are considered: Forest, Agricultural Land, Barren Land, Settlements, and Water Bodies (as per the source: NRSC, LULC classification, 1995). The land use/land cover classification at a 1:50,000 scale includes Level I with 8 classes, Level II with 31, and Level III with 54 classes (NRSC, 2012).

The examination and mapping of land use and land cover alterations, frequently conducted through remote sensing and Geographic Information Systems (GIS), are imperative for environmental monitoring, urban planning, resource management, and evaluating the environmental impact of human activities. Whereas land use emphasizes the human exploitation of land, land cover is concerned with the physical condition of the surface.

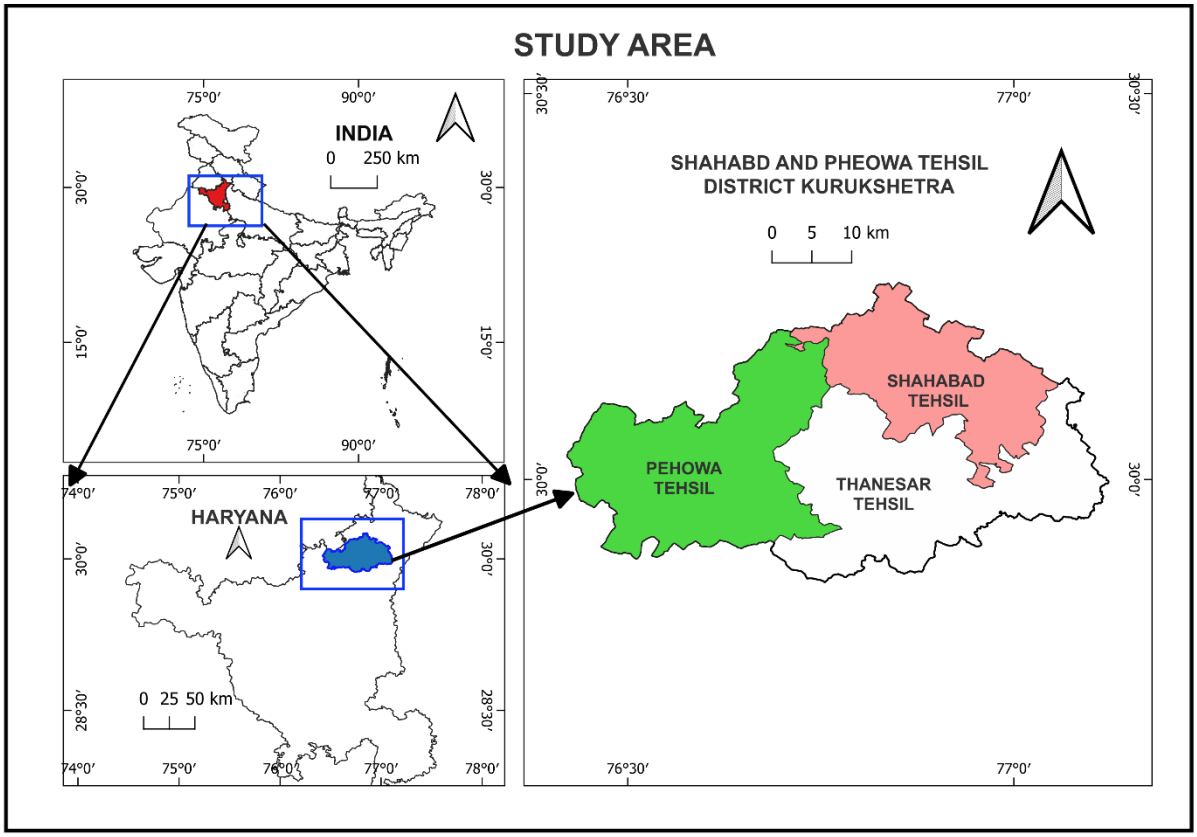
The study of land use holds multifaceted significance. It is instrumental in ensuring optimal resource allocation, fostering economic development, aiding environmental conservation, enhancing societal welfare, diminishing disaster risks, mitigating climate change impacts, and shaping legal and policy frameworks. Effective land use management endeavors to harmonize human requirements with environmental sustainability.

