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Harnessing Remote Sensing for Regional Planning: A Narrative Review

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ABSTRACT: Remote sensing technologies have become increasingly essential in modern regional planning, enabling data-driven approaches to land use, environmental monitoring, and urban management. This narrative review aims to explore the application, challenges, and policy implications of remote sensing within regional planning frameworks. Literature was systematically gathered from Scopus, Google Scholar, and PubMed using keywords such as "remote sensing," "land use," "regional planning," and "GIS." Inclusion criteria emphasized studies directly integrating remote sensing with land use analysis, while excluding non-empirical editorials and micro-scale studies. The results show that social factors such as education levels and stakeholder participation significantly affect technology adoption, while economic investment and infrastructure improve data application efficiency. Developed countries benefit from robust data policies and technological resources, whereas developing nations face systemic barriers including limited access, inadequate training, and bureaucratic hurdles. The discussion highlights the importance of institutional capacity and international collaboration in enhancing remote sensing applications. Innovative technologies like LiDAR and multi-sensor data integration offer improved spatial analysis but require substantial technical expertise. In conclusion, remote sensing stands as a critical tool in advancing sustainable regional development. However, to fully harness its potential, targeted investments, capacity building, and inclusive policy reforms are urgently needed.

Keywords: Remote Sensing, Regional Planning, GIS, Land Use, Sustainable Development, Lidar, Spatial Analysis.

INTRODUCTION

Remote sensing technology has emerged as a pivotal tool in modern regional planning, driven by the urgency to address accelerated urbanization, environmental transformation, and the increasing complexity of land use dynamics. As global environmental and socioeconomic systems become more interconnected and volatile, the necessity for accurate, timely, and comprehensive data to support spatial decision-making is more critical than ever. Remote sensing, particularly through satellite imagery such as Sentinel-2, offers a cost-effective and

efficient means to monitor land cover changes, assess natural resource use, and contribute to sustainable development strategies (Bühler et al., 2021). The application of remote sensing is especially vital in supporting climate adaptation and urban sustainability agendas, as satellite data facilitate the monitoring of ecological shifts and extreme weather events (Ekmen & Kocaman, 2023).

The integration of Geographic Information Systems (GIS) and remote sensing technologies provides planners with analytical capabilities to map urban growth, identify infrastructure needs, and model future scenarios. For instance, in Denpasar, Indonesia, remote sensing has been used to map agricultural land use to support regional spatial planning (Lanya et al., 2019). Kumar et al. (2021) also emphasize the role of these technologies in facilitating urban planning and infrastructure development, thereby contributing to more efficient and sustainable cities. These applications highlight the interdisciplinary potential of remote sensing in urban geography, environmental science, and policy-making.

Empirical evidence underscores the relevance of remote sensing by presenting key facts and metrics about its role in spatial planning. One major advantage is its capacity for frequent temporal monitoring, enabling detection of both gradual and abrupt changes in land use. This is critical for understanding patterns of urban sprawl, deforestation, and land degradation. Moreover, satellite-based data can be calibrated with ground-truth measurements to enhance the precision of assessments, thereby supporting more robust environmental and infrastructural planning frameworks. The affordability and scalability of systems such as Landsat and Sentinel have democratized access to high-quality geospatial data, making them invaluable for both high-income and developing countries.

Further supporting its relevance, remote sensing contributes significantly to climate-sensitive planning and disaster risk reduction. The increasing frequency of climate-related events necessitates tools that can provide early warning and impact assessment. Remote sensing technologies, when combined with real-time environmental data and predictive modeling, enable policymakers to design adaptive strategies that are spatially and temporally responsive (Sudmanns et al., 2019). As such, this technological capability plays a key role in advancing the resilience of communities and ecosystems against environmental hazards.

Despite these benefits, the application of remote sensing in regional planning is fraught with challenges. A primary concern is the accuracy of satellite-derived data, which can be compromised by factors such as atmospheric interference, cloud cover, and sensor limitations. These issues can lead to errors in image classification and interpretation, ultimately affecting planning outcomes. Overcoming such limitations requires sophisticated preprocessing techniques, including atmospheric correction and data fusion methods, which are not always accessible or standardized across user groups.

