Remote Sensing Analysis of Land Use and Land Cover in Nariangarh Tehsil, Ambala District, Haryana: A 2018 Study

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Abstract

This study aimed to decipher the Land Use and Land Cover (LULC) patterns in Naraingarh Tehsil, Ambala District, Haryana, utilizing satellite imagery from 2018. Given the pivotal role of LULC in understanding ecological, socio-economic, and environmental dynamics, accurate data extraction is crucial. Historically reliant on governmental revenue documents and topographical maps, the modern era has embraced remote sensing and Geographic Information Systems (GIS) for comprehensive LULC analyses. In this context, Naraingarh, an administrative tehsil of Ambala, was chosen for its intricate socio-economic and geographical dosser. Using Landsat 8 Operational Land Imager (OLI) satellite imagery, preprocessing measures such as radiometric calibration, atmospheric correction, and spatial subsetting were executed. A supervised classification approach using the Maximum Likelihood Algorithm (MLA) enabled demarcation into distinct LULC categories. Analysis via the QGIS software revealed that the majority of the tehsil's landscape (71.1%) is dominated by croplands, followed by bare lands (13.4%), built-up areas (12.8%), vegetation (2.5%), and water bodies (0.1%). The results accentuate Naraingarh's agrarian character and the vital interplay of urban-rural dynamics, vegetation zones, and potential ecological restoration areas. The study underscores the importance of sustainable land management strategies to ensure harmonious development in conjunction with ecological conservation.

Keywords*: Land Use and Land Cover (LULC), Remote Sensing Analysis, Sustainable Development, Landsat 8, Satellite Imagery, Ecological Preservation*

Land use (LU) and land cover (LC) are foundational concepts in environmental studies and resource management, each offering a distinct lens through which the Earth's surface transformations can be comprehended. Land cover delineates the physical attributes of the land, such as vegetation, water bodies, and built environments. Conversely, land use elucidates the human interactions with these covers, encompassing purposes like agriculture, recreation, and habitation.

In today's rapidly changing global landscape, accelerated by population growth and urban expansion, there is an intensified alteration in LU and LC patterns. Recognizing these shifts is paramount for integrated urban planning, ecological preservation, and discerning climate change

ramifications. Moreover, it aids in promoting sustainable resource management, biodiversity conservation, and safeguarding vital ecosystem services.

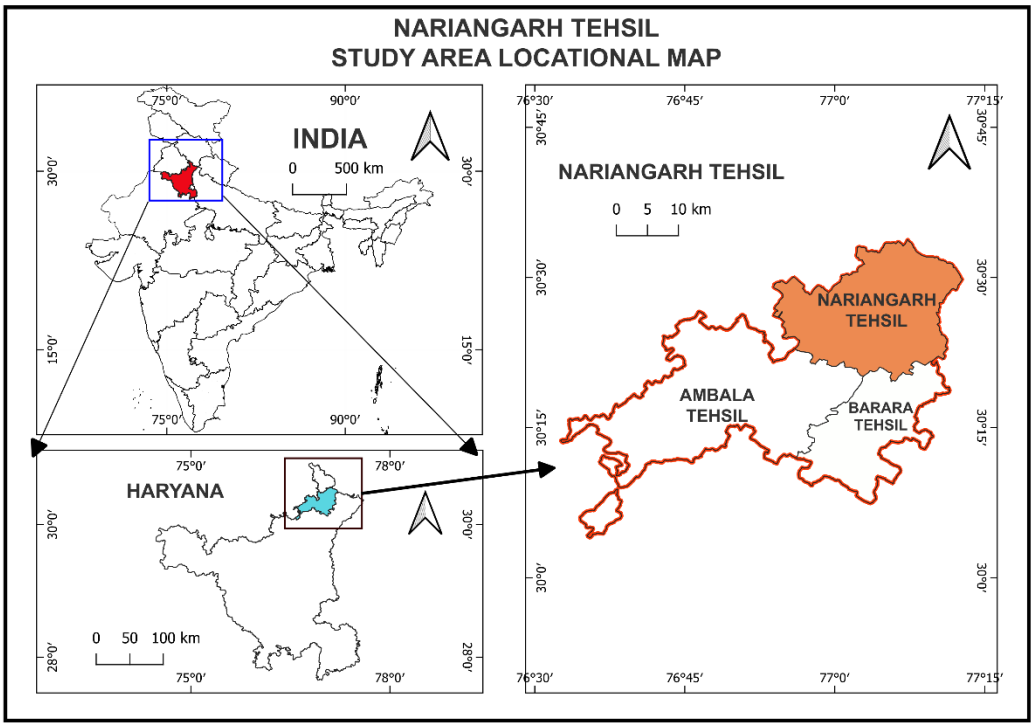
Historically, LU data extraction relied heavily on governmental revenue documents. Despite their value, these sources lacked spatial accuracy. Topographical maps, although broader in scope, were marred by sporadic updates, compromising their contemporary relevance. Conversely, soil maps, despite their specificity, were often confined to narrow project objectives.