The land use and cover classification is inherently intricate and subjective, often tailored to specific user needs. The U.S. Geological Survey (USGS) utilizes the "Land Use and Land Cover Classification System" (LULC), a hierarchical system offering detailed categorizations of land use and cover. This system encompasses broad categories at Level I (such as urban, agricultural, and forest). It progresses to more detailed classifications through Levels II to IV, with Level IV providing highly specific classifications, like crop-specific categories within the agricultural sector.

This study performs a comparative analysis of land use and land cover in the Shahabad and Pheowa tehsils of the Kurukshetra district in Haryana, applying hierarchical Level I classifications through remote sensing technology. In a rapidly evolving world, understanding these aspects is vital. Modern technologies, particularly remote sensing, and GIS, have markedly enhanced our ability to accurately track and analyze these changes, offering profound insights into land use and cover dynamics.

Study Area:

The present study involves a comparative analysis of land use and land cover in the Shahabad and Pehowa Tehsils of the Kurukshetra district in Haryana, utilizing advanced remote sensing techniques.



Shahabad Tehsil: Shahabad, located in the northern part of Haryana within the Kurukshetra district, lies at approximately 29.97°N latitude and 76.15°E longitude. It covers an area of 181 km², comprising 165.43 km² of rural land and 16.00 km² of urban land.

The region is characterized by a flat topography with fertile alluvial plains, forming part of the Indo-Gangetic plain known for its agricultural suitability. Shahabad experiences a typical North Indian climate with hot, dry summers, a monsoon season bringing significant rainfall, and cool winters with foggy conditions.

Agriculturally, Shahabad is a predominant area with crops such as wheat, rice, sugarcane, cotton, and various fruits and vegetables. The natural vegetation is limited due to extensive cultivation. Water resources include the Ghaggar-Hakra River and various canals like the Western Yamuna Canal and Bhakra Canal, crucial for irrigation.

The tehsil has a population of 1,30,176, with a density of 718 inhabitants per square kilometer. It shows a literacy rate of 70.01%, with a higher rate among males than females. Shahabad is well-equipped with a road network, educational institutions, and healthcare facilities.

Pehowa Tehsil: Pehowa, also in the northern part of Haryana, is situated about 30 kilometers from Kurukshetra and 160 kilometers from Chandigarh. It encompasses an area of 548 km², with 528.08 km² rural and 19.50 km² urban.

Like Shahabad, Pehowa is part of the Indo-Gangetic plain, featuring flat, fertile terrain ideal for agriculture. The climate is divided into hot summers, a monsoon season, and cold winters. The Ghaggar-Hakra River and the Markanda River, along with canal systems, provide substantial irrigation support.

Agriculture is the primary occupation, with the cultivation of crops like wheat, rice, sugarcane, cotton, and various fruits and vegetables. The natural vegetation is mostly

agricultural, with limited wild growth due to farming. Pehowa's wildlife includes various bird species, particularly during the winter months.

With a population of 2,55,307 and a density of 466 inhabitants per square kilometer, Pehowa has a literacy rate of 62.82%. The region benefits from good road connectivity and facilities for trade, commerce, and small-scale industries.

The comparative analysis of Shahabad and Pehowa Tehsils through remote sensing will offer insights into their land use and cover patterns. This study will examine the agricultural practices, water resource management, vegetation cover, settlement patterns, and overall land use efficiency. Remote sensing will provide precise and up-to-date information, aiding in the understanding of how these regions utilize their geographical and environmental resources. Such an analysis is vital for sustainable development and resource management in the Kurukshetra district.

Data Used:

The research utilized data sourced from the Landsat 8 Operational Land Imager (OLI), an essential tool accessible via the Earth Explorer portal (https://earthexplorer.usgs.gov). The Landsat 8 OLI is equipped with a range of spectral bands, each characterized by distinct wavelengths and spatial resolutions. For this analysis, the following bands were employed, each with its specific features:

Band 2 (Blue): This band has a wavelength range between 0.450 and 0.51 µm and offers a spatial resolution of 30 meters.

