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Landsat 8 Imagery Insights: A Study on Barara Tehsil's Land Use and Cover, March 2018

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Abstract
This research elucidates the Land Use and Land Cover (LULC) patterns of Barara Tehsil in Ambala District, Haryana, as of March 2018. Distinct from mere physical manifestations, LULC offers a blend of terrestrial attributes and their human induced utilization, significantly reshaping local ecological and socio-economic prospects. Utilizing satellite imagery from the Landsat 8 Operational Land Imager (OLI) and sound methodologies including preprocessing and supervised classification techniques, the study delineates Barara's terrestrial configuration. Findings indicate that croplands overwhelmingly dominate, occupying 73.71% of the area, reflecting Barara's strong agrarian character and socio-economic dependency on agriculture and allied activities. While built-up and bare land areas comprise around 12% each, revealing socio-economic growth pathways and potential conservation zones, the region's water bodies and vegetation are relatively small, encompassing only 0.1% and 2.13% respectively. Despite their limited expanse, these areas play a critical role in ecological diversity, groundwater recharge, and local livelihoods. Such LULC insights, combined with Barara's socio-economic metrics and geographical position within Ambala District, emphasize the need for viable and sustainable developmental strategies. The study highlights the paramount importance of a holistic understanding of LULC patterns in policy-making, resource management, and the fostering of sustainable human-environment dynamism.

Keywords: Land Use and Land Cover (LULC), Satellite imagery, Agrarian character, Socio-economic dependency, Sustainable development

In geographical and environmental research, the concepts of Land Use (LU) and Land Cover (LC) are foundational, providing comprehensive insights into resources management through land use changes. LC characterizes the Earth's physical manifestations, encompassing vegetation, water bodies, and terrain characteristics. Conversely, LU enquiresthe human utilization of these covers and resources, covering sectors such as recreation, habitation, and agriculture.

Contemporary overall dynamics, underscored by escalating population figures and rapid urban expansion, have precipitated marked fluctuations in LU configurations and their corresponding LC changes. Construing these transitions is paramount for effective urban planning, environmental stewardship, and evaluations of climatic repercussions. Furthermore, such cognizance is vital for promoting sustainable resource management, reinforcing biodiversity, and ensuring the uninterrupted delivery of essential ecosystem services, inclusive of freshwater availability and food provision.

Traditionally, LU datasets were predominantly extracted from governmental fiscal documentation. Despite their value, these records often presented limitations in spatial granularity. Topographic delineations from cartographic bodies, albeit expansive, were periodically constrained by outdated renditions. Soil cartographies, albeit specific, were spatially limited, typically earmarked for particularized projects.

The technological renaissance has elevated remote sensing as the preeminent mechanism for LU and LC data retrieval. Utilizing satellite modalities, this methodology facilitates the acquisition of detailed, multi-spectral terrestrial imageries. The extensive spatial scope, amalgamated with periodic revisitation capabilities, ensures contemporaneous and nuanced LC classifications. Furthermore, the amalgamation of this data into Geographic Information