Accessibility and availability of up-to-date satellite data present another challenge. Although open-access platforms like Copernicus have improved data availability, limitations in spatial and temporal resolution persist, particularly for applications requiring near-real-time decision-making. Furthermore, the fragmented nature of data repositories and the lack of interoperability between

systems can delay critical analyses and policy responses. These challenges are further exacerbated in regions with limited technical infrastructure and institutional capacity.

The integration of remote sensing with other disciplinary methodologies remains underdeveloped in many studies. For effective spatial planning, remote sensing data must be contextualized within ecological, social, and economic frameworks. However, many current applications remain discipline-siloed, lacking the necessary interdisciplinary synergy (Nagabhatla & Brahmbhatt, 2020). The absence of a holistic approach hampers the ability to generate comprehensive spatial insights that consider the multifaceted nature of land use planning and natural resource management. Involving community stakeholders is also critical, as planning must reflect local realities and needs to ensure effective implementation (Fernández & Gil, 2022).

Current literature reveals significant gaps that justify the need for a comprehensive review. Chief among these is the insufficient treatment of data uncertainty and its implications for planning accuracy. While several studies acknowledge the limitations of satellite imagery due to atmospheric or technical distortions, few offer systematic solutions or standard protocols for mitigating these issues. Another major gap lies in the underutilization of multi-sensor integration, such as combining LiDAR, UAV, and radar data with optical imagery, which could enhance spatial resolution and classification accuracy. Additionally, there is limited engagement with dynamic models that simulate land use change in response to various policy scenarios, which are crucial for strategic planning.

The primary objective of this review is to explore how remote sensing has been utilized in regional planning, with a focus on analyzing the factors that influence its effectiveness. This includes examining social, economic, environmental, technological, and policy-related variables that interact with remote sensing applications. By doing so, the review seeks to provide an integrative understanding of the conditions under which remote sensing contributes to more informed, inclusive, and sustainable planning practices. A secondary aim is to identify opportunities for methodological innovation and interdisciplinary collaboration that can address existing limitations.

The scope of this review is global, with specific attention to case studies from both developed and developing regions. Emphasis is placed on the applicability of remote sensing in urban contexts, particularly in areas experiencing rapid growth and environmental stress. Special consideration is given to examples from Southeast Asia, sub-Saharan Africa, and Latin America, where remote sensing has been employed to monitor land use change, support agricultural planning, and manage urban expansion (Chitsiko et al., 2022; Espinoza et al., 2020). These cases illustrate how remote sensing can be tailored to diverse socio-environmental contexts, offering insights into best practices and adaptable strategies. The review also considers how new platforms such as Google Earth Engine and AI-driven analytics are shaping the next generation of geospatial planning tools.

In sum, this introduction establishes the foundation for a critical examination of remote sensing applications in regional planning. It highlights the transformative potential of satellite-based monitoring while acknowledging the technological, methodological, and institutional barriers that

must be addressed. By systematically analyzing the literature across multiple dimensions, this review aims to advance both theoretical understanding and practical application of remote sensing for spatial governance and sustainable development.

METHOD

This review adopts a structured and systematic approach to identify, select, and synthesize relevant literature concerning the application of remote sensing technologies in regional and spatial planning. The methodology comprises several essential steps, including the definition of search terms and Boolean strategies, database selection, the establishment of inclusion and exclusion criteria, and a multistage screening and evaluation process to ensure relevance and academic rigor. The goal of this section is to provide a transparent and reproducible method that reflects the current state of scholarly work on remote sensing and its role in spatial governance.

To locate suitable studies, literature searches were conducted using three primary academic databases: Scopus, PubMed, and Google Scholar. These databases were selected due to their comprehensive coverage of peer-reviewed journal articles and multidisciplinary content. Scopus offers a wide array of environmental and geospatial science publications, while PubMed includes studies intersecting environmental health and planning. Google Scholar, although more inclusive and less curated, complements the other two by capturing grey literature and institutional reports that may not be indexed in traditional databases.