Band 3 (Green): It operates within a wavelength range of 0.53 to 0.59 µm and also maintains a spatial resolution of 30 meters.

Band 4 (Red): This band features a wavelength range of 0.64 to 0.67 µm, with a spatial resolution of 30 meters.

Band 5 (Near-Infrared): With a wavelength range of 0.85 to 0.88 µm, this band too has a spatial resolution of 30 meters.

Band 6 (SWIR 1): Operating within a wavelength range of 1.57 to 1.65 µm, it has a spatial resolution of 30 meters.

Band 7 (SWIR 2): This band covers a wavelength range of 2.11 to 2.29 µm and has a spatial resolution of 30 meters.

In terms of Data Selection and Curation, the dataset was meticulously curated to ensure its robustness and applicability. The selection was limited to cloud-free images taken in February 2020, coinciding with the end of the Rabi cropping season. This specific timeframe was chosen to optimize the data's relevance and accuracy, highlighting the importance of timely and explicit satellite imagery in environmental research. The selection process was tailored to obtain the most representative and clear images, in line with the study's goals. This approach significantly enhances the reliability and effectiveness of the research's analytical methods.

Methodology:

This research methodology is intricately designed, comprising several pivotal stages crucial for the precise analysis of satellite imagery data. The subsequent sections elucidate these stages:

Preprocessing of Satellite Imagery: The accuracy and refinement of satellite imagery analysis are contingent upon rigorous preprocessing procedures. The preprocessing measures implemented in this study are enumerated as follows:

a. Radiometric Calibration: Satellite sensors capture the Earth's radiation as digital numbers (DNs). These DNs are transmuted into actual radiance values utilizing calibration coefficients from the satellite sensor's metadata. This transformation is imperative for an authentic representation of the radiative intensity.

b. Atmospheric Correction: The journey of electromagnetic radiation through the Earth's atmosphere involves interactions such as scattering and absorption. These phenomena have the potential to modify the spectral signatures registered by satellites. Specialized algorithms congruent with the satellite sensor type and atmospheric conditions were deployed to rectify these atmospheric perturbations and derive actual surface reflectance values.

c. Spatial Subsetting: The focus of the study was primarily on Shahabad and Pheowa Tehsil within the Kurukshetra District, Haryana. Spatial subsetting of the satellite imagery was performed to ensure that the analysis is not only geographically pertinent but also computationally efficient.

These preprocessing activities are fundamental as they provide the bedrock for the precision and applicability of the land use and land cover (LULC) classifications deduced from the satellite imagery.

Supervised Classification Methodology: A cornerstone of this study is the delineation and categorization of LULC through the analysis of satellite imagery, a process pivotal for domains such as urban planning and environmental stewardship. The study adopted a supervised classification approach, harnessing pre-existing regional knowledge.

