



"Quantitative Assessment of Land Use Dynamics in East Jaintia Hills: A GIS and Remote Sensing Approach to Coal Mining Impacts".

Author Details

Name: Phrangshai Hynniewta

Designation: Assistant Professor

Work place: Captain Williamson Sangma State University, Tura, Balalgre, Meghalaya & Research scholar at William Carey University, Shillong

Abstract

The East Jaintia Hills district of Meghalaya, India, has been significantly impacted by coal mining activities, leading to notable changes in land use patterns. This research paper employs Geographic Information Systems (GIS) and remote sensing techniques to quantitatively assess these land use dynamics. By analyzing satellite imagery and spatial data over time, this study aims to provide insights into the environmental consequences of coal mining and inform sustainable land management practices.

Keywords: Land use dynamics, GIS, remote sensing, coal mining, East Jaintia Hills, Meghalaya, environmental impact, Datasets, Data Preprocessing, Geo-referencing, Image Enhancement, Radiometric Correction, temporal changes, Visualization

1. INTRODUCTION

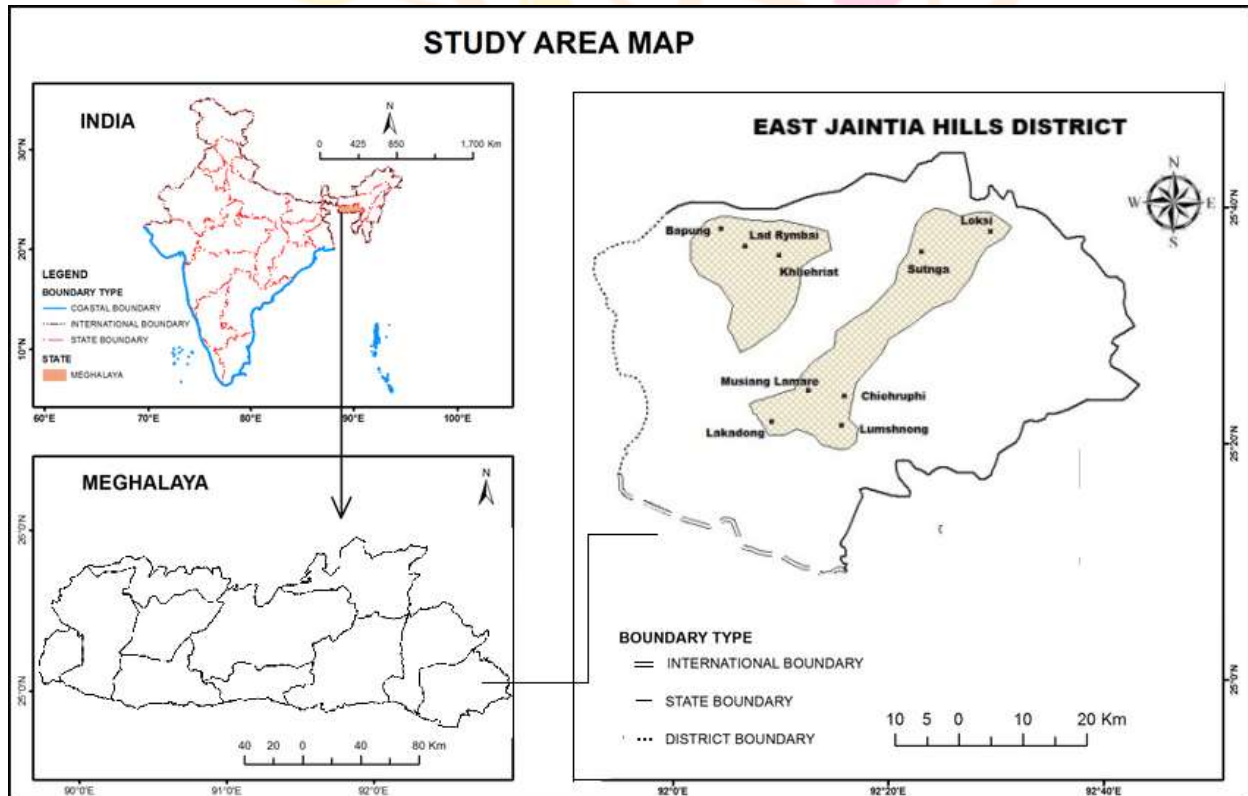
Coal mining is a critical economic activity in the East Jaintia Hills region, contributing to local livelihoods but also resulting in substantial environmental degradation. The objective of this study is to quantify the changes in land use due to coal mining operations using advanced GIS and remote sensing methodologies. Understanding these dynamics is essential for policymakers and stakeholders aiming to balance economic development with environmental conservation.

