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Satellite Surveillance of Land Use and Land Cover: Unveiling the Terrain of Shahabad Tehsil of District Kurukshetra, Haryana via Landsat 8 in February 2020

Dr. Suresh Kumar Deswal [1], Ajay Chauhan[2], Pawan Kumar[3], Ms. Dimple [4]

1. Associate Professor, Govt. PG College Ambala Cantt., Email ID drdeswalsuresh@gmail.com, Phone no. 9416387317

2. Associate Professor, Govt. PG College Ambala Cantt., Email ID Ltajaychauhan@gmail.com, Phone No.9785881819

3. Assistant Professor, Govt. PG College Ambala Cantt., Email ID pkdhaka25@gmail.com, Phone no 9877263052

4. Assistant Professor, Govt. P.G. College for Women, Sector-14, Panchkula, Email ID dimplesinghal1906@gmail.com, Phone No 8847672457

Abstract:
This study delves into the Land Use and Land Cover (LULC) dynamics of Shahabad Tehsil in Kurukshetra District, Haryana, utilizing data from the Landsat 8 Operational Land Imager (OLI) and processed through QGIS software. Emphasizing the intricate interplay between ecological and socio-economic factors, the research categorizes the region into five LULC classes: water bodies, vegetation, cropland, bare land, and built-up areas. The analysis reveals a landscape heavily inclined towards agriculture, with a significant portion of bare land indicative of potential agricultural expansion or underutilized areas. The limited extent of urban areas, undergoing steady expansion, poses challenges for sustainable development and resource management. Vegetation cover, though minimal, plays a vital role in ecological balance, highlighting the need for conservation efforts. The study underscores the importance of harmonizing agricultural practices with environmental sustainability and urban development to ensure the region's long-term ecological integrity and socio-economic prosperity.

Keywords: Land Use and Land Cover (LULC), Remote Sensing, Urban Expansion, Environmental Sustainability, Socio-Economic Development

Introduction:

Land is one of the most basic and important natural resource (Petrson 2006). Land use (LU) and land cover (LC) are pivotal concepts in understanding terrestrial transformations in geographical and environmental contexts. LC refers to the Earth's physical surface, encompassing natural and man-made features like vegetation, water bodies, and urban areas. LU, in contrast, delves into human activities and their interaction with these land covers, such as agriculture, urban development, and conservation. Land Cover is defined as observed physical features on the Earth's Surface. When an economic function is added to it, it becomes Land Use. (FAO, 2005).

Dimple, Singh Ravinder (2000) Land Use and Land Cover Change along Shivaliks between River Ghaggar and Yamuna summarized that LULC is an intricate interplay of cultural, economic and physical factors in a space-time continuum.

In the current era, marked by rapid urban expansion and population growth, changes in LU and LC are significant, with both spatial and temporal dimensions. These alterations have profound implications for urban planning, environmental conservation, and climate change assessments. Additionally, they are crucial for sustainable resource management, biodiversity conservation, and the maintenance of ecosystem services.

For identifying the land use and land cover classes the classification scheme developed by NRSA in 1995 is used. On the basis of this Scheme 8 land use and land cover classes are created. However five LULC classes have been adopted for the present paper. These land use and land cover classes are: 1 Forest 2. Agricultural Land 3. Barren Land 4.Settlements 5. Water Bodies (source: NRSC, LULC classification, 1995).

Historically, LU data primarily came from government records, which lacked spatial detail, and topographical maps, hindered by infrequent updates. Soil maps, while detailed, were limited in scope. The advent of remote sensing technology has revolutionized data collection in LU and LC studies. This method, utilizing satellite imagery, provides high-resolution, multi-spectral images, offering broad spatial coverage and frequent updates, thus enabling precise and current land classifications. Geographic Information Systems (GIS) further enhance this data, allowing for sophisticated spatial analyses.

A significant challenge in LU and LC research is the inconsistency in classification terminologies across different organizations. Terms like "forest" can vary in definition, leading to discrepancies in data interpretation. To mitigate this, a hierarchical classification system is often adopted, facilitating both broad and detailed categorizations. This study focuses on exploring LU and LC at hierarchical Level 1 using remote sensing techniques.

