

Remote Sensing and Geospatial Analytics for Climate Change Assessment and Natural Resource Management

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Abstract: Climate change poses unprecedented challenges to ecosystems, water resources, agriculture, and human settlements. Effective assessment and sustainable management of natural resources require continuous, large-scale, and high-resolution environmental monitoring. Remote sensing combined with geospatial analytics provides a powerful framework for observing climate-induced changes across temporal and spatial scales. This paper presents an integrated analysis of satellite-based remote sensing data and geographic information system (GIS) techniques for climate change assessment and natural resource management. The study examines the use of multispectral and hyperspectral imagery, thermal sensing, and radar data for monitoring land use change, vegetation dynamics, water availability, and climate extremes. Advanced geospatial analytics, including machine learning-based classification and trend analysis, are discussed as tools for enhancing predictive capability. The paper highlights applications in drought assessment, deforestation monitoring, coastal vulnerability analysis, and sustainable land management. Challenges related to data uncertainty, resolution limitations, and integration with socio-economic data are critically analyzed. The findings underscore the role of remote sensing and geospatial analytics as essential decision-support systems for climate adaptation and resource governance in a changing global environment.

Keywords: Remote Sensing, Geospatial Analytics, Climate Change, Natural Resources, Environmental Monitorin

1. Introduction

Climate change has emerged as one of the most critical global challenges, influencing atmospheric processes, hydrological cycles, and ecological stability. Traditional ground-based monitoring methods are often limited in spatial coverage and temporal frequency, making them insufficient for capturing complex environmental changes at regional and global scales. Remote sensing technologies overcome these limitations by providing continuous, synoptic, and repeatable observations of the Earth's surface. Geospatial analytics, when integrated with remote sensing data, enables the extraction of meaningful patterns, trends, and predictive insights. These tools are increasingly used for climate change assessment and natural resource management, supporting evidence-based policymaking and sustainable development initiatives [1]. This paper explores the theoretical foundations, methodological frameworks, and applied use cases of remote sensing and geospatial analytics in addressing climate change impacts.

2. Review of Related Work

The Remote sensing has long been used to monitor land cover, vegetation indices, and surface temperature. The introduction of high-resolution satellite platforms and open-access datasets has significantly expanded its applicability [2]. Recent studies have demonstrated the effectiveness of geospatial analytics in detecting long-term climate trends, mapping vulnerability hotspots, and assessing ecosystem health [3]. Machine learning techniques have further improved classification accuracy and predictive modeling capabilities [4]. However,

challenges persist in integrating multi-source datasets, addressing scale mismatches, and translating scientific outputs into actionable policy insights [5].

3. Remote Sensing Data Sources

Remote sensing platforms include optical satellites, thermal sensors, and synthetic aperture radar (SAR) systems. Multispectral imagery enables vegetation and land use analysis, while thermal data supports temperature and drought assessment. Radar-based systems provide all-weather monitoring capabilities, making them valuable for flood mapping and terrain analysis. The integration of these data sources enhances analytical robustness.

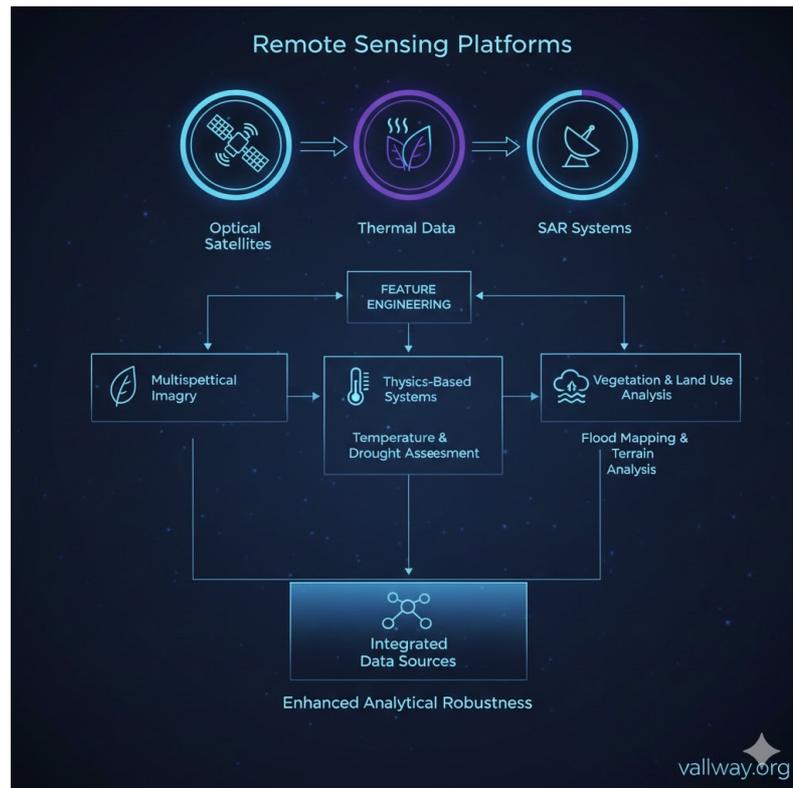


Fig. 1 Remote Sensing Platforms

4. Geospatial Analytics Framework

Geospatial analytics involves data preprocessing, feature extraction, classification, and temporal trend analysis. GIS platforms serve as the foundation for spatial data integration and visualization. Machine learning algorithms such as random forests and support vector machines are used for land cover classification and change detection. Time-series analysis enables the identification of climate-induced trends.

5. Climate Change Assessment Applications

Remote sensing supports climate change assessment through monitoring temperature anomalies, precipitation variability, and extreme events. Vegetation indices are used to assess ecosystem response to climatic stress. Spatial analysis of climate indicators enables regional vulnerability mapping and risk assessment, supporting adaptation planning.

6. Natural Resource Management

Geospatial analytics plays a vital role in managing forests, water resources, and agricultural land. Deforestation monitoring helps identify illegal land use changes, while water resource assessment supports sustainable allocation strategies. In agriculture, satellite-derived data supports crop health monitoring and yield forecasting, contributing to food security under changing climate conditions [6].

7. Decision Support and Policy Implications

Remote sensing-based geospatial systems function as decision-support tools by providing timely and objective environmental information. These systems enhance transparency and accountability in resource governance. Integration with socio-economic data further strengthens policy relevance, enabling holistic sustainability assessments.

8. Challenges and Limitations

Key challenges include data uncertainty, cloud cover interference, and limited ground validation. High computational requirements and data processing complexity can restrict adoption in resource-limited regions. Addressing these challenges requires capacity building, methodological standardization, and interdisciplinary collaboration.

9. Future Directions

Future research should focus on integrating artificial intelligence with remote sensing for automated climate monitoring. The use of real-time satellite data and cloud computing platforms will enhance scalability and accessibility.

10. Conclusion

Remote sensing and geospatial analytics are indispensable tools for climate change assessment and natural resource management. Their ability to provide comprehensive, timely, and scalable environmental insights supports sustainable development and climate resilience. Continued technological and methodological advancements will further strengthen their role in addressing global environmental challenges.

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