2. STUDY AREA

The East Jaintia Hills district is characterized by its unique topography, rich biodiversity, and significant coal reserves. The area has experienced rapid industrialization due to mining activities since the late 20th century. This section will detail the geographical features, climate, and socio-economic context of the region.

East Jaintia Hills district in Meghalaya, located in the northeastern part of India, is known for its rich mineral resources, particularly coal. The region has a long history of coal mining, which has been a significant part of its economy. The district is part of the Jaintia Hills range, which is characterized by steep slopes and deep valleys, providing an ideal geological setting for coal deposits.

The coal mining activities in East Jaintia Hills primarily involve the extraction of high-quality coal, mainly through the traditional "rat-hole" mining method. This method involves digging small and narrow tunnels into the earth, making it labor-intensive and often dangerous. The coal extracted is predominantly used for local consumption and sold to other parts of India.



While coal mining has contributed to the economic development of the area, it has also raised concerns about environmental degradation and the safety of miners. The unregulated nature of the mining process has led to deforestation, pollution of water bodies, and health hazards for workers. In recent years, there have been efforts to regulate mining activities, but challenges remain in balancing economic benefits with environmental sustainability and worker safety.

The East Jaintia Hills region is also home to indigenous communities who rely on agriculture and forestry. The ongoing coal mining activities have led to tensions between the need for economic growth and the preservation of the region's natural resources and heritage.

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In East Jaintia Hills district of Meghalaya, coal mining is concentrated in several notable areas. The district is known for its high-quality coal deposits, and there are some key locations where mining is particularly prominent. Here are some famous sample points associated with coal mining in the region:

Laskar (or Lakadong) Area: Located in the central part of East Jaintia Hills, this area is known for the extraction of high-quality coal, especially the "Lakadong coal," which is prized for its low ash content and high calorific value. Lakadong coal is often used in various industries and is in demand for its superior quality.

Sutnga: Sutnga, located in the southern part of East Jaintia Hills, has been a significant coal mining area. The region has seen extensive mining activities, and many of the local coal mines are operational here. The coal extracted from Sutnga is used for local consumption and for export to other regions.

Narpuh: Narpuh is another important coal mining region in East Jaintia Hills, known for its large-scale mining activities. The area is rich in coal deposits, and mining has been a major economic activity here for decades.

Rymbai: Rymbai, located near the borders of East Jaintia Hills, is known for its mining operations, where coal extraction is common. The region has been historically important for coal mining and has contributed significantly to the local economy.

Musiang-Lamare: Located in the eastern part of East Jaintia Hills, Musiang-Lamare is a significant coal mining area. The region is known for its deposits of high-quality coal, and traditional mining practices, such as "rat-hole" mining, are common here. The coal from Musiang-Lamare is primarily used for local consumption and also for industrial purposes in nearby regions.

Khliehriat: Khliehriat is the district headquarters of East Jaintia Hills and an important coal mining center. This area has been a major coal-producing region for many years. The coal extracted here is of good quality and is used in various industries. Khliehriat has several active mines and has seen considerable infrastructure development due to the mining activities.

Loksi: Loksi is another notable coal mining area in East Jaintia Hills. The region is home to numerous coal mines that use traditional mining methods. Although the area is relatively smaller in terms of industrial activity compared to other locations, it still contributes significantly to the coal supply in the district.

Ladrymbai: Ladrymbai, located in the southern part of East Jaintia Hills, is known for its coal deposits. The mining activities here are a mix of large-scale and smaller, more localized operations. The coal from Ladrymbai is used for local consumption and exported to other parts of the country.

Byrwai: Byrwai, located in the northeastern part of the district, is also known for coal mining. This area has a large number of small-scale coal mines, and the extraction process is primarily done using the "rat-hole" method. Byrwai is one of the key coal-producing areas in East Jaintia Hills.

