Academic Synergy: A Multidisciplinary Research Outlook in Humanities and Social Sciences

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Integrated Land Use and Land Cover (LULC) Analysis and Agro-Scientific Evaluation within a 10 km Buffer: A Comparative Multi-Site Study

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Abstract

This study presents a comprehensive Land Use and Land Cover (LULC) classification and agro-scientific assessment for three project sites within a 10 km buffer, representing agro-industrial, riverine, and urban-influenced landscapes. The study area contains the following land use types like agriculture, vegetation/fallow land, settlement and water bodies along with riversand. Using Sentinel-2A satellite imagery and supervised classification techniques, spatial distribution of land use categories was analyzed and quantified. The study highlights variations in agricultural potential, ecological stability, and urban pressure across the sites. Site A demonstrates strong agricultural dominance and development suitability, Site B reflects a dynamic riverine ecosystem with moderate agricultural productivity, while Site C shows significant urban influence and ecological stress. The findings highlights Agro industrial site is dominated with Agriculture with support from Vegetation & availability of perennial water bodies shows high productivity, Riverine site being a floodplain dominated by vegetation depicts dynamic changes according to hydrological changes, good presence of riversand shows ecological sensitivity Settlement being the major land use with fragmentation of agriculture clearly depicts high anthropogenic activities low vegetation density buffering capacity near urban site and also emphasize the importance of integrating remote sensing with agro-scientific analysis for sustainable land use planning, resource management, and environmental conservation. It is evident from the study that as compared to other sites overall Agriculture is on decline more fallow land patterns can be seen with presence of Landuse conflict, River dependency for irrigation. The study of individual projects sites with other surrounding villages for comparison gives a better understanding of the environment.

Keywords: LULC, Remote Sensing, Agro-Scientific Assessment, Riverine Ecosystem, Urbanization, Agriculture, GIS

1. Introduction

Studying Land Use and Land Cover (LULC) is about more than just drawing lines on a map—it is the foundation for understanding how we use our land and how natural ecosystems are holding up. In areas with heavy farming and active river systems, this analysis is especially crucial. It helps us see the direct tug-of-war between natural processes and human activities. This study takes a deep dive into the areas within a 10 km radius of our project sites, blending land classification with agricultural science. We have selected three very different locations to get a complete picture of the landscape:

Site A: An agro-industrial area.

Site B: A river floodplain along the Ganga.

Site C: An urban-influenced stretch of the Yamuna River in Agra.

By comparing these three sites, we can evaluate how resources are spread out, measure farming potential, check ecological health, and see where development is putting the most pressure on the environment. Ultimately, this chapter goes beyond just listing land categories. We want to interpret what these categories mean for local agriculture and ecology, giving you a complete, big-picture understanding of how these land systems work.

2. Literature Review

Land Use and Land Cover (LULC) classification has become a vital tool in environmental analysis, particularly with advancements in remote sensing and Geographic Information Systems (GIS). It plays a crucial role in understanding landscape dynamics, agricultural productivity, and ecological sustainability. The foundational work of *Anderson et al.* established standardized LULC classification systems, enabling consistent categorization of land cover types. With the advancement of satellite-based observations, researchers such as *Jensen J.R.* highlighted the importance of multispectral imagery in improving classification accuracy. Data from platforms like Landsat and Sentinel-2 have significantly enhanced the monitoring of land use changes over time.

In India, LULC studies have been widely applied to agricultural and river basin analysis. Contributions from *Roy P.S. and the National Remote Sensing Centre* have demonstrated the utility of remote sensing in mapping agricultural land, forests, and wastelands, supporting land resource management and policy decisions. Agro-scientific research indicates that land use patterns are closely linked to soil fertility, irrigation availability, and cropping systems. In alluvial river basins such as the Ganga River and Yamuna River, sediment deposition plays a significant role in enhancing soil productivity. However, riverine systems are highly dynamic and sensitive, and activities like sand mining can disrupt sediment balance, groundwater recharge, and agricultural sustainability. Urbanization has emerged as a major driver of land use change, particularly in peri-urban regions. Rapid expansion of settlements in cities such as Agra has led to the conversion of agricultural land into built-up areas, resulting in fragmentation, reduced productivity, and increased environmental stress.Recent studies emphasize the integration of LULC analysis with sustainability frameworks, especially within buffer zones (e.g., 10 km radius) commonly used in Environmental Impact Assessment (EIA). Comparative multi-site approaches further enhance understanding by evaluating how different landscapes respond to developmental pressures. Despite advancements, challenges such as spectral similarity, seasonal variation, and limited ground validation persist. However, improvements in satellite technology and analytical techniques continue to enhance the accuracy and applicability of LULC studies.

3. Methodology

3.1 Data Sources: The analysis is based on high-resolution multispectral satellite imagery derived from Sentinel-2A datasets. These datasets provide spectral information across multiple bands, enabling accurate differentiation between land cover types such as vegetation, water bodies, built-up areas, and agricultural fields.