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# GIS-Based Analysis of Land Use, Vegetation and Soil Characteristics of Jhargram Block, West Bengal

Ajijul Mir
Department of Forestry
North Eastern Hill University
Meghalaya, India

Debaaditya Mukhopadhyay
ICFRE-Rain Forest Research Institute,
Jorhat, Assam, India
and Techno India University,
West Bengal, Kolkata, India

Masjuda Khatun
ICAR-National Bureau of Soil Survey & Land Use Planning, Regional Centre Kolkata, India

Sk Mujibar Rahaman
National Atlas and Thematic Mapping Organisation, Kolkata, India

**Abstract - Remote sensing and Geographic Information System (GIS) techniques provide effective tools for regional environmental assessment by enabling integrated analysis of land surface characteristics. This study presents a GIS-based assessment of land use land cover (LULC), vegetation condition, soil texture and climatic variability for Jhargram block, West Bengal, using Landsat 8 OLI imagery and ancillary datasets. The results indicate that agricultural land (49.76%) dominates the landscape, followed by forest cover (37.87%), with built-up areas occupying a smaller proportion. NDVI analysis reveals generally moderate vegetation condition with localized zones of lower values, reflecting spatial variability linked to land use, soil properties and moisture availability. Soil texture mapping shows the predominance of sandy clay loam and clay loam soils, which are moderately susceptible to erosion under variable rainfall conditions. The integrated interpretation of land use, vegetation, soil and climate information demonstrates that GIS-based multi-indicator approaches provide a comprehensive spatial understanding of environmental characteristics and land sensitivity at the block level. The study highlights the usefulness of simple, reproducible geospatial frameworks for regional environmental assessment and land management applications, particularly in data-scarce and semi-rural regions.**

***Keywords - GIS; Remote Sensing; LULC; NDVI; Soil; Jhargram***

## I. INTRODUCTION

Land use change, vegetation dynamics and soil characteristics play a crucial role in shaping regional environmental conditions and influencing land management outcomes [1, 11]. Increasing population pressure, coupled with growing climate variability, has intensified the need for spatially explicit assessment of land resources to support effective planning and sustainable management. In many semi-rural and agrarian regions, inappropriate land use and declining land quality have emerged as key challenges affecting ecosystem stability and agricultural productivity [7].

Geographic Information System (GIS) and remote sensing techniques provide effective tools for monitoring land surface processes and environmental change across spatial and temporal scales [5, 12, 16]. These technologies enable systematic observation of land use dynamics, vegetation condition and environmental variability, offering significant advantages over conventional field-based assessments, particularly in data-scarce regions [3, 13, 15]. The integration of spatial datasets within a GIS framework further allows visualization and analysis of complex environmental patterns, supporting regional-scale assessment and informed decision-making [4].

Satellite-derived vegetation indices, particularly the Normalized Difference Vegetation Index (NDVI), have been widely used to assess vegetation condition and land surface dynamics due to their simplicity, robustness and sensitivity to changes in vegetation cover [6, 2]. However, several studies have emphasized that NDVI-based assessments are most informative when interpreted alongside land use, soil properties, and climatic context, as vegetation response is strongly influenced by underlying biophysical conditions [1, 5, 14].

Soil texture is a fundamental determinant of land response to both land use and climate variability, influencing infiltration capacity, moisture retention, and erosion susceptibility [9, 11]. Similarly, rainfall and temperature variability exert strong controls on vegetation growth and soil moisture availability, particularly in rainfed agricultural systems common in eastern India [8, 14]. Integrating soil and climate information with land use and vegetation indicators therefore provides a more realistic representation of environmental conditions than single-layer analyses.

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In this context, the present study applies GIS and remote sensing techniques to analyze land use/land cover, vegetation condition, climate trends, and soil texture of Jhargram block, West Bengal. By integrating multiple satellite-derived and ancillary spatial datasets, the study demonstrates how a simple and reproducible multi-indicator geospatial framework can enhance regional environmental assessment. The approach provides spatially explicit information relevant to land management and planning and contributes to a growing body of work emphasizing integrated geospatial analysis for understanding land sensitivity and environmental stress at local and regional scales.

## II. STUDY AREA

Jhargram block is located in Jhargram district of West Bengal, India, and is characterized by undulating terrain, lateritic soils and a landscape dominated by agricultural land interspersed with forest patches. The region is largely rainfed and sensitive to rainfall variability, soil degradation and land-use pressure, making it a relevant setting for examining block-level sustainability planning.