Chyrmang: Chyrmang, a relatively smaller but significant coal mining region, contributes to the overall coal production in the district. The mining activities in Chyrmang are typically local and rely on traditional mining techniques. The coal extracted is mainly used for local needs.

Bapung: Bapung, located in the western part of East Jaintia Hills, is another area where coal mining is prevalent. The region has been home to various small and medium-sized coal mines. Bapung plays a crucial role in the coal economy of East Jaintia Hills, with the extracted coal being used for both local and regional consumption.

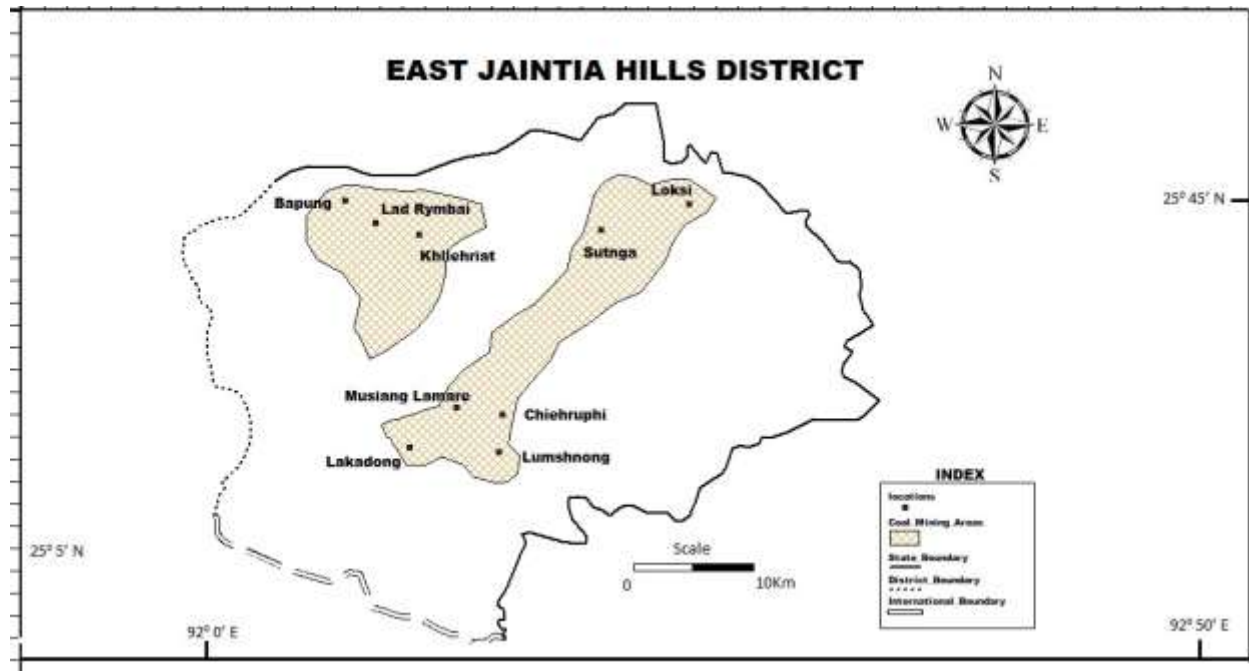
3. **METHODOLOGY**

This study aims to quantitatively assess the land use dynamics in East Jaintia Hills, specifically focusing on the impacts of coal mining. A combination of Geographic Information Systems (GIS) and Remote Sensing (RS) techniques will be used to analyze temporal changes in land use patterns and evaluate the environmental implications of coal mining. The methodology for this research is structured around three primary stages: data collection, processing, and analysis.

3.1 Study Area Selection and Data Collection

The study will focus on the East Jaintia Hills, a region in the Indian state of Meghalaya known for its significant coal mining activities. The following steps will be undertaken in this phase:

(a) Study Area Delineation: The East Jaintia Hills District boundaries are defined using administrative boundaries or natural topographic features available in public domain GIS datasets.



(b) Data Collection: Satellite Imagery of High-resolution remote sensing images is obtained from sources such as Landsat for two different time periods (2010 and 2020) to analyze land use change over time. These images have at least a 30-meter spatial resolution for Landsat data.

(c). GIS Datasets: Topographic maps, administrative boundaries, land use land cover (LULC) maps, and soil data for the East Jaintia Hills region are being sourced from government agencies, research institutes, or open-access databases.

