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Remote Sensing Application in Land Use and Land Cover Mapping: A Case Study of Thanesar Tehsil, Kurukshetra District, By Using Landsat 8 Imagery (Feb.2020)

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Abstract: This study examines the Land Use and Land Cover (LULC) of Thanesar Tehsil, Kurukshetra District, Haryana, utilizing data from the Landsat 8 Operational Land Imager (OLI) and the QGIS software suite. The research endeavors to scrutinize Land Use and Land Cover (LULC) patterns as of February 2020, utilizing a supervised classification methodology, specifically employing the Maximum Likelihood Algorithm (MLA) for the purpose of categorization. The LULC classification reveals a dominantly agrarian landscape with significant proportions of bare land, alongside smaller extents of water bodies, vegetation, and built-up areas. The study highlights the intricate interplay between the physical landscape and socio-economic dynamics within Thanesar Tehsil. The findings highlight the crucial role of agriculture in the region, while also reflecting the ongoing urbanization and potential areas for ecological conservation. This LULC analysis provides valuable insights for strategic planning, sustainable development, and ecological preservation in Thanesar Tehsil.

Keywords: Land Use and Land Cover (LULC), Landsat 8 OLI, Remote Sensing, Agriculture, Environmental Conservation

Introduction:

In contemporary society, comprehensive information on various intricate and interrelated aspects of its functioning is essential for effective decision-making. One such critical aspect is land use, a key factor in overcoming challenges related to uncontrolled and unplanned development, environmental degradation, loss of prime agricultural lands, destruction of wetlands, and depletion of fish and wildlife habitats. Accurate and real time land use data are imperative for analyzing and understanding environmental processes and problems, which is crucial for enhancing or maintaining living conditions and standards.

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).

"Land is the basic natural resources it is perhaps regarded as a resource base rather than a resource itself" (Mather 1986). Land Use: This term refers to the human-modified or -utilized portions of land, encompassing various uses such as residential, agricultural, commercial, industrial, recreational, conservation, and infrastructural (roads and buildings). It involves strategic planning and decision-making concerning the allocation and arrangement of land for specific human activities.

Land Cover: Contrasting with land use, land cover pertains to the physical and biological cover over the Earth's surface, including natural and artificial elements such as vegetation, water bodies, bare soil, urban areas, and snow or ice. It essentially describes the surface's physical materials and features.

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).

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 (NRSC, 2012).

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

The importance of studying land use is manifold. It ensures optimal resource allocation, fosters economic development, aids environmental conservation, enhances social well-being, reduces disaster risks, mitigates climate change, and informs legal and policy frameworks. Effective land use balances human requirements with 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 providing detailed categorizations of land use and cover. This system includes broad categories at Level I (e.g., urban, agricultural, forest) and becomes increasingly detailed through Levels II to IV, with Level IV offering very specific classifications, like crop-specific categories within agriculture.

This study focuses on the exploration of land use and land cover at hierarchical Level I using remote sensing technology. Understanding these aspects is essential in a world experiencing rapid changes. Modern technologies, particularly remote sensing and GIS, have significantly enhanced our ability to accurately track and analyze these changes, offering detailed insights into land use and cover dynamics.

Study Area:

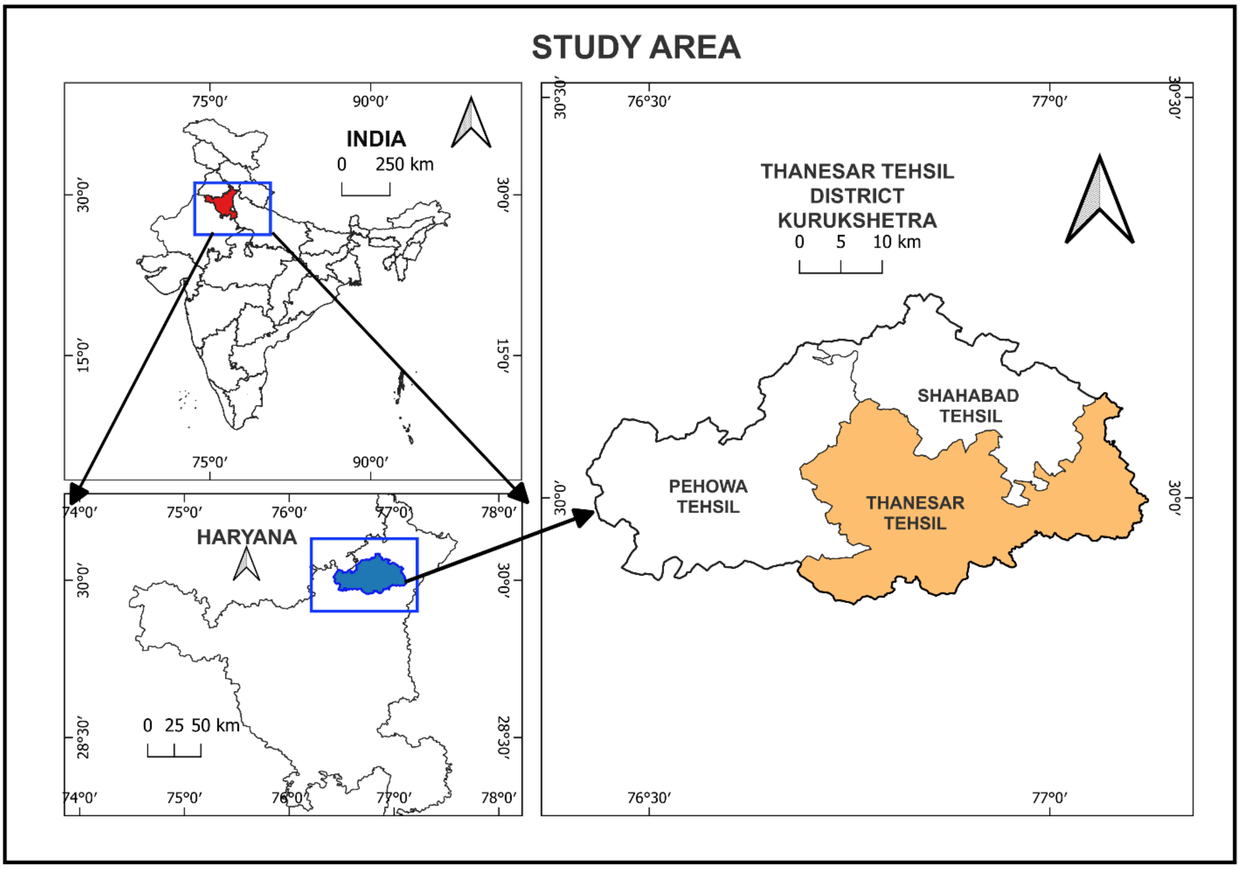
Thanesar Tehsil, situated in the Kurukshetra District of Haryana, India, is a region of significant historical and cultural importance. Located approximately 150 kilometers northwest of Chandigarh, the state capital, Thanesar is renowned as one of the oldest cities in the region, encompassing a total area of 801 km², including 762.13 km² rural and 38.87 km² urban zones.

Predominantly characterized by a flat and fertile Gangetic alluvial plain, Thanesar's landscape is highly conducive to agriculture, which forms the backbone of the local economy. The region is traversed by the Saraswati and Yamuna rivers, complemented by a local canal system that supports irrigation. The prevalent alluvial soil type is exceptionally fertile, facilitating diverse crop cultivation.

The climate is typical of North India, with hot, dry summers and cool, dry winters, punctuated by a monsoon season crucial for agricultural activities. The predominant vegetation comprises agricultural crops such as wheat, rice, sugarcane, cotton, and various vegetables, alongside citrus fruit orchards.

Urbanization in Thanesar includes the city of Thanesar, which has experienced significant growth, influencing land use and infrastructure development. The city holds immense historical and religious significance, including sites related to the Mahabharata and various temples.

As of the 2011 Census, Thanesar Tehsil had a population of 5,79,172, with a density of 723 persons per square kilometer, showcasing a stark contrast between its rural (518 persons/km²) and urban (4735 persons/km²) areas. The tehsil houses approximately 1,12,485 residences, divided into 37,514 urban and 74,971 rural homes. Literacy rates stand at 68.26%, with a noticeable gender disparity in education.



Data Used:

The research employed data acquired from the Landsat 8 Operational Land Imager (OLI), a critical resource accessible through the Earth Explorer portal (https://earthexplorer.usgs.gov). The Landsat 8 OLI provides a diverse array of spectral bands, each characterized by specific wavelengths and spatial resolutions. The bands utilized in this study, along with their respective attributes, include:

- Band 2 (Blue): Wavelength range of 0.450 - 0.51 µm and a spatial resolution of 30 meters.
- Band 3 (Green): Wavelength range of 0.53 - 0.59 µm and a spatial resolution of 30 meters.
- Band 4 (Red): Wavelength range of 0.64 - 0.67 µm and a spatial resolution of 30 meters.