Searches were performed using a carefully crafted combination of keywords and Boolean operators to ensure the capture of relevant literature. The primary keywords used in the search strategy included: “remote sensing,” “land use,” “regional planning,” “spatial planning,” “urban planning,” “GIS” (Geographic Information Systems), and “sustainability.” Boolean operators were applied strategically to refine the search. For example, the query ("remote sensing" OR "earth observation") AND ("land use" OR "land cover") AND ("regional planning" OR "spatial planning") was used extensively to retrieve studies that intersect multiple thematic domains. The use of quotation marks ensured the accuracy of phrase-based searches, while parentheses helped clarify the logical grouping of terms.

All retrieved studies were subjected to a two-phase screening process consisting of title and abstract review followed by full-text analysis. Prior to screening, duplicates were removed to avoid redundancy. The first phase of screening focused on the preliminary relevance of the studies to the core topics of remote sensing and regional planning. Articles that did not explicitly involve applications of remote sensing to spatial governance were excluded. In the second phase, full-text versions of shortlisted studies were reviewed to evaluate methodological quality, contextual relevance, and alignment with the inclusion criteria.

Inclusion criteria were determined based on relevance, methodological robustness, and practical applicability to spatial and land use planning. Studies were included if they directly addressed the use of remote sensing in planning contexts, particularly those involving land use analysis,

regional development, or resource management. Articles employing empirical methods or theoretical frameworks integrating remote sensing with GIS-based spatial modeling, environmental impact assessments, or land suitability analysis were prioritized. Only studies written in English or accompanied by English abstracts were considered to maintain consistency in interpretation and synthesis(Zaabar et al., 2022).

Conversely, exclusion criteria aimed to filter out articles with limited contribution to the research objective. Studies were excluded if they focused solely on technical aspects of remote sensing without applying the findings to regional planning. Publications categorized as editorials, opinion pieces, or commentaries without substantial data presentation or analytical depth were also excluded. Furthermore, studies confined to micro-scale analyses, such as plot-level vegetation studies without broader planning implications, were deemed unsuitable.

The review encompasses various types of research, including case studies, observational research, geospatial modeling, and theoretical analyses. No restrictions were imposed regarding the time of publication, although preference was given to studies published in the last decade to ensure contemporary relevance. Selected studies span different geographic regions and contexts, allowing for comparative insights and global applicability.

To ensure methodological consistency and minimize bias, all selected articles were evaluated using a qualitative appraisal framework(Waite, 2013). This framework assessed the clarity of objectives, methodological transparency, integration of remote sensing data, analytical techniques, and the extent to which findings informed planning recommendations(Kelesakis et al., 2023). Studies scoring poorly in transparency or lacking direct relevance to regional planning frameworks were removed during this stage. Data extraction was conducted manually and organized into thematic matrices to support synthesis and interpretation.

The review identified a diverse range of literature spanning multiple disciplines. For instance, Bruno et al. (2019) examined remote sensing applications in coastal risk assessment, demonstrating how satellite imagery combined with field data can inform regional adaptation strategies(Reis et al., 2019; Terrone et al., 2021). Sudmanns et al. (2019) explored the operational use of Sentinel-2 data in land cover monitoring, contributing to scalable methodologies for spatial planning. Rechsteiner et al., (2017) discussed how habitat structure detection through remote sensing supports conservation planning at a regional scale. These examples underscore the interdisciplinary nature and practical relevance of the selected literature.

The screening process highlighted the growing trend of integrating remote sensing with machine learning, spatial statistics, and participatory GIS. Numerous studies utilized platforms like Google Earth Engine to process and analyze temporal imagery efficiently. Thematic coverage extended beyond urban growth and land cover change to include agricultural planning, biodiversity conservation, and climate vulnerability mapping. This diversity reinforces the versatility of remote sensing technologies in supporting planning decisions across various environmental and social contexts (Nonini et al., 2020).