3.2 Data Preprocessing and Image Enhancement

To ensure that the collected remote sensing data is suitable for analysis, several preprocessing steps is performed in this study

(a) Georeferencing: All satellite imagery are georeferenced to a common coordinate system (i.e, WGS 84/UTM) to ensure spatial accuracy and consistency across different datasets.

(b) Radiometric Correction: Atmospheric and radiometric corrections are performed to minimize the effects of sensor noise, atmospheric interference, and solar angle variations, ensuring accurate reflectance values for analysis.

(c) Image Enhancement: The important techniques such as histogram equalization and contrast stretching are applied to enhance the visual quality of the images, particularly in regions where mining activities may have led to soil degradation or deforestation.

3.3 Land Use Land Cover Classification

Land use and land cover (LULC) classification is central to understanding the spatial dynamics of the study area, especially the impacts of coal mining. This step that includes in the mapping of Land Use, Land Cover change detection are as follows:-

(a) Supervised Classification: A supervised classification method (e.g., Support Vector Machine or Maximum Likelihood) are used to categorize land cover types such as forest, agricultural land, water bodies, barren land, and coal mining areas. Training sites for classification will be selected based on field data and existing land use maps.

(b) Training and Testing Samples: A set of sample points are used to train and test the classification algorithm. These points are entered manually selected based on the visual interpretation of high-resolution imagery and/or field data.

(c) Classification Accuracy Assessment: The accuracy of the LULC classification are evaluated using metrics like the confusion matrix, overall accuracy, and Kappa coefficient by comparing the results to ground-truth data or high-resolution imagery.

3.4 Temporal Analysis of Land Use Change

Here to assess land use dynamics, temporal comparisons of LULC classifications for two time periods (2010 and 2020). The following analyses are performed:

(a) Change Detection Analysis: Post-classification comparison or Change Vector Analysis (CVA) is performed to quantify changes in land use, focusing on the expansion or contraction of coal mining areas. Change detection tools in GIS will help to identify specific land cover changes (e.g., forest to mining land, agricultural land to barren land).

Change detection analysis is a crucial method for understanding the dynamics of land use and land cover (LULC) over time. In the context of East Jaintia Hills district, this analysis focuses on the changes that occurred between 2010 and 2020. The findings from this analysis provide insights into environmental impacts, socio-economic developments, and policy implications.

The analysis utilized satellite imagery from two distinct periods: 2010 and 2020. High-resolution images were sourced from platform such as Landsat satellite. These images were processed using Geographic Information System (GIS) software to classify different land use types. The LULC classification system typically includes categories such as:

Forest Lands

Agricultural Lands

Built Up Lands

Water bodies

Wastelands

Shifting Cultivation-Abandoned

Shifting Cultivation-Current

Each category was identified based on spectral signatures and ground truthing data collected during field surveys.

Several techniques were employed for change detection. The Post-classification Comparison is a method involved classifying both time periods separately and then comparing the results to identify changes. Normalized Difference Vegetation Index (NDVI) was calculated to assess vegetation health and density changes over the decade. The Overall Changes in Land Use/Land Cover between 2010 and 2020 shows significant changes as observed in the LULC of East Jaintia Hills.

Forest Cover: There was a decrease in forest cover by approximately 8%. This decline can be attributed to increased agricultural expansion and illegal logging activities. The remaining forest areas showed signs of fragmentation, which could impact biodiversity.

Agricultural Land:

Agricultural land increased by about 12%. This growth is primarily due to shifting cultivation practices adopted by local farmers seeking to enhance food production. However, this expansion often encroached upon forested areas, leading to habitat loss.

Built Up Lands:

Urbanization saw a notable rise of around 5%. The growth of towns like Khliehriat contributed to this increase as infrastructure development progressed. The urban sprawl has led to increased demand for resources such as water and energy.