Modern methodologies have witnessed a paradigm shift with the advent of remote sensing. Utilizing aerial technologies, notably satellites, this approach captures extensive, multi-spectral terrestrial images. Its wide reach and periodic revisitation ensure current and detailed LC classifications. Augmenting this is the Geographic Information Systems (GIS), which amalgamates and enables sophisticated spatial analyses.

A salient challenge in LU and LC research is the inconsistency in classification terminologies across varied agencies. Terms like "forest" can be ambiguous, differing based on the criteria of individual organizations. Addressing such inconsistencies necessitates a hierarchical classification framework, which permits both broad and precise categorizations. This study aims to enquire into LU and LC characterizations using remote sensing, emphasizing hierarchical Level 1 classifications. In summary, understanding the nuances of LU and LC is critical in today's dynamic context, and advancements in technology, such as remote sensing and GIS, amplify our capacity to interpret these changes with increased accuracy.

Study Area:

Naraingarh, is one of the important Tehsil within Ambala District of Haryana, which reflects the region's complex socio-economic and geographical fabric. As an administrative tehsil, Naraingarh is crucial to facilitating Ambala District's local governance and administration, revenue collection, agriculture promotion and community development.



Spread over 481 km², Naraingarh comprises 464.13 km² of rural expanse and 16.93 km² of urban area. Its population stands at 2,28,747, with a notable divide between its urban (30,962) and rural (1,97,785) inhabitants. The population density here is 476 inhabitants per square kilometre. Housing structures too echo this rural-urban dichotomy with 6,207 urban houses juxtaposed against a vast rural housing landscape of 36,611 households. Additionally, the literacy rate of the Tehsil is commendable, with 68.43% of the population being literate, showcasing 73.71% and 62.48 % males and females respectively.

Set against the broader dossier of Ambala District, Naraingarh provides a sample of the district's characteristics. Geographically, Ambala, situated between 30.2102° N and 30.6799° N latitude, and 76.6104° E and 77.0195° E longitude, unfolds over three administrative tehsils, including Ambala City, Brara, and Naraingarh. While Ambala City remains the largest in terms of area and population,Naraingarh holds second position and significance.

Ambala District's physiography is a unique blend of flat and rolling alluvial plains (Bangar and Khadar plains), seasonal flowing streams and rivers, and the captivating Shivalik Hills. The Ghaghar and Markanda rivers, coupled with seasonal streams like Tangari, Beghna, Sombhaand Markanda, underline its topographical landscape. The climatic conditions fluctuate seasonally, with the Shivalik Hills influencing local weather events and patterns. Summer months often experience temperatures exceeding 40°C, with winter plunging to near zero levels. Autumn and spring though transitional seasons, evident pleasant weather in the region.