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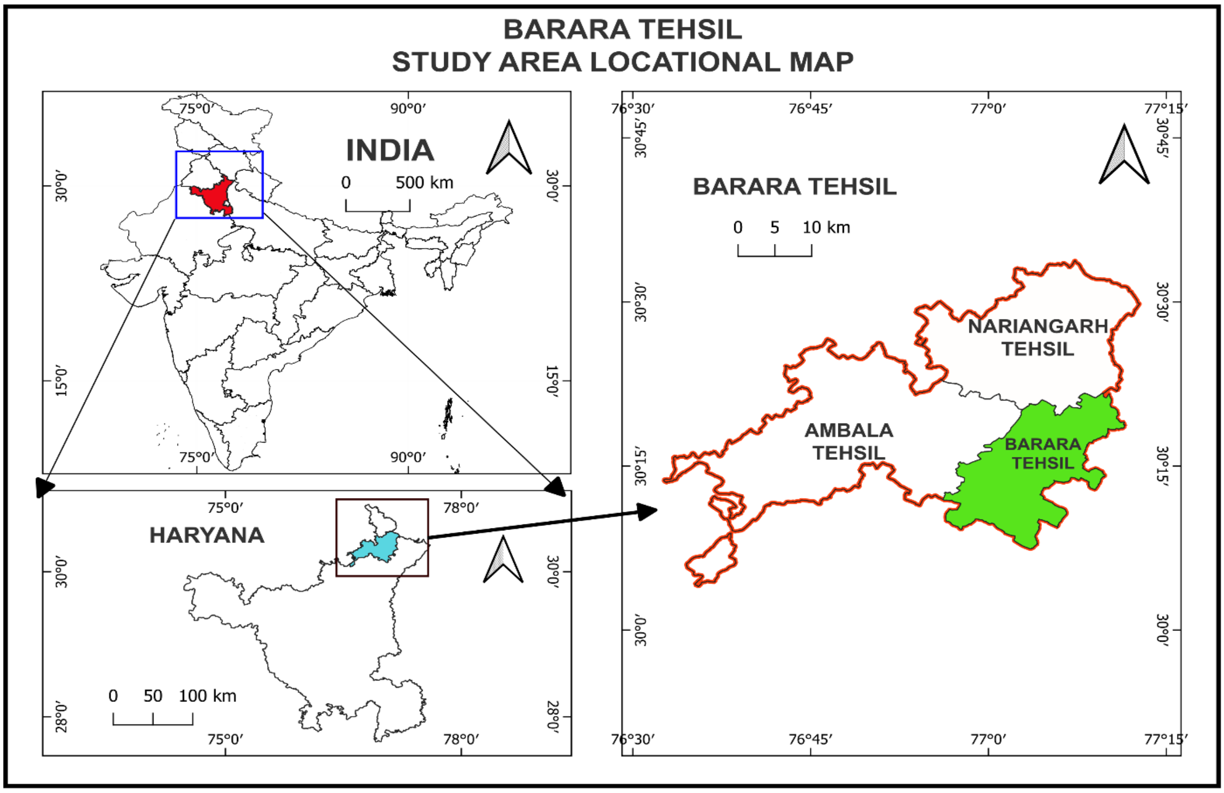
Systems (GIS) expedites advanced spatial evaluations and cartographic delineations.
A recurrent challenge within LC and LU analyses is the heterogeneity in classification lexicons across distinct organizations. For example, designations such as "forest" may exhibit ambivalence, contingent on the interpretive criteria of diverse bodies. To counteract such variances, scholars advocate the deployment of a hierarchical taxonomy, encompassing both macro and micro categorizations. This study seeks to elucidate LU and LC taxonomies at the hierarchical Level 1, leveraging remote sensing methodologies. In summation, a profound grasp of LU and LC is instrumental in circumnavigating the challenges presented by the ever-evolving contemporary landscape. Cutting-edge technological apparatuses, particularly remote sensing, and GIS, augment our competencies in surveilling and deciphering these terrestrial metamorphoses with unparalleled accuracy and profundity.

Study Area:

Barara, situated in Ambala District of Haryana, serves as both a town and tehsil. In the Indian administrative framework, a tehsil functions as a pivotal sub-district, instrumental in local administration, governance, and revenue generation. As per the 2011 census, Barara Tehsil, designated under the sub-district code 00360, sprawls over an area of 357 km², sub-divided into 335.90 km² rural and 21.10 km² urban terrains. This tehsil houses a populace of 2,44,039, comprising a notable rural majority of 2,14,394 against an urban fraction of 29,645. The demographic density stands at 684 inhabitants per square kilometer. Housing in Barara is classified into approximately 45,283 dwellings, with urban structures numbering 5,870 and rural establishments at 39,413.



Investigating the literacy metrics, 69.79% of Barara's residents are literate, comprising 75.28% literate males and 63.66% literate females. This tehsil, covering about 138 villages, forms a significant part of Ambala District's administrative demarcation.
Ambala District, lies in Haryana's northern quadrant, showcases a diverse interplay and result of topography, hydrological attributes, and socio-economic dynamics. Geographically extended between latitudes 30.2102° N and 30.6799° N and longitudes 76.6104° E and 77.0195° E, Ambala formssignificant contour of Haryana's topographical canvas. From an administrative perspective, the district is segmented into three primary tehsils: Ambala City,

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Brara, and Naraingarh, with Ambala City manifesting as the most extensive both in territorial scope and population density.

Ambala's landscape is a fusion of alluvial plains, fluvial systems, and the northeastern Shivalik Hills. This physiographical expanse, coupled with the district's climatic intricacies, shapes its agricultural, economic, and ecological matrix. Significant urban hubs like Ambala City, Ambala Cantt, and the tehsil of Barara underscore its urban evolution, while its agrarian fabric signifies the predominant rural essence.

With its confluence of diverse geographical, climatic, and socio-economic elements, Ambala District emerges as a pivotal zone in Haryana. The district's strategic geographic positioning further accentuates its role as a transportation nexus and commercial pillar. Given Ambala's ecological and socio-economic prominence, it necessitates judicious and sustainable developmental initiatives.