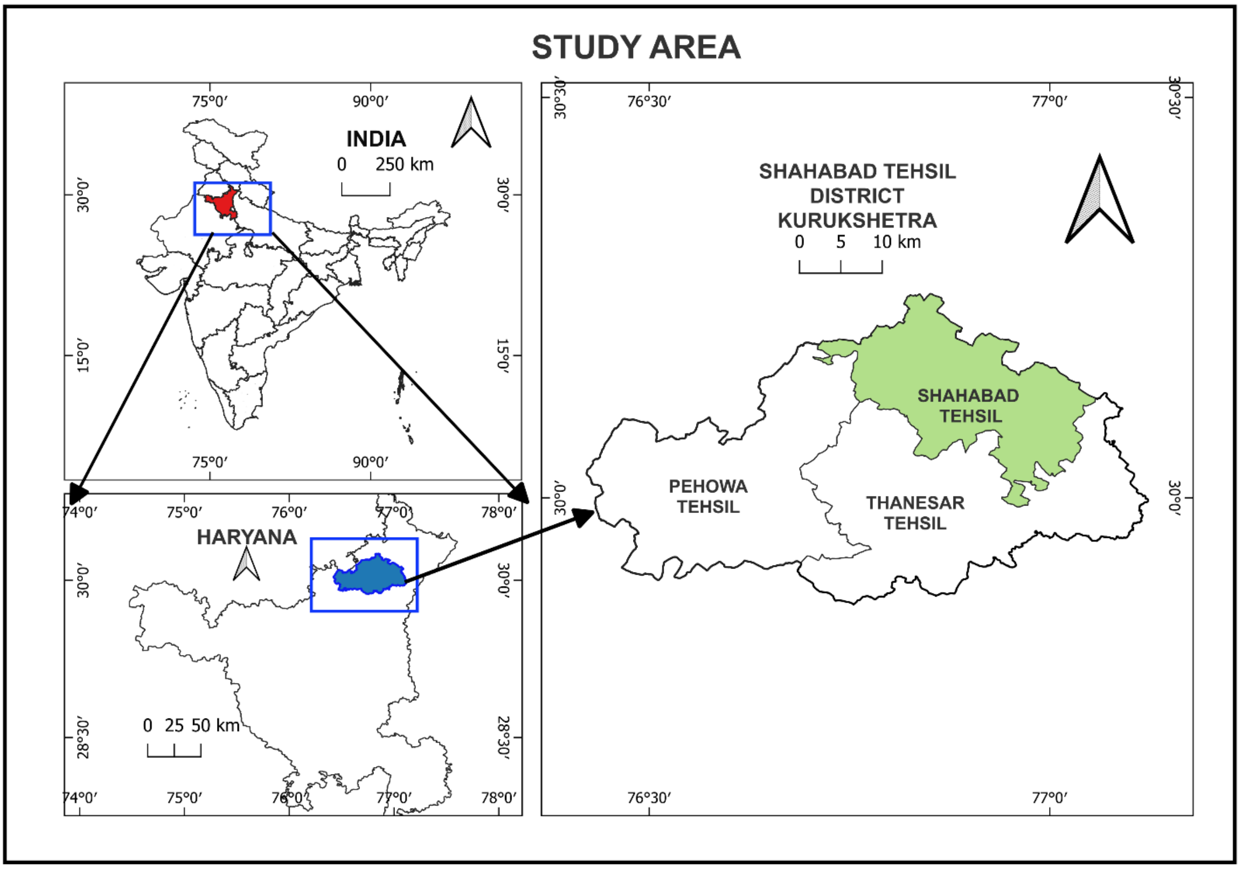
In summary, understanding LU and LC is crucial in addressing the complexities of a rapidly changing world. Modern technologies, particularly remote sensing and GIS, have significantly enhanced our ability to track and analyze these changes. These tools provide greater accuracy and detail in terrestrial analysis, essential for informed decision-making in urban planning, environmental management, and policy formulation. The study of LU and LC is therefore integral to comprehending and managing the impacts of human activities on the environment and ensuring sustainable development.