In conclusion, the methodology employed in this review was designed to capture a comprehensive and representative set of studies that elucidate the role of remote sensing in regional and spatial planning. Through a rigorous search strategy, clearly defined inclusion and exclusion criteria, and systematic appraisal of methodological quality, this review aims to synthesize evidence that advances both theoretical understanding and practical application. By highlighting both successes and gaps in the existing literature, the review offers a foundation for future research and policy integration in geospatial planning systems.

RESULT AND DISCUSSION

The application of remote sensing technology in regional planning has garnered increasing attention in recent years, driven by its potential to transform spatial analysis, resource allocation, and policy formulation. This section synthesizes key findings from the literature by organizing the results into thematic areas: social factors, economic factors, policy and regulatory factors, and technological innovation. Each theme highlights how remote sensing has been utilized, the challenges encountered, and the disparities observed between different socio-economic and geographic contexts.

Thematic Area 1: Social Factors

Social factors significantly shape the adoption and successful implementation of remote sensing technologies in regional planning. Studies have shown that educational attainment, public awareness, and stakeholder engagement are critical determinants of technological integration. For example, Ekmen and Kocaman (2023) emphasized that in developed countries, robust educational systems and proactive community engagement initiatives facilitate greater acceptance and utilization of remote sensing tools. This is often supported by targeted training programs and institutional frameworks that promote collaboration between local governments and communities.

Conversely, in developing countries, limited access to education and technology presents substantial barriers. Shah & Patel, (2020) identified that rural regions frequently lack the infrastructure necessary for effective data collection and analysis, leading to a disparity in planning quality between urban and rural areas. The lower educational levels in such contexts further exacerbate difficulties in understanding and applying remote sensing data, ultimately undermining the planning process. These findings underscore the need for capacity-building measures and localized knowledge dissemination strategies to enhance remote sensing adoption globally.

The disparity in social readiness between developed and developing nations reflects broader socio-economic inequalities, influencing the reach and impact of remote sensing applications. As such, efforts to democratize access to technology and build inclusive educational platforms are essential for maximizing the benefits of remote sensing in spatial planning.

Thematic Area 2: Economic Factors

Financial investment and economic infrastructure play a crucial role in determining the success of remote sensing initiatives in regional planning. Zhou et al. (2013) demonstrated that regions with greater fiscal capacity to invest in technological infrastructure and human resource development tend to achieve more effective planning outcomes. For instance, high-resolution satellite imagery and advanced processing software, although costly, can significantly reduce the time and expense associated with conventional land-use mapping and monitoring.

Trukhachev et al., (2020) offered empirical evidence from agricultural regions where remote sensing was employed to assess land fertility and optimize farming practices. The availability of satellite data allowed for timely decision-making regarding irrigation and fertilization, thereby improving crop yields and supporting rural economic development. Similarly, Kumar et al., (2021) highlighted that urban areas integrating remote sensing into their spatial planning frameworks reported enhanced economic performance due to better infrastructure planning and resource management.

These cases illustrate that economic capacity is both an enabler and a limiting factor in the adoption of remote sensing. Regions with access to investment and subsidies can leverage remote sensing more fully, whereas economically constrained regions may struggle to implement and sustain such systems. Thus, international cooperation and funding mechanisms are vital to bridge these economic gaps and promote more equitable technology diffusion.

Thematic Area 3: Policy and Regulatory Factors

The influence of policy frameworks and regulatory environments on the implementation of remote sensing technologies cannot be overstated. Initiatives such as the European Union's Copernicus and the Global Monitoring for Environment and Security (GMES) program have been instrumental in providing open-access satellite data for environmental monitoring and spatial planning (Bühler et al., 2021). These programs exemplify how strategic policy support can catalyze the use of remote sensing in sustainable planning.