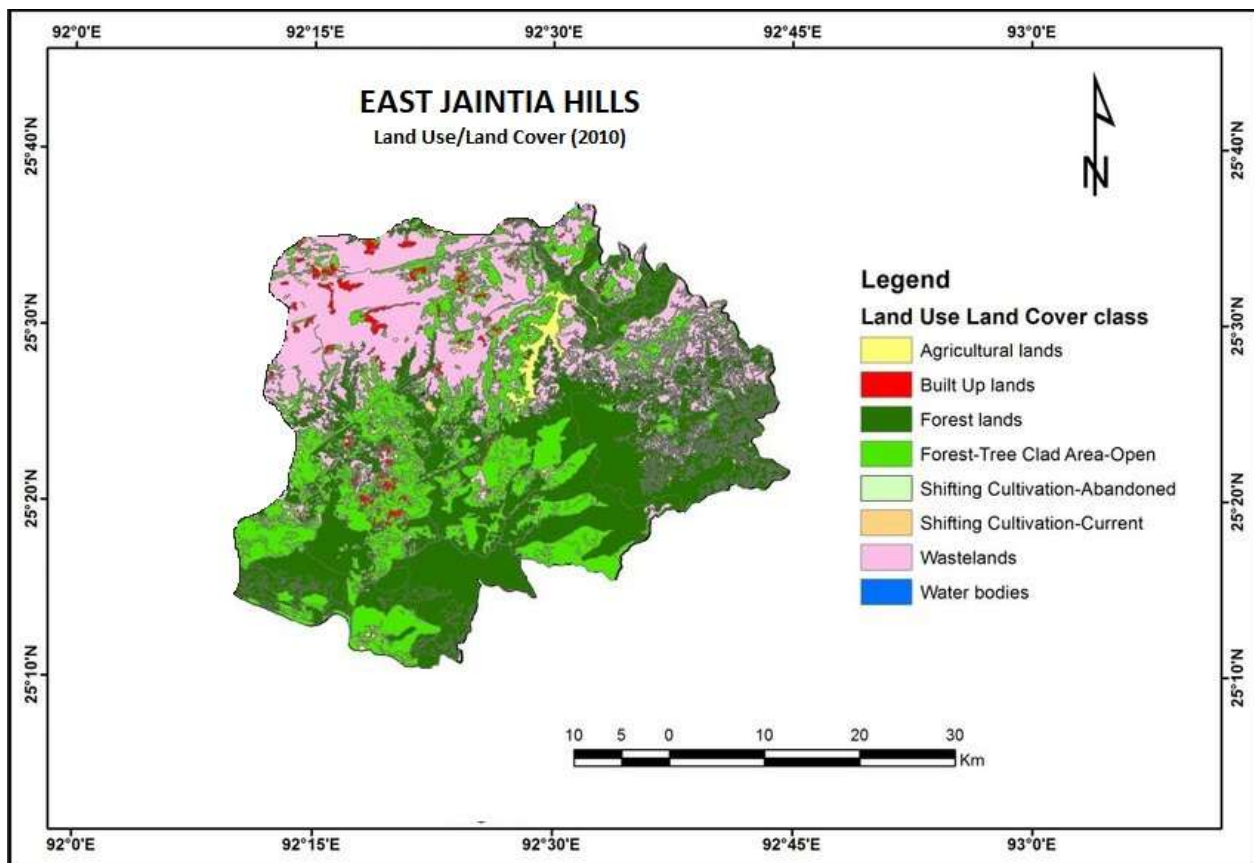
Water Bodies:

Water bodies remained relatively stable with minor fluctuations due to seasonal variations; however, some smaller ponds experienced drying up due to climate change effects.