Study Area:

Shahbad Tehsil, within Kurukshetra District, Haryana, India, is an administrative division situated at approximately 29.97°N latitude and 76.15°E longitude, encompassing an area of 181 km², comprising 165.43 km² rural and 16.00 km² urban zones. This tehsil, part of the Indo-Gangetic plain, is characterized by flat, fertile alluvial plains, conducive to agriculture. It experiences a typical North Indian climate with distinct summer, monsoon, and winter seasons, influencing its primary agricultural economy. The main crops include wheat, rice, sugarcane, cotton, and various fruits and vegetables.

Water resources, notably from the Western Yamuna and Bhakra Canals, are vital for irrigation, supporting the region's agrarian lifestyle. The Ghaggar-Hakra River also contributes to agricultural sustainability and groundwater recharge. Shahbad's alluvial soil is a key factor in its agricultural productivity.

With a population density of 718 inhabitants per square kilometer, Shahbad has a total population of 1,30,176, divided into 42,607 urban and 87,569 rural residents. It features a literacy rate of 70.01%, with 75.41% male and 63.88% female literacy. The tehsil's infrastructure includes a network of roads, educational institutions, healthcare facilities, and markets, integral to the local governance and development.



Data Used:

In this study, the primary dataset was obtained from the Landsat 8 Operational Land Imager (OLI), accessible via the Earth Explorer portal at https://earthexplorer.usgs.gov. The Landsat 8 OLI provides a comprehensive array of spectral bands, each characterized by unique wavelengths and spatial resolutions, pivotal for diverse environmental and geographical analyses.

The specific OLI bands utilized in this research, along with their respective spectral and spatial attributes, include:

- Band 2 (Blue), with a wavelength range of 0.450 to 0.51 micrometers (µm) and a spatial resolution of 30 meters (m),
- Band 3 (Green), encompassing wavelengths from 0.53 to 0.59 µm, also with a spatial resolution of 30 m,
- Band 4 (Red), covering the 0.64 to 0.67 µm wavelength spectrum, with a spatial resolution of 30 m,
- Band 5 (Near-Infrared), spanning 0.85 to 0.88 µm in wavelength and maintaining a spatial resolution of 30 m,
- Band 6 (Short-Wave Infrared 1, or SWIR 1), ranging from 1.57 to 1.65 µm in wavelength, with a spatial resolution of 30 m, and
- Band 7 (SWIR 2), with a wavelength range of 2.11 to 2.29 µm and a spatial resolution of 30 m.

The selection and curation of data were conducted with meticulous attention to ensure its relevance and precision for the study. In this regard, the dataset incorporated solely cloud-free images from February 2020. This period coincides with the concluding phase of the Rabi agricultural season, underscoring the importance of temporal accuracy and clarity in imagery for satellite-based academic research. Such a methodical approach in data selection is crucial for obtaining reliable and pertinent results in environmental and land use studies, leveraging the advanced capabilities of remote sensing technologies.

Methodology:

1. Satellite Imagery Preprocessing: The accuracy and precision of satellite image analysis critically depend on meticulous preprocessing. This process is complex due to the nature of satellite data collection. The preprocessing methodologies implemented were as follows: a. Radiometric Calibration: Satellite sensors detect Earth's radiation as digital numbers (DN). To accurately translate these DNs into true radiative intensity values, they are converted using calibration constants found in the satellite sensor's metadata. b. Atmospheric Correction: The electromagnetic radiation captured by satellites can be altered by atmospheric scattering and absorption, which may distort the spectral signatures. To correct these atmospheric effects and accurately retrieve surface reflectance values, specific algorithms were utilized. These algorithms are chosen based on the type of satellite sensor and the prevailing atmospheric conditions. c. Spatial Subsetting: For enhanced computational efficiency and relevance to the targeted study area - Shahabad Tehsil in Kurukshetra District, Haryana - a spatial subset of the satellite imagery was selected. This process ensures that the analysis is both geographically pertinent and computationally efficient.

Rigorous preprocessing is essential as it underpins the accuracy of the subsequent land use and land cover (LULC) classifications obtained from the satellite imagery.

2. Supervised Classification Approach: The process of delineating LULC using satellite imagery is fundamental to various applications, such as urban planning and environmental conservation. In this context, supervised classification, a method that relies on prior knowledge of the area of interest, is crucial.