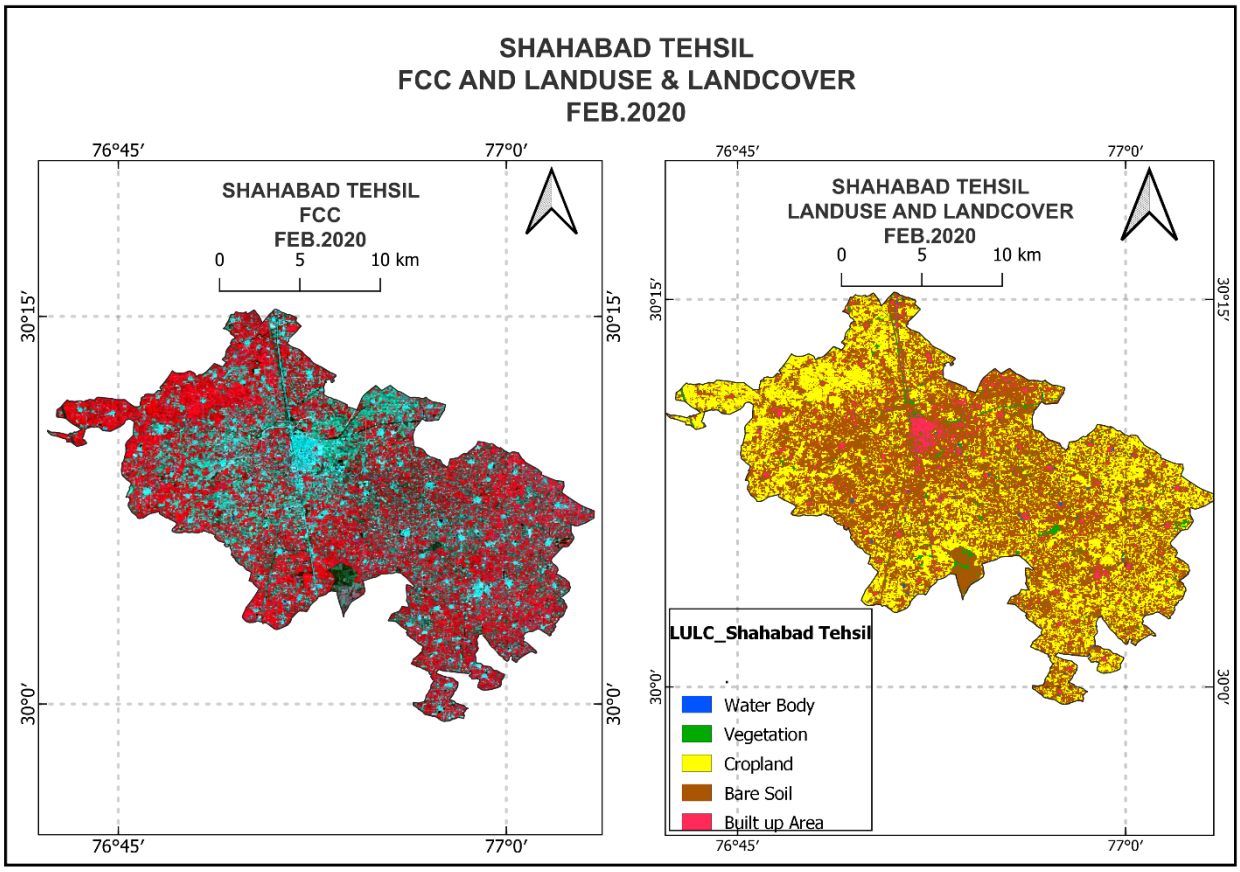
The fulcrum of this approach is the Maximum Likelihood Algorithm (MLA). Grounded in probabilistic theory, the MLA scrutinises its spectral values and assesses the likelihood that a particular pixel corresponds to a specific class. This methodology entails evaluating the mean and variance of each band for every class, culminating in the pixel's classification into the class with the highest probability. This presupposes that the spectral values of pixels within each class are generally distributed across the bands.

Employing the MLA, the satellite imagery was partitioned into fundamental LULC categories such as water bodies, vegetation, cropland, bare land, and built-up areas. The effectiveness of the supervised classification, particularly of the MLA, is intimately connected with the astute selection of training samples, a critical factor for the precise conversion of satellite-derived spectral data into coherent LULC categories.

Software Used: The analysis and interpretation of LULC data, extracted from Landsat 8 satellite imagery, were conducted utilizing the QGIS software suite. QGIS is acknowledged as an open-source geospatial platform, celebrated for its extensive capabilities in data visualization, manipulation, and rigorous geospatial analyses. The absence of licensing constraints significantly elevates the utility of QGIS, making it an invaluable asset for extensive application across many geospatial research and analytical projects.