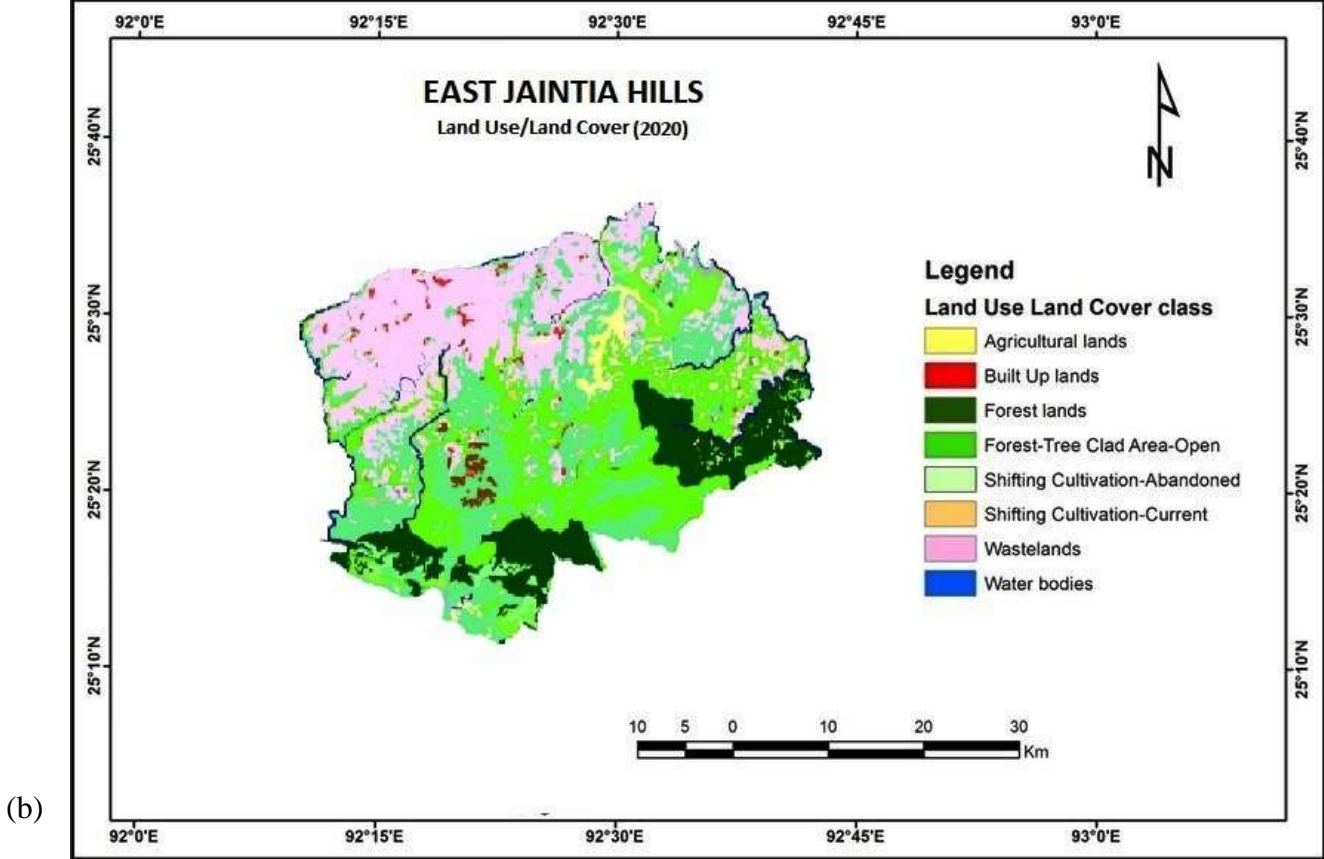
Wastelands:

Barren land decreased slightly by about 3%, indicating a shift towards more productive uses of previously unutilized lands.

The spatial distribution of these changes highlighted specific hotspots where human activities significantly impacted LULC. Areas near urban centers exhibited rapid conversion from forested regions to built-up environments. The areas with high agricultural activity showed encroachment into adjacent forests, particularly in the valleys where soil fertility is higher.



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Metrics: Metrics like the extent (area) of land cover change, rate of change, and transition matrix (e.g., forest to mining, mining to barren land) will be calculated to evaluate the magnitude and direction of land use changes.

(c) Hotspot Identification: Hotspot analysis is carried out to identify regions with the most significant land use change due to coal mining, using spatial analysis tools in GIS.

3.5 Assessment of Coal Mining Impact on Land Use

The core aim of this methodology is to quantify the impacts of coal mining on land use in East Jaintia Hills. The following assessments will be undertaken:

(a) Spatial Distribution of Mining Areas: The spatial extent of coal mining areas are mapped and monitored over time to understand the growth pattern of mining activities.

(b) Deforestation Assessment: The loss of forest cover in proximity to mining sites is quantified to assess the environmental impact of mining activities on vegetation and biodiversity.

(c) Soil Degradation and Erosion Risk: Based on land cover changes, the areas that have undergone soil degradation, erosion, or loss of fertility due to mining are identified. Additional soil data may be incorporated to analyze these effects.