At the heart of this methodology is the Maximum Likelihood Algorithm (MLA). Based on probabilistic principles, the MLA determines the probability that a pixel belongs to a certain class based on its spectral values. This assessment takes into account the mean and variance of each band for every class, assigning the pixel to the class with the highest probability. It is important to note that this method assumes a normal distribution of pixel spectral values across bands for each class.

In this study, the MLA was used to segment satellite imagery into key LULC categories, which include: • Water Body: Identifying areas such as lakes, rivers, and reservoirs. • Vegetation: Covering areas with greenery, from tree canopies to shrubs. • Cropland: Regions used for agriculture. • Bare Land: Areas with minimal vegetation. • Built-up Land: Urban and rural settlements, including man-made structures.

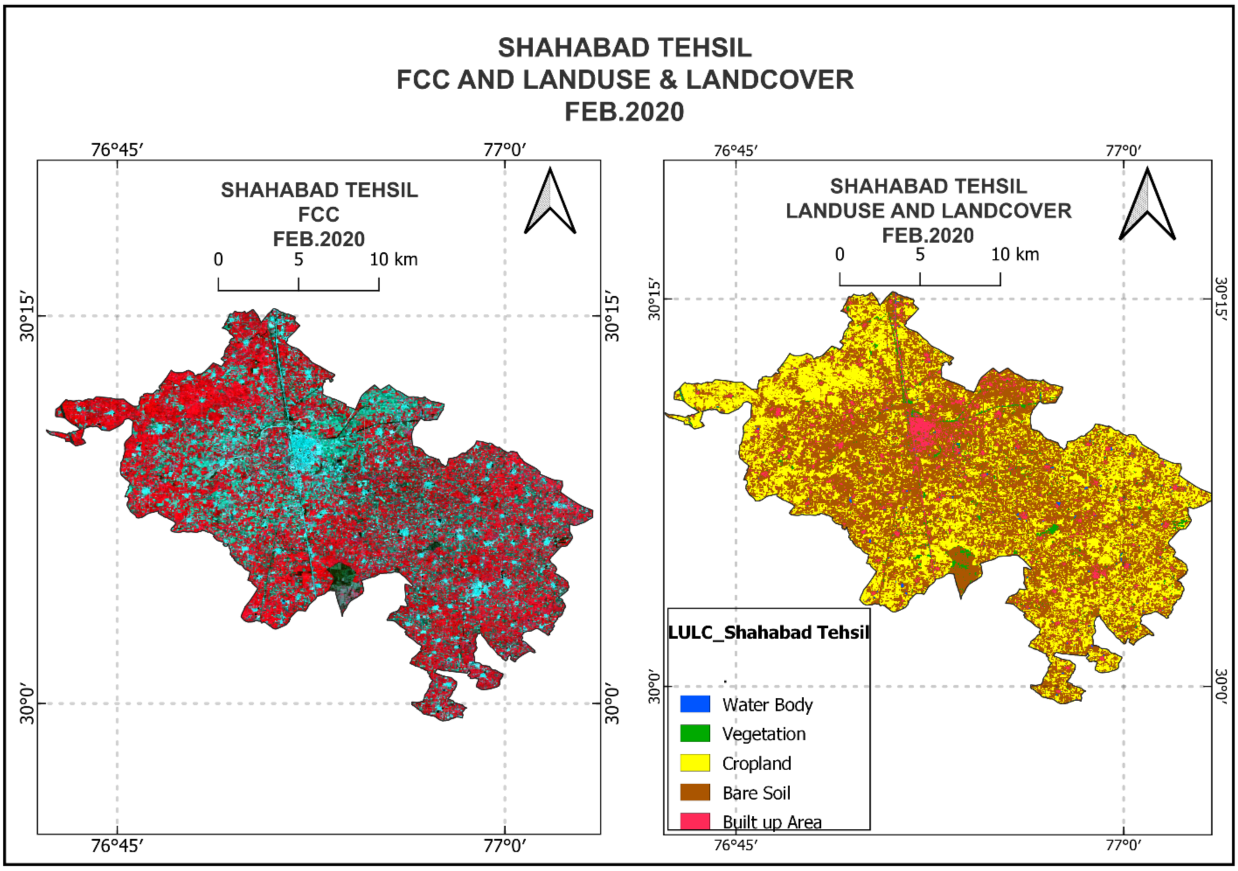
The effectiveness of supervised classification, particularly the MLA, is closely linked to the careful selection of training samples. This ensures the accurate interpretation of satellite-derived spectral signatures into meaningful LULC categories.