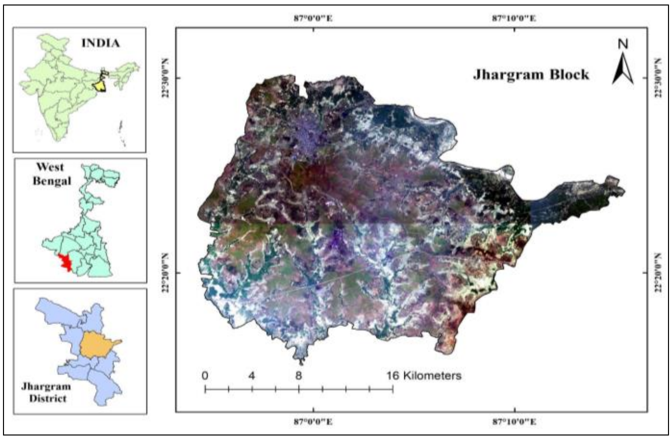


**Fig. 1.** *Location map of the study area*

## III. DATA AND METHODS

The study employs a GIS-based, multi-indicator approach to assess land use/land cover, vegetation condition, soil texture, and climatic variability at the block level. The methodological framework emphasizes the integration of widely used satellite-derived and ancillary datasets to provide a spatial understanding of environmental characteristics relevant for regional assessment [5, 4].

Landsat 8 Operational Land Imager (OLI) data acquired on 15 March 2024 (Path 139, Row 44–45) with a spatial resolution of 30 m were used as the primary data source. Landsat 8 provides multispectral observations suitable for land use and vegetation analysis and has been extensively applied in environmental and regional studies [10]. Standard image preprocessing steps, including radiometric correction and cloud masking, were applied to minimize atmospheric and sensor-related effects. The processed imagery was clipped to the administrative boundary of Jhargram block to ensure spatial consistency across all analyses. Land use/land cover (LULC) classification was performed using a supervised classification approach to identify major land-use categories relevant at the block scale. Broad classes, including agricultural land, forest, built-up areas, water bodies, and barren land, were delineated to capture dominant land-use patterns while maintaining interpretability. Class-wise area statistics were calculated to quantify the spatial distribution of each LULC category. Similar classification approaches using Landsat data have been widely adopted for regional land use assessment [3]. Vegetation condition was evaluated using the NDVI, derived from red and near-infrared spectral bands of Landsat 8 OLI. NDVI is a widely used indicator of vegetation vigor and land surface dynamics due to its simplicity and robustness [6, 2]. The NDVI map was used to examine spatial variability in vegetation condition across the block and to identify areas exhibiting relatively lower vegetation values. Climatic context was provided using rainfall and temperature data compiled from secondary sources to examine interannual variability affecting the study area. Climate variability plays a significant role in influencing vegetation growth and soil moisture dynamics, particularly in rainfed agricultural systems [8]. Soil texture data were obtained from existing soil maps and integrated within the GIS environment. Soil texture classes were used as indicators of intrinsic land sensitivity, as soil properties strongly influence infiltration, moisture retention, and erosion susceptibility [9, 7]

All spatial datasets were integrated within a GIS framework to enable visual comparison and spatial interpretation. The analysis focused on identifying spatial patterns and relationships among land use, vegetation condition, soil texture, and climatic variability rather than developing predictive models. By combining multiple geospatial indicators, the study adopts a reproducible and scalable approach suitable for regional environmental assessment and land management applications [4, 3].

## IV. RESULTS AND DISCUSSION

The LULC analysis indicates that agricultural land (49.76%) is the dominant land-use category in Jhargram block, followed by forest cover (37.87%), while built-up (10.35%) areas occupy a smaller proportion of the total area (Fig. 2a and 3). Such land-use patterns are typical of semi-rural regions in eastern India, where agriculture and forest resources play a central role in local livelihoods [1].