(d) Water Bodies Impact: Changes in water bodies (e.g., rivers, lakes) caused by mining runoff, soil erosion, and pollution are also taken into consideration in this study, particularly focusing on water quality.

3.6 Integration of GIS and Remote Sensing Data

GIS Analysis: GIS is used to integrate the spatial data layers obtained from remote sensing, field surveys, and secondary data sources. Spatial analysis tools will be used to correlate land use changes with the spatial distribution of coal mining activities.

Buffer Zone Analysis: Buffer zones are created around mining areas to analyze the surrounding land use change, especially focusing on the impact of mining on nearby forests, water bodies, and agriculture.

4. **REPORTING AND INTERPRETATION OF RESULTS**

(a) **Visualization:** Maps, graphs, and charts are used to visually represent the land use changes, the extent of mining, and the environmental impacts across the two decades time. Temporal maps are developed to showcase land use change and coal mining's impact at different stages.

(b) **Interpretation:** The results are therefore analyzed and discussed in terms of the spatial and temporal patterns of land use change, highlighting the role of coal mining as a major factor influencing land dynamics. Environmental consequences such as habitat loss, soil degradation, and water quality degradation are also emphasized. The findings from the change detection analysis have several implications:

Environmental Impact: The reduction in forest cover raises concerns regarding biodiversity loss and ecosystem services that forests provide.

Sustainability Challenges: Increased agricultural practices may lead to soil degradation if not managed sustainably.

The change detection analysis between 2010 and 2020 reveals significant transformations in the land use/land cover patterns within the district. Understanding these changes is essential for informed decision-making regarding environmental conservation and sustainable development strategies moving forward.

There has been an overall decrease in forest cover by approximately 8%, an increase in agricultural land by about 12%, a rise in urban areas by around 5%, while water bodies remained stable with minor fluctuations, leading to critical implications for sustainability and environmental management strategies in the region.

5. **FINDINGS AND RECOMENDATIONS**

The study is concluded by summarizing the key findings related to the impacts of coal mining on land use dynamics in the district. Policy recommendations for sustainable land management, mitigation of adverse environmental impacts, and suggestions for further research are also provided.

The methodology used here combines the GIS and remote sensing tools to perform a comprehensive analysis of land use dynamics in a mining context. By integrating spatial and temporal data, this study aims to provide a thorough understanding of how coal mining activities are shaping the landscape of East Jaintia Hills.

Geographic Information System (GIS) mapping has been instrumental in analyzing land use and land cover (LULC) changes in the East Jaintia Hills district of Meghalaya, particularly concerning coal mining activities. This study reveals significant environmental transformations attributed to extensive mining operations.

A study focusing on the period between 2010 and 2020 utilized remote sensing and GIS techniques to assess LULC changes in East Jaintia Hills. The findings indicated a substantial reduction in forest cover, with dense forests decreasing from 33.23% to 25.49% and open forests from 18.38% to 15.96%. Conversely, areas classified as barren land, which include mining sites, expanded from 5.76% to 12.87% during the same period. This underscores the direct impact of coal mining on deforestation and landscape alteration.

Another comprehensive review highlighted the efficacy of GIS in monitoring environmental degradation due to coal mining in East Jaintia Hills. The study emphasized GIS's role in mapping land degradation, assessing water quality, and evaluating impacts on local biodiversity. The spatial analysis capabilities of GIS facilitate the identification of affected areas, aiding in the development of targeted mitigation strategies.

Furthermore, this research has demonstrated that coal mining activities have led to the conversion of agricultural lands and forests into mining areas, resulting in habitat loss and soil erosion. The use of GIS and remote sensing has been pivotal in quantifying these changes, providing visual representations that inform policymakers and stakeholders about the extent of environmental impacts.

In summary, GIS mapping has been a crucial tool in documenting and understanding the environmental consequences of coal mining in East Jaintia Hills. The technology's ability to analyze spatial and temporal data has shed light on significant deforestation, land degradation, and ecological disturbances, thereby supporting informed decision-making for sustainable land management in the region.

6. CONCLUSION

This quantitative assessment demonstrates that coal mining has profoundly altered land use patterns in East Jaintia Hills. The integration of GIS and remote sensing provides valuable tools for monitoring these changes effectively. Future research should focus on developing strategies for sustainable resource management that can reconcile economic needs with ecological preservation.

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