Software Used: The analytical interpretation of Land Use and Land Cover (LULC) data, derived from Landsat 8 satellite imagery, was conducted using the QGIS software suite. QGIS, standing for Quantum GIS, is an open-source geospatial analysis tool, noted for its comprehensive functionality. It supports a wide range of capabilities, including data visualization, editing, and complex geospatial analysis. The open-source nature of QGIS enhances its accessibility, as it is not subject to the licensing restrictions typically associated with proprietary software. This aspect of QGIS makes it a valuable tool in geospatial research, providing a platform for extensive spatial data analysis and interpretation without the constraints of software licensing.

Results and Discussion:

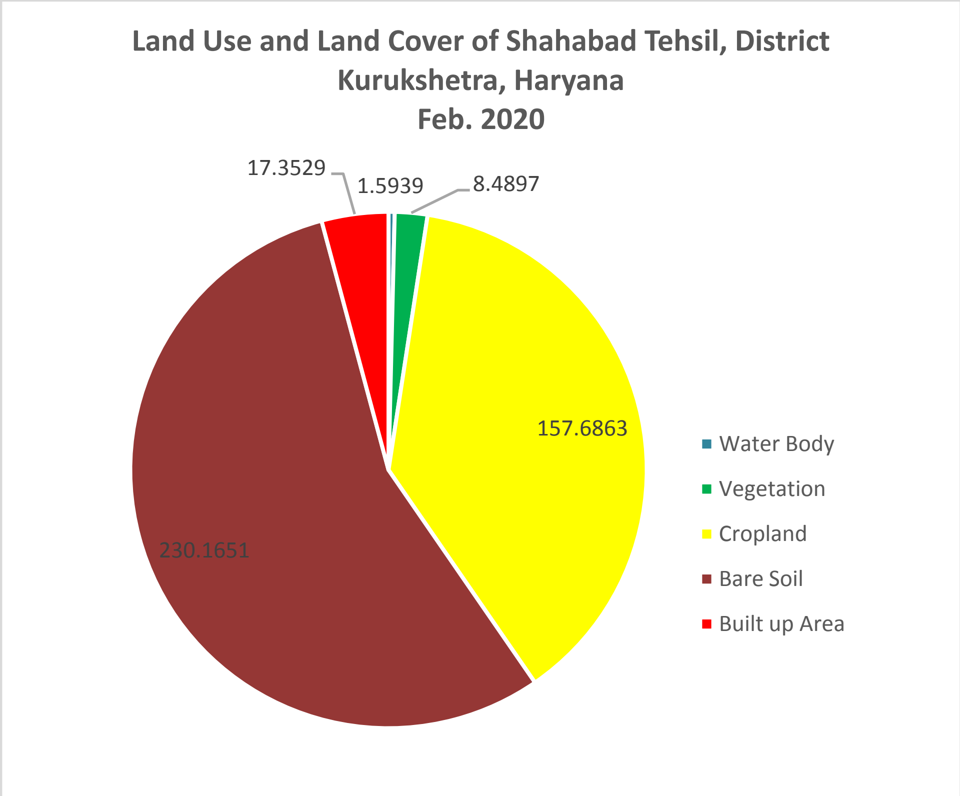
This research is focused on examining the patterns of land use and land cover within Shahabad Tehsil of Kurukshetra District. The study utilizes a combination of data sources: the official website of Kurukshetra (kurukshetra.gov.in), the district boundary maps and data provided by the Survey of India, and satellite imagery data from the Landsat 8 mission. This comprehensive analysis is vital for gaining insights into the ecological and socio-economic dynamics of the region.

For the purpose of this study, land use and land cover classification is divided into five main categories: water bodies, vegetation,cropland, bare land, andbuilt-up areas. Such a categorization is pivotal in evaluating the ecological equilibrium of the district and its capacity to sustain human activities. This classification aids in understanding the intricate balance between human development and environmental conservation, and it is crucial for planning and managing land resources effectively.