Though urban settlements such as Ambala City and Ambala Cantt are predominant, Naraingarh reflects the district's inherent rural essence. Agriculture, a mainstay of Ambala's economy and so for Naraingarh, thrives in the Yamuna-Satluj doab region, nurturing crops like wheat, rice, maizeand sugarcane.

Ambala's strategic geographic positioning has cultivated it into a transportation nexus, with robust infrastructural advancements. Like Ambala City and Ambala Cantt,Naraingarh is also evolving as commercial and agricultural hub, are testament to its growth. Yet, amidst this urban development, the verdant vegetation of the district persists with trees like neem and Sheesham gracing the landscape.

In sum, Naraingarh, as a component of Ambala District, mirrors the larger district's multifaceted nature. Its socio-economic and geographical nuances underscore the interconnectedness of regional governance, economic pursuits, and ecological vitality.

Data Used:

For this analysis, the satellite imagery was sourced from the Landsat 8 Operational Land Imager (OLI), a renowned platform for Earth observation. Researchers and scholars can access this dataset via the Earth Explorer portal, available at https://earthexplorer.usgs.gov.

The specific bands from the OLI, which were employed for this research, are enumerated below with their respective specifications:

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

- Wavelength: 1.57 - 1.65 µm
- Spatial Resolution: 30 m

6. Band 7 (SWIR 2)
    - Wavelength: 2.11 - 2.29 µm
    - Spatial Resolution: 30 m

To ensure the precision and clarity of the images, the selected dataset pertained to those captured in March 2018, a period which strategically aligns with the culmination of the Rabi agricultural season, thereby ensuring minimal cloud interference. This meticulous selection not only underscores the importance of acquiring cloud-free images but also the significance of temporal specificity in satellite-based research.

Methodology:

1. Preprocessing of Satellite Imagery:

Preprocessing forms an indispensable phase in satellite imagery analysis, intended to optimize the accuracy and validity of subsequent evaluations. Given the intricacies inherent in acquiring satellite imagery, a spectrum of preprocessing measures was executed:

a. Radiometric Calibration:
Satellite sensors chronicle the reflected or emitted radiation from terrestrial surfaces as digital numbers (DN). It is imperative to transmute these DNs into genuine radiance values to accurately echo the intensity of radiation perceived by the satellite sensor. This metamorphosis incorporates calibration constants embedded within the satellite sensor's metadata, facilitating the transformation of DNs to radiance.

b. Atmospheric Correction:
The terrestrial atmosphere has the potential to modulate the spectral signatures registered by satellite sensors, a consequence of the scattering and absorption phenomena of electromagnetic radiation. In order to ensure the imagery faithfully reflects terrestrial conditions, devoid of atmospheric perturbations, atmospheric corrections are instituted. A compendium of algorithms, tailored to the satellite sensor and prevailing atmospheric dynamics, are mobilized to rectify these aberrations, aiming to retrieve authentic surface reflectance values.

c. Spatial Subsetting:
To bolster computational efficacy and target a specific geographical enclave, the comprehensive satellite imagery undergoes spatial subsetting. This strategic exercise isolates theNariangarhtehsil withinAmbala District of Haryana State from the broader image, anchoring the analysis to the study's stipulated objectives.

The meticulous execution of these preprocessing maneuvers is paramount to ensure the veracity of land use and land cover (LULC) interpretations derived from satellite imagery.

2. Supervised Classification:

Extraction of LULC patterns from satellite imagery serves as a linchpin for diverse endeavors, from urban development blueprints to ecological stewardship. Supervised classification, underpinned by the analyst's pre-existing comprehension of the study zone, emerges as a pivotal method in this regard.

Within this classification paradigm, the Maximum Likelihood Algorithm (MLA) is distinguished by its probabilistic foundation. This algorithm, in essence, quantifies the likelihood of a pixel resonating with a specific class predicated upon its spectral signatures. The algorithm harmoniously integrates the mean and variance metrics of each band for every class and designates the pixel to the class exhibiting the maximal probability quotient. Central to this methodology is the presumption of normal distribution of pixel spectral values within each band for each class.