Data Source and Specifications:

For the present study, satellite imagery was procured from the Landsat 8 Operational Land Imager (OLI). This dataset is publicly available and can be accessed via the Earth Explorer portal.

The employed OLI bands, integral for the analysis, along with their respective specifications, are detailed below:

- **Band 2 (Blue)**
- *Wavelength*: 0.450 - 0.51 µm
- *Spatial Resolution*: 30 m
- **Band 3 (Green)**
- *Wavelength*: 0.53 - 0.59 µm
- *Spatial Resolution*: 30 m
- **Band 4 (Red)**
- *Wavelength*: 0.64 - 0.67 µm
- *Spatial Resolution*: 30 m
- **Band 5 (Near-Infrared)**
- *Wavelength*: 0.85 - 0.88 µm
- *Spatial Resolution*: 30 m
- **Band 6 (SWIR 1)**
- *Wavelength*: 1.57 - 1.65 µm
- *Spatial Resolution*: 30 m
- **Band 7 (SWIR 2)**
- *Wavelength*: 2.11 - 2.29 µm
- *Spatial Resolution*: 30 m

It is noteworthy to mention that the analysis incorporated only those images that were devoid of cloud cover, captured in March 2018. This temporal selection aligns with the terminal phase of the Rabi agricultural season, ensuring the data's relevance and applicability for the study's objectives.

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Methodology:

1. **Satellite Imagery Preprocessing:** Preprocessing stands paramount in ensuring the integrity of satellite image analysis. Recognizing inherent intricacies in satellite data acquisition, this study meticulously embarked on the following preprocessing strategies:

a. **Radiometric Calibration:** Within satellite datasets, Earth's reflected or emitted radiance is initially captured as digital numbers (DN). To attain fidelity in representing the received radiation's intensity, it's imperative to transmute these DNs into genuine radiance values. Such transformations lean on calibration constants inherent within the satellite sensor's metadata.
b. **Atmospheric Correction:** Spectral signatures documented by satellite sensors potentially confront atmospheric distortions due to electromagnetic radiation's scattering and absorption. To distil the imagery, reflecting unadulterated terrestrial conditions, atmospheric corrections get instituted. A suite of bespoke algorithms, tailored for the specific satellite sensor and prevailing atmospheric nuances, are deployed to discern surface reflectance values, thereby mitigating atmospheric aberrations.
c. **Spatial Subsetting:** To fortify computational prowess and accentuate the analysis's focus, the expansive satellite dataset was spatially subset to cull out regions pertinent exclusively to the Ambala District, Haryana. This precision augments both geographic relevance and computational efficacy.
Proper instauration of these preprocessing steps becomes a sine qua non, laying the groundwork for infallible land use and land cover (LULC) interpretations.

2. **Supervised Classification Approach:** Extricating LULC patterns from satellite imageries is foundational for applications as diverse as urban development paradigms to ecological conservation blueprints. Supervised classification, pivoting on an analyst's foreknowledge of the study locale, becomes instrumental.

Central to this endeavor is the **Maximum Likelihood Algorithm (MLA)**, steeped in probabilistic theory. It embarks on evaluating the likelihood of a pixel's association with a class, anchored in its spectral attributes. This algorithm navigates through each band's mean and variance for each class, ascribing the pixel to its most probable class. A pivotal underpinning is the assumption of a Gaussian distribution of pixel spectral values across bands for each class.
The ensuing classifications demarcated the Barara Tehsil landscape into definitive LULC categories:

1. **Water Body**
2. **Vegetation**
3. **Cropland**
4. **Bare land**
5. **Built-up land**

The efficacious deployment of supervised classification, particularly with MLA, remains tethered to the astuteness in selecting representative training samples. Their adept selection is a linchpin, translating satellite-derived spectral insights into coherent LULC delineations.

3. **Analytical Tools:** The introspective analysis of the LULC data, distilled from Landsat 8 imagery, was orchestrated leveraging the capabilities of QGIS software. Quantum GIS (QGIS), an open-source geospatial software suite, is celebrated for its multifaceted capabilities. Beyond fostering data visualization and manipulation, QGIS thrives in intricate

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geospatial explorations. Its inherent open-source architecture augments its democratized accessibility, decoupling researchers from onerous licensing exigencies.