- Band 5 (Near-Infrared): Wavelength range of 0.85 - 0.88 µm and a spatial resolution of 30 meters.
- Band 6 (SWIR 1): Wavelength range of 1.57 - 1.65 µm and a spatial resolution of 30 meters.
- Band 7 (SWIR 2): Wavelength range of 2.11 - 2.29 µm and a spatial resolution of 30 meters.

Data Selection and Curation: In ensuring the robustness and applicability of the dataset, a rigorous selection process was undertaken. The dataset was confined to cloud-free images captured in February, 2020 coinciding with the conclusion of the Rabi agricultural season. This strategic choice was made to maximize the relevance and accuracy of the data, highlighting the importance of temporal specificity and clear, unobstructed imagery in satellite-based environmental research. The selection criteria were geared towards obtaining the most representative and undistorted images pertinent to the study's objectives, thereby enhancing the reliability and validity of the subsequent analysis.

Methodology:

1. **Preprocessing of Satellite Imagery**: The accuracy and precision in analyzing satellite imagery are critically dependent on thorough preprocessing steps. Given the inherent challenges in satellite data acquisition, the following preprocessing measures were meticulously implemented:

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

b. **Atmospheric Correction**: As electromagnetic radiation passes through the Earth's atmosphere, it encounters scattering and absorption, which can distort the spectral signatures captured by satellites. To address these atmospheric anomalies and obtain true surface reflectance values, we employ specialized algorithms. These algorithms are specifically chosen based on the type of satellite sensor and prevailing atmospheric conditions.

c. **Spatial Subsetting**: Focusing on the area of interest, namely the Thanesar Tehsil within the Kurukshetra District, Haryana, we performed a spatial subsetting of the comprehensive satellite imagery. This process ensures that the analysis is geographically relevant and computationally efficient.

Rigorous preprocessing is indispensable, as it underpins the accuracy and relevance of subsequent land use and land cover (LULC) classifications derived from the satellite imagery.

2. **Supervised Classification Methodology**: The identification and categorization of LULC through satellite imagery is foundational for various applications, ranging from urban planning to environmental conservation. In this study, a supervised classification approach is employed, capitalizing on pre-existing knowledge about the region.

The cornerstone of this approach is the Maximum Likelihood Algorithm (MLA). Based on probabilistic theory, the MLA determines the probability that a given pixel belongs to a particular class based on its spectral values. This process involves assessing the mean and variance of each band for every class and assigning the pixel to the class with the highest probability. It is predicated on the assumption that the spectral values of pixels within each class are normally distributed across the bands.

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

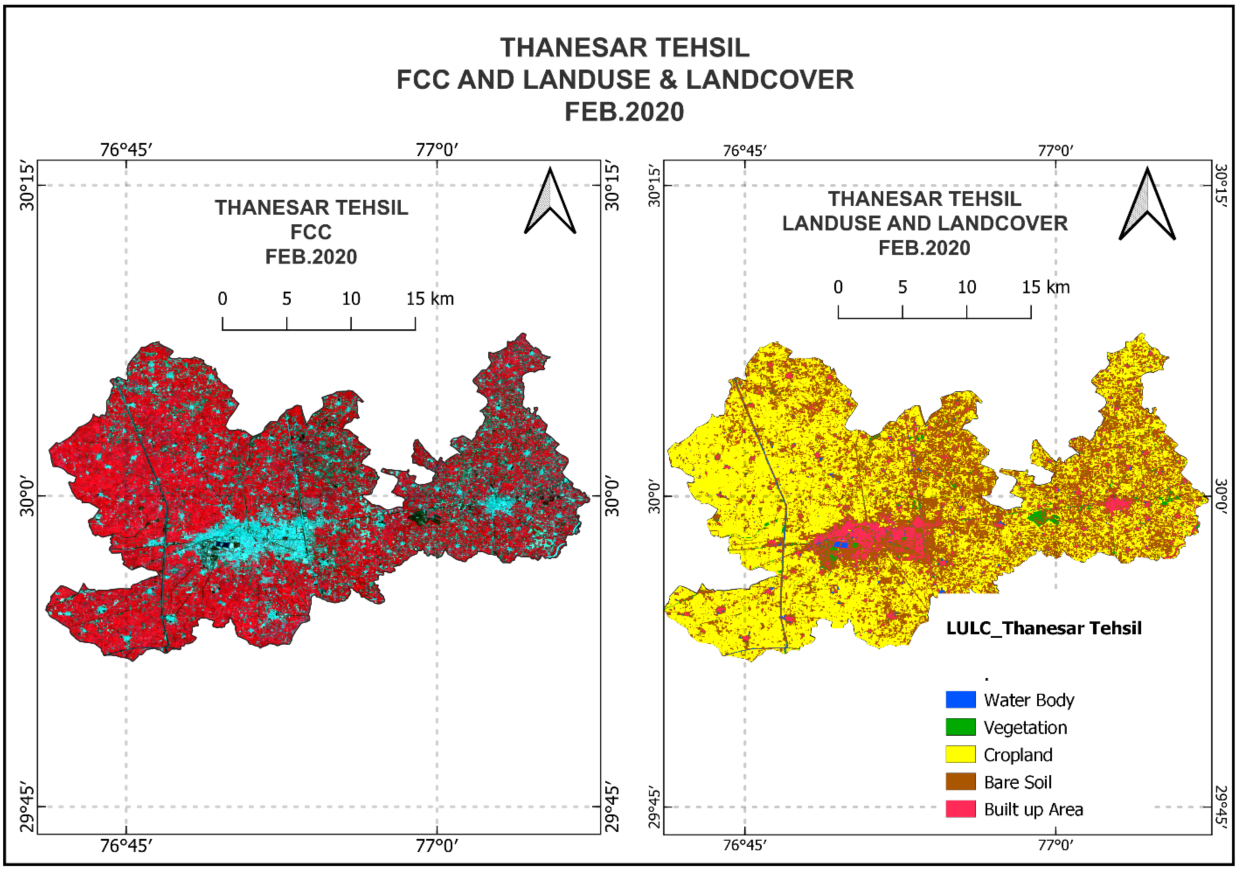
- **Water Bodies**: Identifying aquatic regions such as lakes, rivers, and reservoirs.
- **Vegetation**: Covering areas with plant life, including forests and grasslands.
- **Cropland**: Lands used for agricultural activities.
- **Bare Land**: Regions with minimal or no vegetation.
- **Built-up Land**: Urban and rural developments, including man-made structures.