Land Use and Land Cover Analysis:

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**	



The Land Use and Land Cover (LULC) data of Shahabad Tehsil, Kurukshetra District, Haryana as of February 2020, provides a comprehensive understanding of the region's geographical and socio-economic characteristics. The total area under study is 415.2879 square kilometers, which is divided into various LULC classes as follows:

1. **Cropland (37.97%)**: Dominating the landscape with 157.6863 sq. km, this category underscores Shahabad's agricultural emphasis at least in terms of areas covered. However, one major chunk of the cropland area reclined under the bare land. As the bareland also include the harvested sugarcane cultivated area. This is the biggest limitation of the satellite data as the harvested sugar cultivated areas lied in the bare land class of LULC by means of similar reflectance. The region's fertile alluvial plains, underground water resources and favorable climate conditions facilitate the cultivation of wheat, rice, sugarcane, cotton, and various fruits and vegetables and fodder crops.

2. **Bare Land (55.42%)**: The largest category, occupying 230.1651 sq. km, includes areas with minimal or no vegetation, such as fallow lands and uncultivated fields. This significant proportion of bare land may indicate land awaiting cultivation (harvested sugarcane fields) or areas less suitable for agriculture.

3. **Built-up Area (4.18%)**: Spanning 17.3529 sq. km, this class represents urbanized and developed lands. The built-up areas include residential, commercial, and industrial zones, reflecting the tehsil's infrastructural development and urbanization.

4. **Vegetation (2.04%)**: Covering 8.4897 sq. km, this class includes forests, grasslands, and other vegetative lands. The presence of vegetation, though not extensive, is significant for ecological balance and agricultural support. Vegetation incorporated the forest cover, planted vegetation, tree cover and deserted vegetation cover etc.

5. **Water Body (0.38%)**: Encompassing 1.5939 sq. km, this category includes natural and artificial aquatic features like ponds, lakes, and canals. The relatively small percentage reflects limited water body coverage, which aligns with Shahabad's reliance on rivers and canals for irrigation and water resources. Major sources of water bodies in Shabad tehsil are rainfall and Markanda river. Another peculiar feature is that water bodies traversely laid in the rural landscape.

In light of Shahabad's geographical attributes – its location in the fertile Indo-Gangetic plain, typical North Indian climate, and the presence of crucial water resources like the Western Yamuna Canal and Bhakra Canal – the LULC data reveals a landscape predominantly dedicated to agriculture. The extensive bare land indicates potential for agricultural expansion or need for land management strategies. Meanwhile, the built-up areas align with the tehsil's administrative and commercial importance within the Kurukshetra district. This LULC analysis offers critical insights for future urban planning, resource management, and environmental conservation in Shahabad Tehsil.

Conclusion:

The Land Use and Land Cover (LULC) dynamics within Shahabad Tehsil, Kurukshetra District, carry significant ecological and socio-economic consequences. Predominantly agricultural in nature, the tehsil's landscape is a testament to its agrarian-based economy. However, this agricultural preponderance also signals potential risks to land sustainability and agricultural resource viability. The expansive presence of bare land, a product of both agricultural activities and urban expansion, presents notable challenges in terms of land management and ecological conservation.

Urbanization, though currently limited in scope, is on an upward trajectory, exerting increasing demands on land resources and potentially leading to ecological disturbances. This urban expansion underscores the necessity for sustainable urban planning and resource allocation strategies.

Furthermore, the tehsil's relatively sparse vegetation cover highlights a critical area of concern for environmental sustainability. It underscores the urgent need for focused efforts in forest conservation and tree plantation to mitigate ecological degradation and promote biodiversity.

The water bodies in Shahabad, albeit small in total area, are integral to the ecological health and sustainability of the rural landscape. Their preservation and effective management are crucial for maintaining the ecological balance, supporting agriculture, and ensuring water security in the region.

Overall, the LULC patterns in Shahabad Tehsil necessitate a balanced approach, harmonizing agricultural productivity with environmental conservation and sustainable urban development, to ensure the long-term ecological and socio-economic well-being of the area.

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