Results and Discussion:

In this research, the Shahabad and Pehowa Tehsils within the Kurukshetra District of Haryana are examined for their varied land use and land cover (LULC) characteristics. A comprehensive analysis of these patterns provides intricate understanding of the socio-economic forces, environmental state, and developmental progression in the region. Employing data from Landsat 8 satellite imagery, the study seeks to illuminate the agricultural orientation of the district as well as the spatial interrelations between its urban and rural sectors.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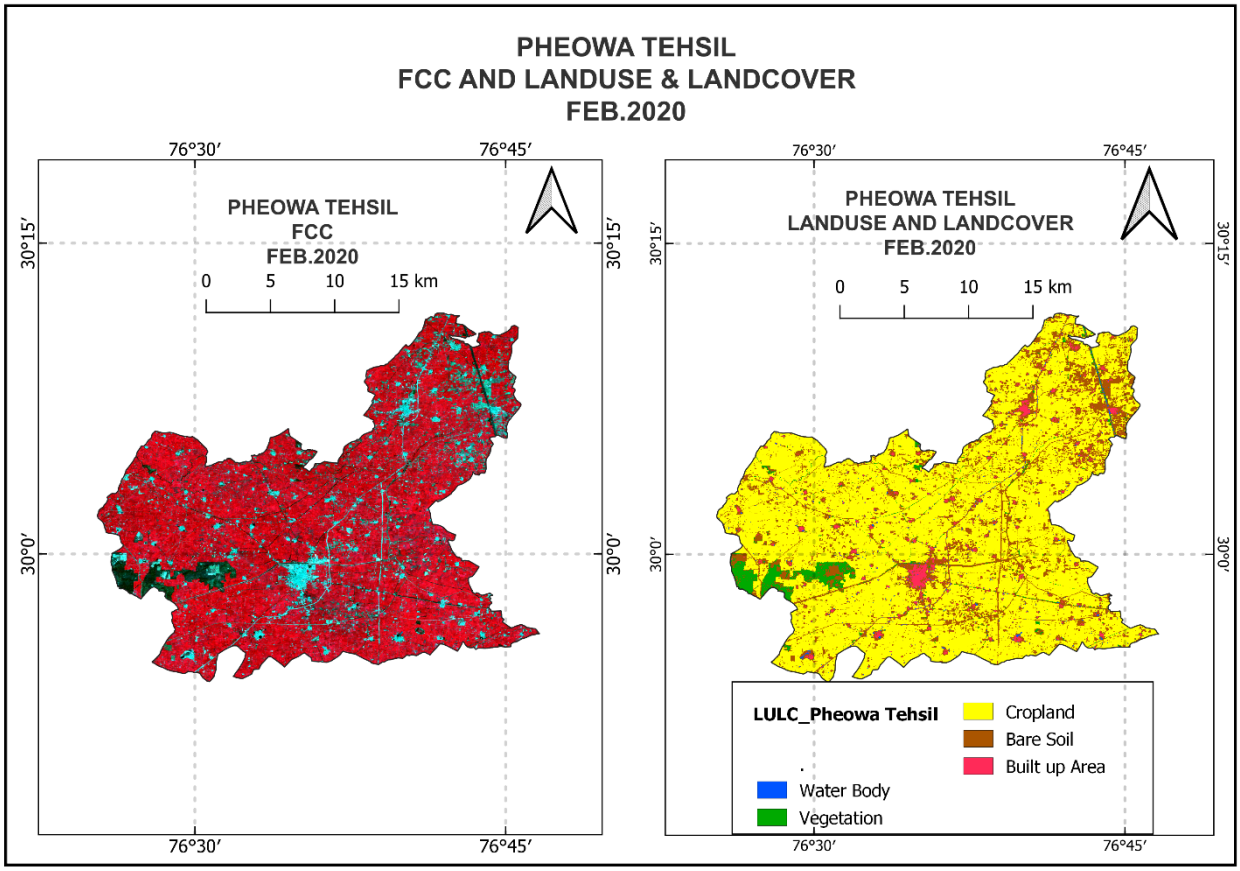
LULC_Shahabad Tehsil
Water Body
Vegetation
Cropland
Bare Soil
Built up Area
76°45′
77°0′
30°15′
30°0′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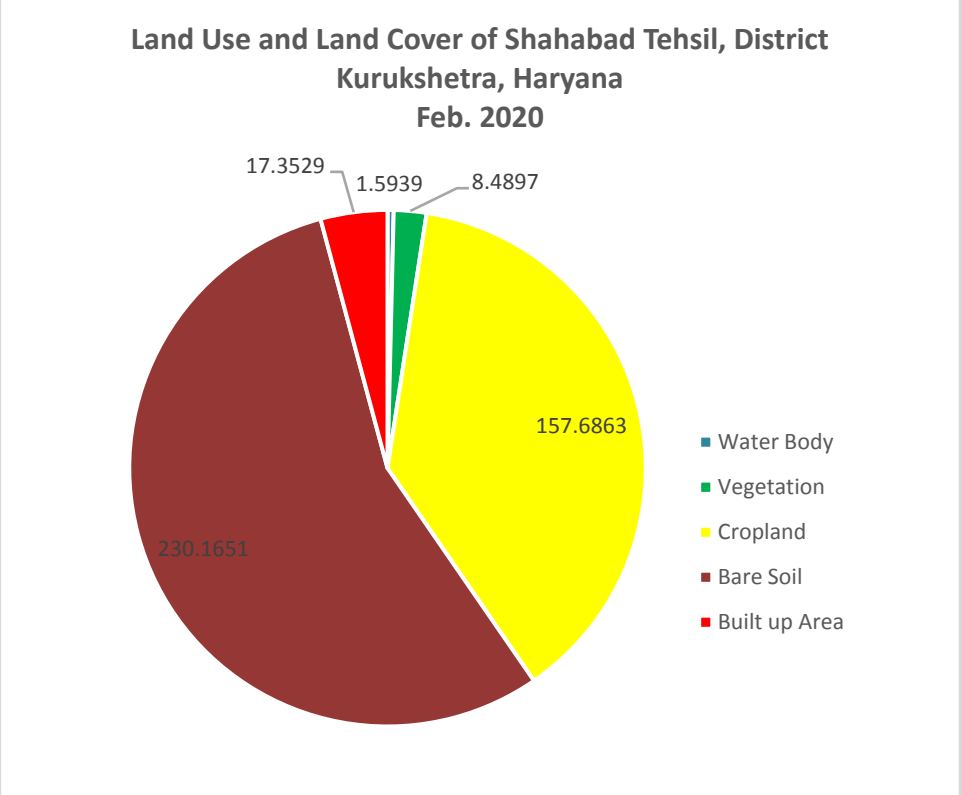
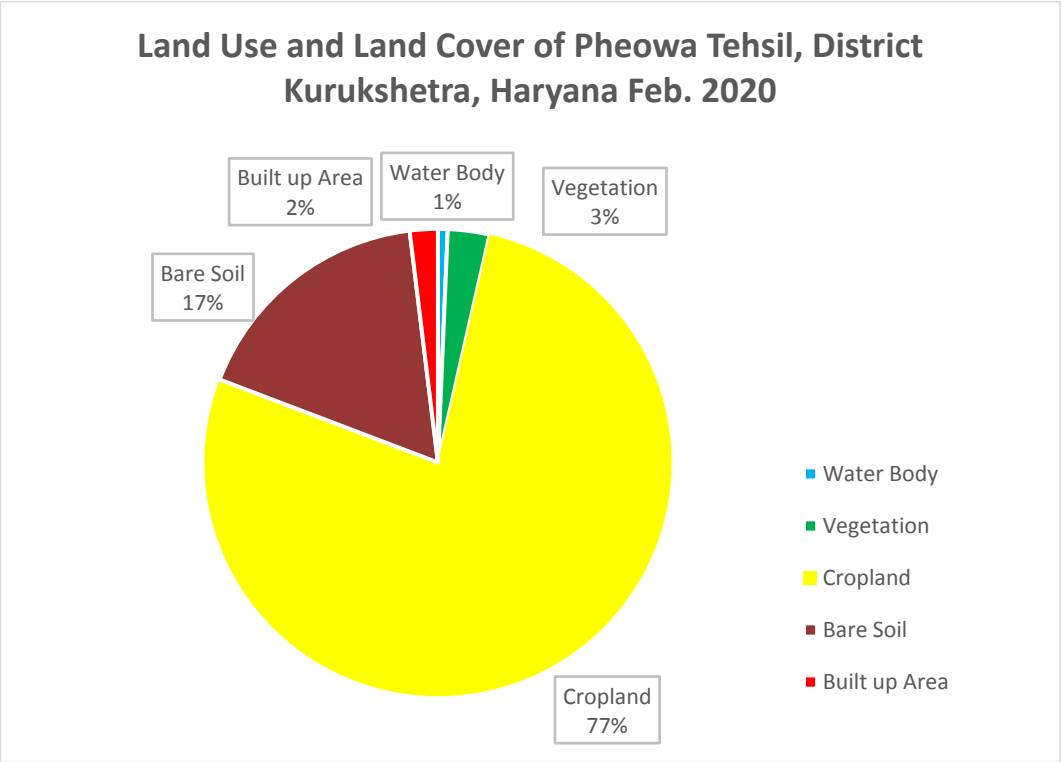
LULC_Pheowa Tehsil
Cropland
Bare Soil
Built up Area
Water Body
Vegetation
76°30′
76°45′
30°15′
30°0′