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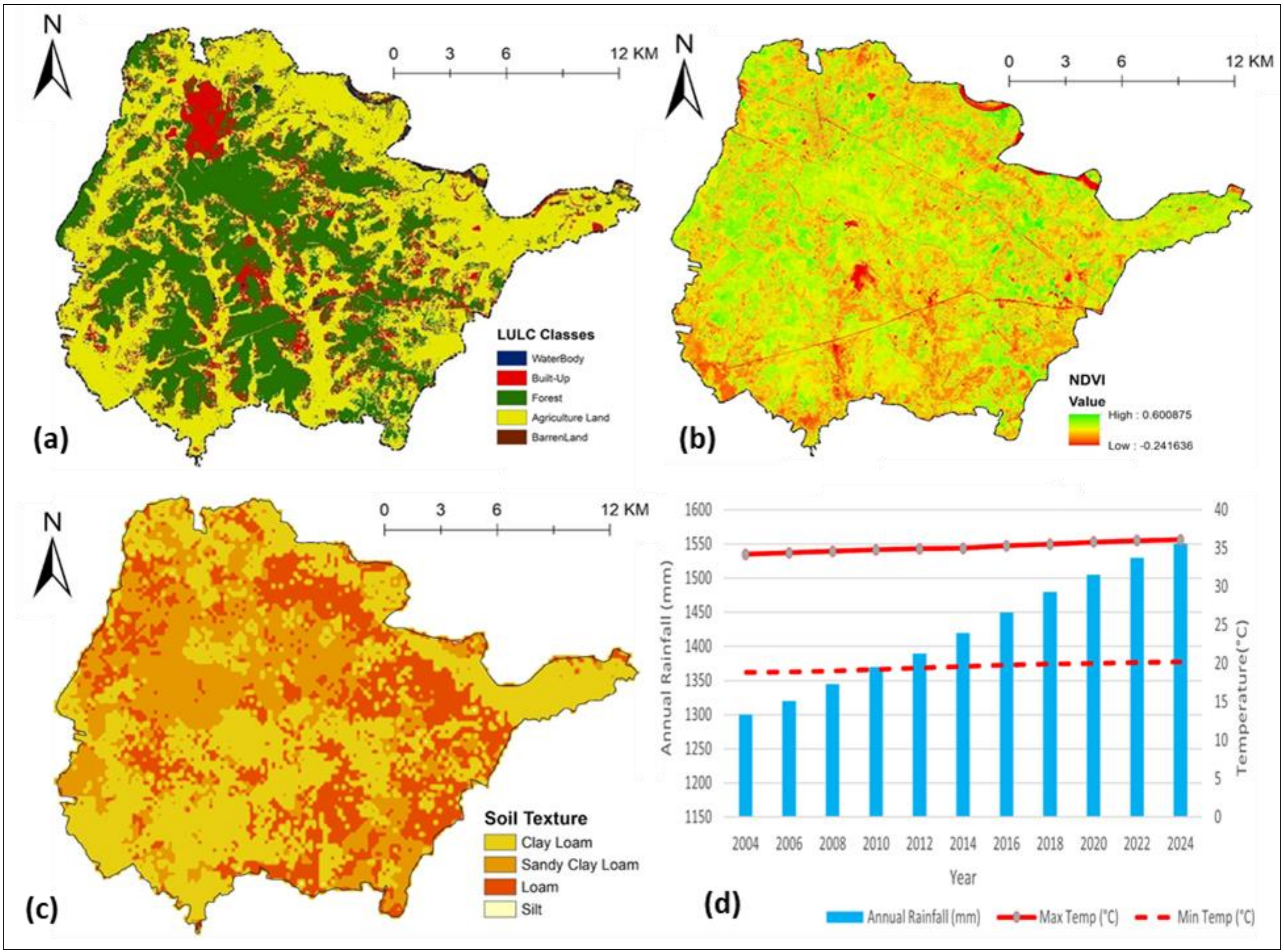


**Fig. 2.** (a) Land use/land cover (LULC) map of Jhargram block derived from Landsat 8 OLI imagery (2024), showing major land-use classes. (b) Spatial distribution of NDVI indicating variability in vegetation condition across the block. (c) Soil texture distribution highlighting dominant soil types and intrinsic land sensitivity. (d) Long-term trends in annual rainfall and temperature (2004–2024) illustrating hydro-climatic variability affecting the study area.

NDVI results show generally moderate vegetation condition across the block, with localized areas of lower NDVI values (Fig. 2b). Previous studies have demonstrated that spatial variability in NDVI can reflect differences in land use, soil conditions, and moisture availability [6, 2]. Although NDVI does not directly measure productivity, it remains a widely accepted indicator for regional vegetation assessment.

Soil texture analysis shows the predominance of sandy clay loam and clay loam soils (Fig. 3c), which are moderately susceptible to erosion under intensive land use and variable rainfall conditions [9, 7]. Analysis of rainfall and temperature trends indicates interannual variability, which influences vegetation growth and soil moisture conditions (Fig. 3d). Climate variability has been recognized as a key driver of land surface processes and vegetation dynamics, particularly in rainfed agricultural systems [8].