The effectiveness of the supervised classification, particularly the MLA, is closely linked to the careful selection of training samples. The precision in choosing these samples significantly enhances the accurate interpretation of the satellite-derived spectral data into meaningful LULC categories.

Software Used: The analysis and interpretation of Land Use and Land Cover (LULC) data, derived from Landsat 8 satellite imagery, were conducted using the QGIS software suite. Quantum GIS (QGIS) is a widely acknowledged open-source geospatial platform, notable for its comprehensive functionality. This software not only enables effective visualization and alteration of geospatial data but also excels in conducting detailed geospatial analyses. The open-source nature of QGIS enhances its accessibility, offering an advantage by removing the restrictions associated with licensing fees. This aspect of QGIS is particularly beneficial for widespread application in various geospatial research and analysis endeavors.

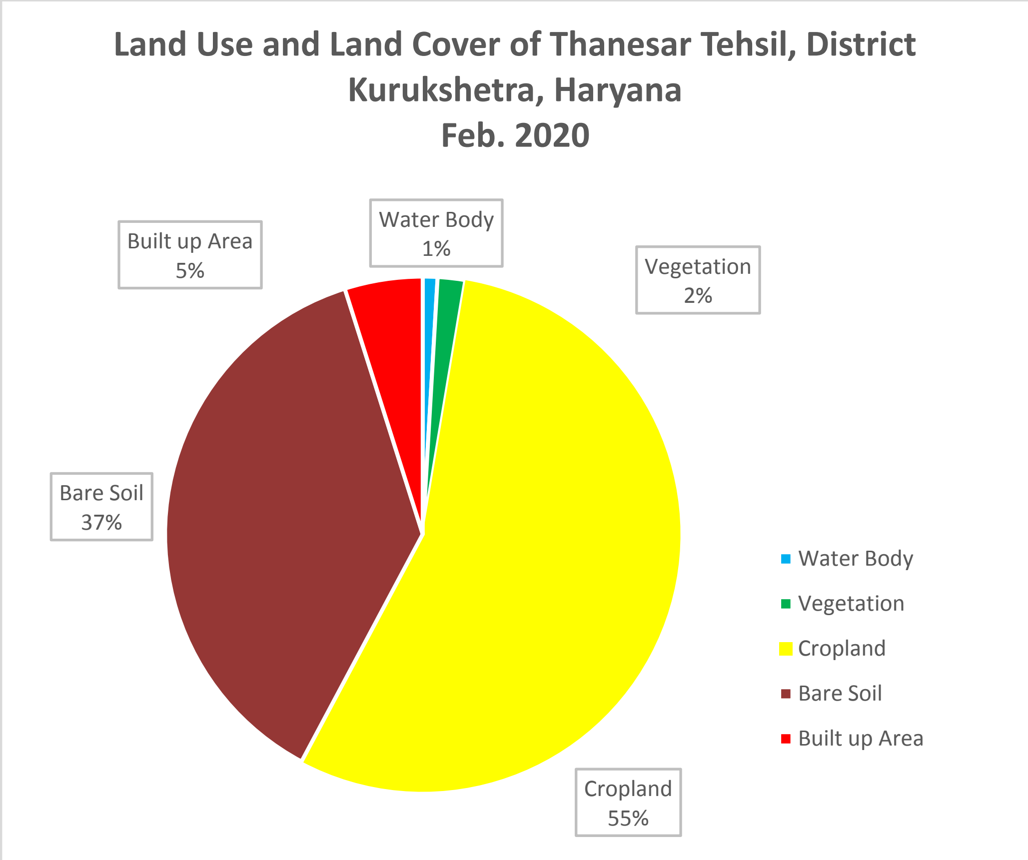
Results and Discussion:

Thanesar Tehsil, is a sub-part of Kurukshetra District of Haryana, presents a mosaic of land use and land cover (LULC) variations. A thorough exploration of these patterns offers a subtle understanding of the socio-economic intricacies, environmental health, and developmental path of the district. This in-depth study, leveraging the Landsat 8 imagery, seeks to unpack the district's agricultural emphasis and the spatial interplay between its urban and rural domains.



Land Use and Land Cover Analysis of Thanesar Tehsil:

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**	



The detailed examination of land use and land cover (LULC) patterns within Thanesar Tehsil, Kurukshetra District, as of Feb. 2020, offers an illustrating perspective into both the physical landscape and the socio-economic perspectives of development in the region. The data stratifies the tehsil into five definitive classes, each reflecting different facets of human and natural interactions.

1. **Water Body**: Encompassing an area of 6.0309 sq. km, this class accounts for 0.92% of the total area. However, It is less than one percent to total study area but very crucial and critical for livelihood and sustainability. It includes natural and man-made aquatic features such as lakes, Johads, and reservoirs. Natural primarily includes nadi. Nalas and wetlands while manmade are johads, ponds, reservoirs, talaabs, canals etc. primary manmade water bodies are in and around Jyotisar and Brahamsarovar, culturally and ritually important.

2. **Vegetation**: Covering 11.2626 sq. km, this category, which includes forests, grasslands, and other vegetative lands, constitutes 1.72% of the total area. This indicates the presence of green cover, albeit limited in extent. Being agriculturally dominated area, forests and vegetation is limited and well below 10 percent required to maintain local ecosystem and environment healthy.

3. **Cropland**: The most predominant LULC class, croplands span 360.3879 sq. km, forming a substantial 55.15% of the total area. This reflects the region's agrarian focus, with extensive areas dedicated to agriculture. This cropland area is highly concentrated and skewed to rural landscape (villages) to their urban counterpart. Besides, large cropland also reflects the large size of population and its demand for food and other essential items. Hydrology and topography also played role for the cropland development in the study area.

4. **Bare Land**: Comprising 243.8316 sq. km, this class makes up 37.31% of the total area. It accounts significantly second position in the land use classes. Bare land refers to areas with minimal or no vegetation, potentially including fallow lands, deserts, and rocky terrains. This significantly large size of bareland is due to post harvesting of sugar cultivation which was under the cropland. Secondly, area under kiln or bhattha for bricks also comes under this land use class. Moreover, open parts of land under plots- currently not used under built up area.

5. **Built-up Area**: It is an area which comes under the settlements- both rural and urban. This class, encompassing urban and developed lands, covers 31.9707 sq. km, equating to 4.89% of Thanesar Tehsil. It reflects the extent of urbanization and infrastructure development in the region.

The total area analyzed for this LULC classification is 653.4837 sq. km. The data underscores the dominance of agricultural land use in Thanesar Tehsil, juxtaposed with significant bare land coverage and relatively smaller proportions of water bodies, vegetation, and built-up areas. This distribution is indicative of the tehsil's land use dynamics and socio-economic fabric, highlighting the primacy of agriculture, the extent of urbanization, and the status of natural resources.

Conclusion: The LULC analysis of Thanesar Tehsil encompasses a predominantly agrarian landscape punctuated by urban developments, flourishing patches of vegetation, and areas that beckon ecological rejuvenation. Each class not only provides insights into the physical attributes such as flat and fertile plains, good surface drainage, adequate weather, and climatic conditions etc of the region but also mirrors its socio-economic continuum. Understanding these categories and their interplay is vital for strategic planning, ensuring sustainable growth, and preserving the ecological integrity of Thanesar Tehsil.

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