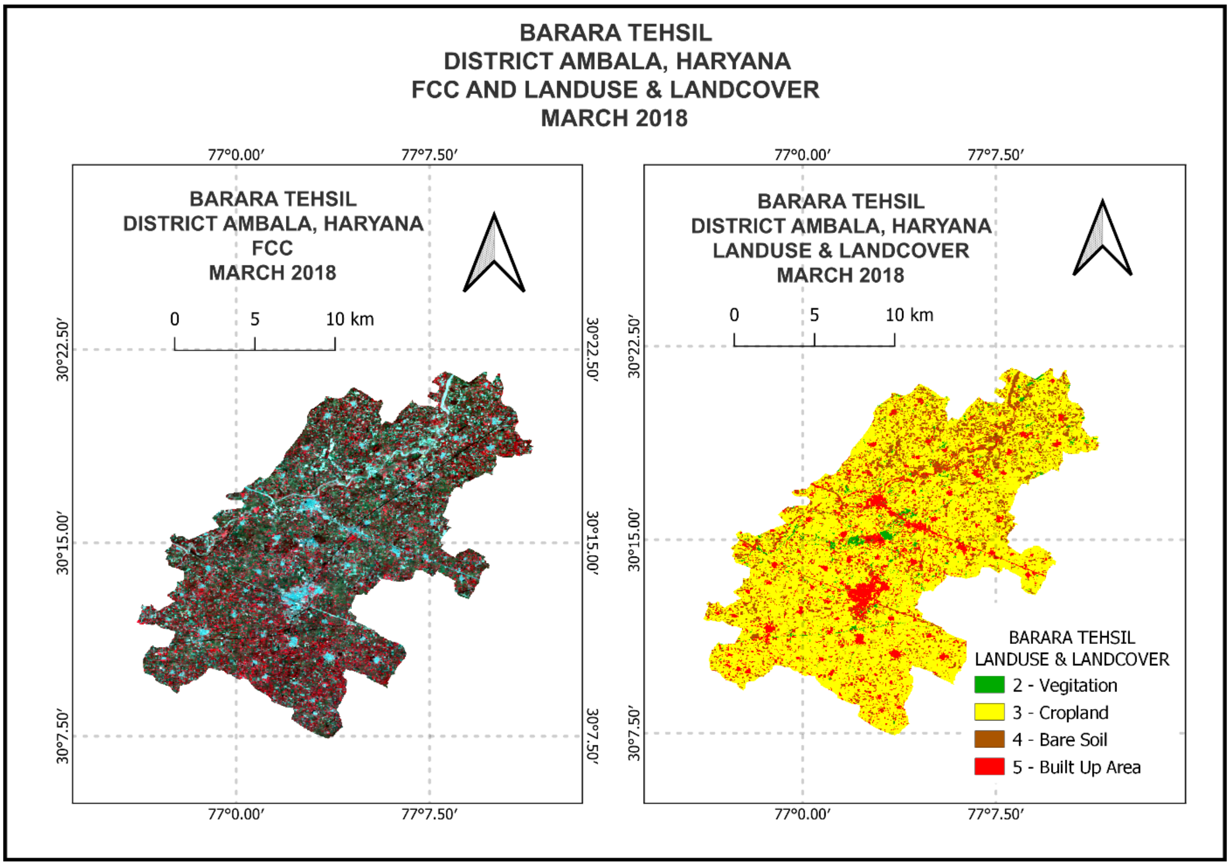
In summation, the methodological robustness enshrined in this study, spanning preprocessing to classification, ensured the meticulous extraction and interpretation of LULC data, fostering a comprehensive understanding of Ambala's terrains and anthropogenic imprints.

Results and Discussion:

Land Use and Land Cover (LULC) patterns serve as vital indicators of both the natural environment and socio-economic activities in a region. A systematic researching of these patterns can illustrate region's ecological health, socio-economic development trajectory, and its interaction with the natural environment. In this analytical discourse, we unknotting the LULC configurations of Barara Tehsil, situated within Ambala District, Haryana, as documented in March 2018.

Land Use and Land Cover Interpretation of Barara Tehsil

Data Overview:



Land Use and Land Cover of Barara Tehsil, District Ambala, Haryana March 2018			
Class Code	Class Name	Area in sq. km	Percentage
1	Water Body	0.3	0.1
2	Vegetation	6.58	2.13
3	Cropland	227.3	73.71
4	Bare land	37.51	12.16
5	Built-up Area	36.94	11.98
	Total Area	303.3	