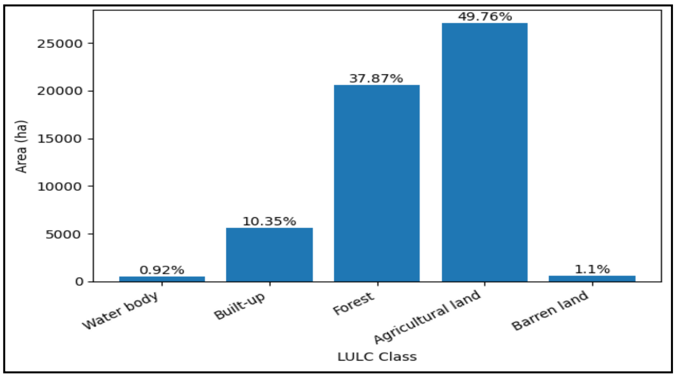


**Fig. 3.** *Bar graph showing land use/land cover distribution of Jhargram block (2024). Bar height represents area (ha), and labels indicate the proportional share (%) of each LULC class*

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The integrated interpretation of land use/land cover, vegetation condition, soil texture, and climatic variability provides a holistic understanding of environmental characteristics and land sensitivity at the block level. Rather than functioning as isolated thematic layers, these geospatial indicators collectively reveal how land use patterns interact with biophysical constraints to shape regional environmental conditions. Such integrated analysis is increasingly recognized as essential for understanding coupled land–vegetation–climate–soil systems, particularly in data-scarce, semi-rural regions [5, 4].

The dominance of agricultural land alongside substantial forest cover, when interpreted together with moderate NDVI values, suggests a landscape that is productive yet environmentally sensitive. Areas exhibiting lower NDVI values within agricultural and transitional zones may represent early signals of land stress associated with soil limitations and moisture variability. Previous studies have emphasized that identifying such spatial gradients is critical for anticipating land degradation before irreversible thresholds are crossed [1, 2]. In this context, NDVI serves not only as a vegetation indicator but also as an indirect proxy for land health when analyzed alongside land use and soil information.

Soil texture plays a key moderating role in determining how land use and climate variability translate into on-ground impacts. The predominance of sandy clay loam and clay loam soils indicates moderate water-holding capacity but heightened susceptibility to erosion under intensive land use and erratic rainfall. When combined with observed climatic variability, this soil context underscores the vulnerability of rainfed agricultural systems to both short-term weather fluctuations and longer-term climate stress [9, 7]. Integrating soil texture with land use and NDVI therefore enhances the diagnostic value of geospatial assessments, allowing identification of areas where similar land uses may respond differently to climatic forcing.

The observed interannual variability in rainfall and temperature further amplifies the importance of integrated geospatial interpretation. Climate variability has been widely documented as a key driver of vegetation dynamics, soil moisture availability, and land surface processes, particularly in monsoon-dependent agricultural regions [8]. By embedding climatic context within land and vegetation analyses, GIS-based approaches enable a more realistic assessment of environmental conditions than static land-use mapping alone. This integration is particularly relevant for understanding cumulative and interacting stresses on land systems rather than isolated drivers.

From a methodological perspective, the findings reinforce the value of multi-indicator geospatial frameworks for regional environmental assessment. Similar studies have demonstrated that integrating land use, vegetation indices, soil properties, and climate data improves the interpretability and applicability of geospatial outputs for land management and planning [4, 3]. Importantly, the approach adopted here relies on widely available datasets and standard GIS techniques, making it both scalable and reproducible across comparable administrative units.

Overall, the results highlight that GIS-based integration of satellite-derived indicators offers more than descriptive mapping; it provides a spatially explicit understanding of land sensitivity, environmental constraints, and management priorities. Such integrative analyses are increasingly important for supporting regional environmental assessment, monitoring land system dynamics, and informing sustainable land management in heterogeneous landscapes [5, 7].

## V. CONCLUSION

The present study demonstrates the effectiveness of GIS and remote sensing techniques in integrating land use, vegetation condition, soil texture and climatic variability to assess environmental characteristics at the block level. Using Jhargram block as a case study, the analysis reveals a landscape dominated by agriculture and forest cover, moderate vegetation condition and soil characteristics that influence land sensitivity under variable climatic conditions. When interpreted together, these indicators provide insights that extend beyond descriptive mapping toward a diagnostic understanding of land–soil–vegetation–climate interactions.

The findings emphasize that NDVI, when analyzed alongside land use and soil context, can serve as an indirect indicator of land condition rather than vegetation status alone. Similarly, the integration of soil texture and climate information enhances the ability to identify areas potentially vulnerable to erosion and moisture stress. Such multi-indicator geospatial frameworks are particularly valuable in semi-rural and data-limited regions, where they offer scalable and reproducible means of environmental assessment.

Overall, the study highlights that GIS-based integration of satellite-derived indicators provides a practical and transferable approach for regional environmental analysis and land management planning. By enabling spatially explicit identification of land sensitivity and environmental constraints, this approach supports informed decision-making and monitoring of land system dynamics at local and regional scales.

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