Land Use and Land Cover Analysis of Shahabad and Pheowa 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 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**	





The comparative analysis of land use and land cover (LULC) for Shahabad and Pheowa Tehsils in Kurukshetra District, Haryana, as per the data from February 2020, reveals notable differences in their land utilization and environmental characteristics.

Cropland: There is a stark contrast in cropland distribution between Pheowa Tehsil and Shahabad is a notable feature of their respective land use and land cover (LULC) patterns. In Pheowa Tehsil, agriculture emerges as the dominant land category, encompassing a significant 77.23% of the total area. This substantial portion underscores the tehsil's robust agricultural focus, indicating a primary reliance on farming practices for sustenance and economic activities. In contrast, Shahabad, despite sharing a similar topography with Pheowa, allocates only 37.97% of its total area to cropland. This considerable difference highlights Shahabad's comparatively lesser emphasis on agriculture and a more diverse land use strategy. The disparity in cropland distribution is primarily attributed to variations in the types of crops cultivated in each tehsil. Pheowa's higher percentage is indicative of a more intensive and expansive cultivation of crops, while Shahabad's lower proportion suggests a more varied land use pattern with less emphasis on traditional agricultural practices. Overall, this disparity in cropland distribution underscores the distinct agricultural profiles of Pheowa and Shahabad, shedding light on the varying economic and environmental dynamics within the region.

Bare Land: In Shahabad Tehsil, a distinctive characteristic is the substantial prevalence of bare land, encompassing a remarkable 55.42% of its total area. This prevalence is notably higher than that observed in Pheowa Tehsil, where bare land constitutes a comparatively modest 17.29%. The stark contrast between the two regions suggests potential disparities in land management practices, prospects for agricultural expansion, or variances in the natural terrain. Further investigation, conducted on the ground, has validated that Shahabad Tehsil engages in the cultivation of large sugarcane crops, particularly noteworthy when compared to Pheowa Tehsil. The sugarcane harvest, which takes place in February, contributes to the elevated proportion of bare land in Shahabad Tehsil. This is attributed to the aftermath of the harvest, where the fields, having been cleared of sugarcane, exhibit a

similar ground energy reflectance as that of bare land. Additionally, it is plausible that the higher concentration of population in Shahabad Tehsil may play a role in the increased prevalence of bare land, either due to more intensive agricultural activities or greater infrastructural development. The interplay of these factors underscores the multifaceted nature of land use dynamics and highlights the need for a nuanced understanding of regional disparities.