For the immediate study, deploying the MLA availed categorization of satellite imagery into pivotal LULC categories, notably:

1. **Water Body:** Demarcating zones dominated by aqueous expanses like lakes, rivers, and reservoirs. Water may be still or running forms. Water's intrinsic spectral properties, particularly in near-infrared bands, render it distinguishable.
2. **Vegetation:**It includes natural canopy and tree cover. It also encompasses zones or areas with a preponderance of tree canopy or assorted vegetation. Chlorophyll's strong reflective and absorptive capabilities demarcate vegetation.
3. **Cropland:** Signifies areas under agrarian use, with spectral signatures fluctuating based on crop variety and growth phase.
4. **Bare Land:** Zones characterized by scant or null vegetation, embody by deserts or exposed terrains.
5. **Built-up Land:** Urbanized expanses inclusive of architectural constructs, thoroughfares, and other anthropogenic edifices, identifiable by elevated reflectance across multiple bands.

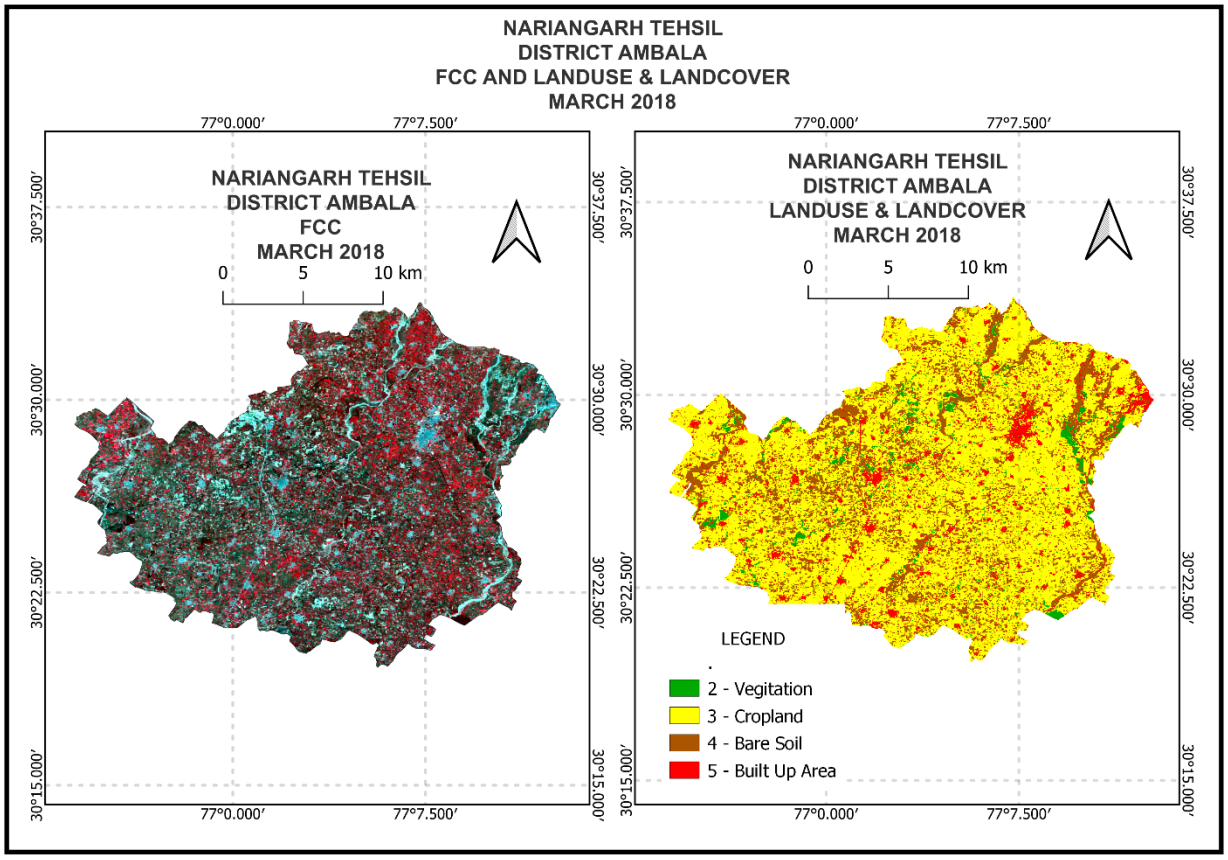
The efficacy of the supervised classification, especially when wielding the MLA, hinges profoundly on the judicious selection of training samples. Their apt selection guarantees the cogent interpretation of satellite-derived spectral data into germane LULC clusters.