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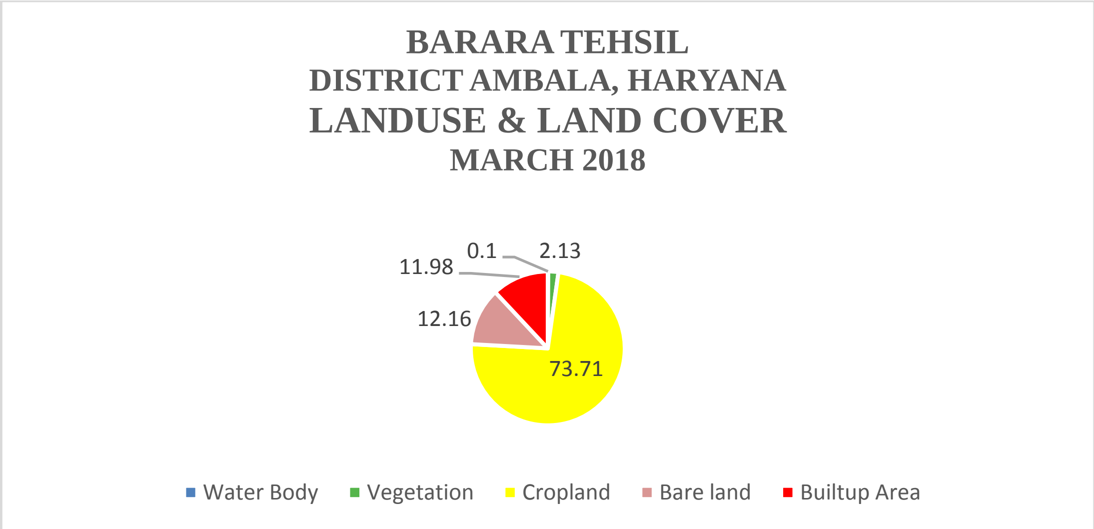

Interpretation and Significance:

1. **Cropland (227.3 sq. km, 73.71%):**

- **Interpretation**: Dominating the land use of Barara Tehsil, croplands underscore the region's predominant agrarian and occupational character. Brara distinguished with highest Cropland among all the three tehsils, other two are Ambala city and Naraingarh.
- **Significance**: This vast expanse reflects not only cropland's high occupancy but also heavy dependence of population on agriculture as an economic mainstay. It speaks to the fertility of the land and indicates the socio-economic dependency of a substantial portion of the population on farming. These croplands contribute directly to local food security, employment, and secondary agrarian industries.

2. **Bare Land (37.51 sq. km, 12.16%):**

- **Interpretation**: Bare lands in Barara, devoid of significant vegetation or agriculture or human uses, constitute over 12% of the area.
- **Significance**: These regions might be fallow lands, sites of over-exploitation, or naturally non-arable areas. They present potential opportunities for land regeneration, reforestation, or sustainable agricultural practices or industrial uses. Conversely, they may also be areas affected by degradation or overexploitation, necessitating conservation interventions.

3. **Built-up Area (36.94 sq. km, 11.98%):**

- **Interpretation**: Nearly 12% of Barara Tehsil is occupied by built-up areas, indicating human habitation- both rural and urban, infrastructure, and other man-made structures.
- **Significance**: These areas are scattered all over the tehsil but more concentrated around the Brara township. Itmirrors the socio-economic development of the tehsil, housing residential areas, industries, markets, roads, and institutions. The built-up areas serve as hubs for commerce, education, healthcare, and other vital services. Their spatial distribution and growth trends can offer insights into urban planning, infrastructure development, and socio-economic dynamics.

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4. **Vegetation (6.58 sq. km, 2.13%):**

- **Interpretation**: The vegetation class, which encircling forests, shrubs, and other green spaces, covers slightly over 2% of the tehsil.
- **Significance**: Such vegetative patches are the ecological base of the region. They perform essential ecosystem services like carbon sequestration, soil conservation, water recharge, detrivores health, and provision of habitat for local fauna. Socio-economically, these areas might support livelihoods through forestry, grazing, or recreational activities and eco-tourism.

5. **Water Body (0.3 sq. km, 0.1%):**

- **Interpretation**: Water bodies cover a tiny proportion of Barara Tehsil, representing lakes, rivers, ponds, and reservoirs. It is lowest in the Ambala district.
- **Significance**: While spatially limited, these aquatic areas are crucial for ecological diversity, agriculture (via irrigation), domestic use, and potentially, local cultural or recreational activities. Water bodies inherently regulate microclimates, recharge groundwater, and serve as habitats for aquatic biodiversity.

Concluding Remarks:

The LULC analysis of Barara Tehsil offers a subtle value of socio-economic and ecological dimensions. The over dominance of cropland underscores the region's agrarian character and significance, while the other land cover categories provide insights into its ecological health, urbanization patterns, and potential areas of conservation. Recognizing and understanding these patterns is paramount for informed policy-making, sustainable resource management, and supporting harmonious human-nature interactions in Barara Tehsil.

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