Built-up Area: The distinction in built-up areas between the two tehsils, Shahabad and Pheowa, underscores significant differences in settlement patterns and infrastructural development. Notably, Shahabad exhibits a notably higher percentage of built-up areas, standing at 4.18%, in contrast to Pheowa's more modest 1.93%. This discrepancy hints at a more pronounced level of urban development in Shahabad, suggesting a landscape characterized by increased commercial activities and infrastructural advancements. One contributing factor to this divergence is the demographic contrast between the two tehsils, with Shahabad boasting a higher population than Pheowa. Additionally, the presence of the national highway passing through Shahabad tehsil has played a pivotal role in transforming the region. The highway has served as a conduit for increased industrialization and commercial ventures in Shahabad, contributing to the higher percentage of built-up areas. In essence, the interplay of population dynamics and strategic geographical factors has led to the emergence of Shahabad as a hub of urban development and economic activities, shaping its distinctive built-up landscape.

Vegetation: The vegetation cover in Pehowa and Shahbad tehsils is reported to be 2.88 percent and 2.04 percent, respectively. Comparatively, Pehowa exhibits a slightly higher vegetation cover than Shahbad tehsil. However, both fall significantly below the recommended threshold of 10 percent, which is essential for sustaining a healthy local environment. Inadequate vegetation cover can lead to various environmental challenges, including soil erosion, reduced biodiversity, and an overall degradation of ecosystem health. Insufficient vegetation can also contribute to climate-related issues, such as increased temperatures and decreased moisture retention in the soil. Therefore, it becomes imperative for local authorities and communities to address this issue and implement measures to enhance the vegetation cover, such as afforestation programs, sustainable land management practices, and community involvement in conservation efforts. By taking proactive steps to increase vegetation cover, these tehsils can work towards creating a more resilient and ecologically balanced environment, promoting the well-being of both the local ecosystem and its inhabitants.

Water Bodies: The variation in the percentage of water bodies between Pehowa and Shahabad tehsils, with Pehowa exhibiting a slightly higher percentage of 0.6 percent compared to Shahabad's 0.38 percent may be attributed to the distinct rural characteristics of these regions. Pehowa's higher percentage could be indicative of a greater prevalence of natural or man-made water features, potentially driven by the tehsil's predominantly rural landscape. This disparity in the presence of water bodies might have significant implications for the local microclimate, biodiversity, and agricultural productivity. Areas with more water bodies often experience altered microclimates due to increased humidity and temperature regulation. Additionally, the presence of water bodies contributes to enhanced biodiversity by providing habitats for various species.

In summary, Shahabad and Pheowa Tehsils exhibit significant contrasts in their land use and cover. While Shahabad is characterized by a larger bare land area and more developed built-up areas, Pheowa is predominantly agricultural with slightly higher proportions of water bodies and vegetation. These findings are instrumental for regional planning, resource allocation, and sustainable development strategies in the Kurukshetra District.

Conclusion:

The land use and land cover patterns in Pheowa Tehsil and Shahabad Tehsil exhibit distinct characteristics, particularly in terms of cropland distribution, bare land prevalence, built-up areas, vegetation cover, and water bodies. Pheowa Tehsil is marked by a dominant focus on agriculture, with cropland occupying a substantial 77.23% of its total area, indicating a strong reliance on farming. In contrast, Shahabad allocates only 37.97% to cropland, emphasizing a more diversified land use strategy. Shahabad stands out for its significant bare land, constituting 55.42%, attributed to large sugarcane cultivation. The stark difference in built-up areas, with Shahabad at 4.18% and Pheowa at 1.93%, underscores Shahabad's higher urban development and infrastructural advancements, influenced by population dynamics and a national highway. While Pheowa has a slightly higher vegetation cover at 2.88%, both tehsils fall below the recommended 10%, necessitating measures for environmental health. Pehowa exhibits a marginally higher percentage of water bodies at 0.6%, potentially influencing microclimates and biodiversity. Addressing these disparities through afforestation and sustainable land management can contribute to a more resilient and ecologically balanced environment in both tehsils.

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