Analytical Tools:

The interpretative analysis of the LULC data, extracted from the Landsat 8 imagery, was orchestrated utilizing the QGIS software suite. QGIS, an acronym for Quantum GIS, is an open-source geographic information system (GIS) tool that proffers capabilities to visualize, modify, and analyze geospatial datasets. Celebrated for its adaptability and scalability, QGIS serves as an all-encompassing nexus for multifaceted geospatial evaluations. Its open-source ethos further ensures unfettered accessibility to a broad spectrum of users, obviating licensing impositions.

Results and Discussion:

The land use and land cover (LULC) characteristics of an area are central in understanding its ecological, social, and economic dynamics. This study insight in the LULC of Nariangarh Tehsil using satellite imagery for 2018, shedding light on the spatial patterns across five distinct categories and their implications.

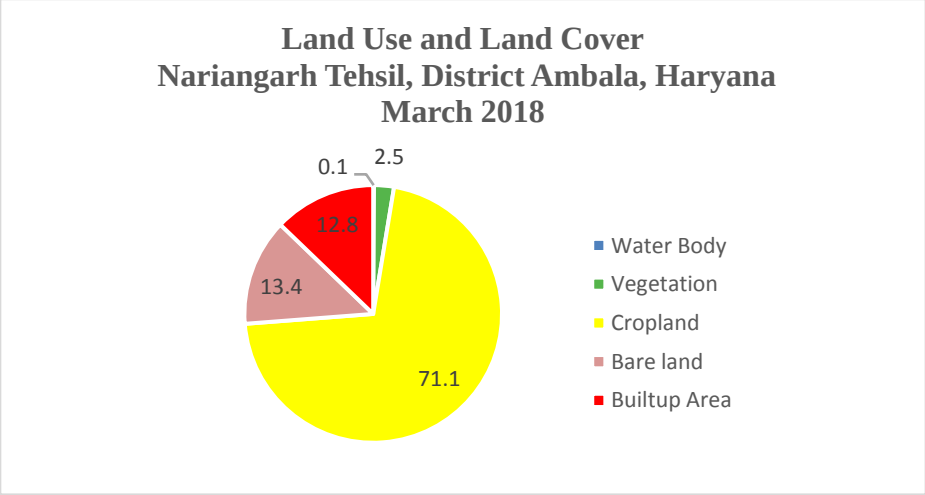


Land Use and Land Cover (LULC) Analysis of Nariangarh Tehsil

Land use and land cover patterns are integral in showing the relationship between human activities and the natural environment. In Nariangarh Tehsil, the 2018 satellite imagery offers

refined perspective on this intricate relationship, revealing details of agricultural, built-up or settlements, and natural landscapes.

Land Use and Land Cover Nariangarh Tehsil, District Ambala, Haryana March 2018			
Class Code	Class Name	Area in sq. km	Percentage
1	Water Body	0.4	0.1
2	Vegetation	14.97	2.5
3	Cropland	328.77	71.1
4	Bare land	99	13.4
5	Builtup Area	33.9	12.8
	Total Area	477.7	



1. **Cropland - 328.77 sq. km (71.1% of Total Area)**

   Undoubtedly, themost extensive land use among all, the cropland is the cornerstone of Nariangarh's LULC landscape. It holds the first position under the LULC landscape. It's reflecting the region's agrarian character, these areas witness to the dependency on agriculture for sustenance and economic growth and consequently societal upliftment. The enormity of this category underscores the region's agronomic potential, attributed to its flat topography, fertile soils and water availability. However, to check soil degradation and maintain productivity, adopting suitable and sustainable agricultural practices is imperative. The prominent reason for high proportion of cropland in Naraingarh is its rural character with small and scattered villages in close proximity with Siwalik foothills with rolling topography.

2. **Bare Land - 99 sq. km (13.4% of Total Area)**

   Bare land accounts distantly second place under the LULC morphology in the district. Bare lands, while seemingly barren, are full of untapped potential. Their emergence is a result of dry river beds, land degradation events, including fellow lands and soil quarrying for brick kiln. However, their rehabilitation offers a silver lining, either by transforming them into productive lands or by introducing afforestation initiatives or can be put under industrial production. Investigating the underlying reasons for such bare patches would offer insights into their best potential uses and consequently future development planning for the region.

3. **Built-up Area - 33.9 sq. km (12.8% of Total Area)**

   Spanning 33.9 sq. km and constituting 12.8% of the total area, the built-up zones in Nariangarh Tehsil offer subtle reflection of the region's diverse settlement patterns.Naraingarh town is the core of built-up area interspersed with small villages around it., representing the central urban pulse of the tehsil, Nariangarh townis the largest built-up expanse in the tehsil. It is complemented by the myriad rural settlements or villages, which together create a mosaic of modernity and tradition. This combination underlines the tehsil's unique blend of urban advancements and the traditional charm inherent to its villages. As such, the built-up areas stand as symbolic intersections of development, culture, and heritage within Nariangarh.

4. **Vegetation - 14.97 sq. km (2.5% of Total Area)**

   Representing the tehsil's green rampart, these vegetation zones cater to diverse ecological functions. Trees, shrubs, and grasslands within this category not only support multiple species but also modulate the local climate. Their role in carbon sequestration and recreational avenues for residents further accentuates their importance. The rolling topography of the tehsil sets up picturesque vegetation canopy. The encroachment of urban or agricultural activities into these green patches, however, suggests a potential need for sustainable management strategies.

5. **Water Bodies - 0.4 sq. km (0.1% of Total Area)**

   Water bodies, though comprising a minor segment of Nariangarh's area, are indispensable for the local ecosystem. Encompassing features like ponds, lakes, and reservoirs, they serve as freshwater repositories, wetlands, biodiversity hubs, and potential aids for agriculture and aquaculture. Their sparse distribution underlines the critical need for their conservation, emphasizing their multifaceted ecological significance.Nariangarh Tehsil, as portrayed through the 2018 LULC data, emerges as an agricultural heartland peppered with urban and rural settlements, overgrown patches, and areas awaiting ecological restoration. This mosaic underscores the necessity of strategic land management, boosting sustainable development while preserving its ecological sanctity.

Conclusion:

Nariangarh Tehsil's 2018 Land Use and Land Cover (LULC) analysis reveals a deeply intertwined relationship between society-resources interrelationships, with agriculture as a managed ecosystem playing a dominant role. The tehsil's physiographical mosaic, carved by expanding croplands, urban-rural land uses, sparse water bodies, and significant vegetation patches, underscores the exquisite balance between economic pursuits and ecological vitality. The blend of built-up areas juxtaposed against the vast agricultural canvas evidentNariangarh's dynamic socio-economic and environment fabric. As urban settlements continue to expand and ecological concerns scale up, the study underline the imperative of sustainable land management practices. In a rapidly evolving landscape, preserving Nariangarh's ecological essence while encouraging development is not only a challenge but a necessity. Embracing integrated planning for resource management and adopting sustainable practices, rooted in the insights garnered from such LULC analyses, can drive the region towards a sustainable future, where viable economic growth with environmental conservation amalgamates seamlessly.

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