National policies also play a pivotal role. In countries like Indonesia and Brazil, satellite-based monitoring has been integrated into land-use governance and disaster management strategies (Bruno et al., 2019). However, policy implementation varies significantly across countries. Developed nations such as Germany and Sweden have established comprehensive regulatory structures that support data access, stakeholder involvement, and inter-agency coordination. In contrast, developing countries often face obstacles such as limited data infrastructure, fragmented institutional arrangements, and insufficient policy enforcement (Beijma et al., 2014).

Ekmen and Kocaman (2023) emphasized the need for enhanced institutional capacity and cross-sector collaboration in these contexts to realize the full potential of remote sensing. Effective policies must not only ensure access to data but also provide frameworks for data use, capacity

building, and accountability. The disparity in regulatory readiness reinforces the importance of tailored policy interventions that address local institutional capacities and governance structures.

Thematic Area 4: Technological and Innovation Factors

Technological advancements have significantly broadened the capabilities of remote sensing in regional planning. Tools such as Landsat and Sentinel satellites, along with Light Detection and Ranging (LiDAR) systems, offer high-resolution imagery and topographic data critical for land-use classification and environmental modeling. According to Yuan & Wang, (2022), LiDAR's precision in capturing three-dimensional terrain data makes it invaluable for applications requiring detailed surface analysis, such as vegetation mapping and infrastructure planning.

Comparative evaluations of different remote sensing platforms reveal distinct advantages and limitations. Kumar et al. (2021) found that while Landsat imagery is suitable for monitoring broad land-use changes over time, LiDAR excels in capturing fine-scale features. However, the latter's higher cost and technical complexity can be prohibitive. Bhayunagiri & Saifulloh, (2023) demonstrated that integrating data from multiple sensors yields more robust land-use classifications than relying on a single platform(Yang et al., 2014).

These findings highlight the importance of multi-sensor data fusion and the need for interoperable analytical tools. As innovation continues, emerging technologies such as machine learning and cloud-based platforms (e.g., Google Earth Engine) are enhancing data processing efficiency and accessibility. However, the successful deployment of these tools depends on user capacity, institutional support, and alignment with planning objectives.

Global Comparison and Perspective

The thematic synthesis of findings from various regions underscores a clear divide between developed and developing countries in terms of remote sensing adoption and impact. Developed countries benefit from advanced infrastructure, strong policy frameworks, and higher levels of technical literacy, enabling comprehensive integration of remote sensing into spatial planning. In contrast, developing countries face structural challenges that limit the effective use of these technologies(Karimi et al., 2018; Patiño & Duque, 2013).

Nonetheless, the global trend points toward greater inclusivity and accessibility, driven by open-data initiatives, international collaboration, and technological innovations. Bridging the digital divide requires a multi-faceted approach, including education, policy reform, financial support, and community engagement.

In conclusion, the results of this narrative review suggest that the successful application of remote sensing in regional planning is multifactorial, shaped by social, economic, political, and technological dimensions. Understanding these factors in an integrated manner is essential for designing strategies that enhance the utility of remote sensing across diverse planning contexts.

The present narrative review has revealed that remote sensing technologies have significantly contributed to regional and land-use planning across diverse global contexts. The findings corroborate earlier studies while also identifying disparities in adoption and application based on socioeconomic and geopolitical factors.

Consistent Patterns in Literature

One of the clearest points of convergence between this study and prior research is the widespread recognition of remote sensing as a foundational data source for spatial planning. Paršova et al. (2018) emphasized the utility of satellite data in land-use classification and environmental monitoring, confirming the central finding of this study that remote sensing contributes directly to evidence-based regional planning. Similarly, Fernandez and Gil (2022) showed that Sentinel satellite data could be applied in forest monitoring, aligning with this study's emphasis on remote sensing as a key driver of sustainable resource management.

Another parallel with existing literature lies in the role of international frameworks and collaborations. Ekmen and Kocaman (2023) highlighted the strategic role of cross-border policy coordination and global initiatives such as the Sustainable Development Goals (SDGs), which echo the present review's observations regarding the importance of remote sensing in supporting developmental targets. European programs like Copernicus and Global Monitoring for Environment and Security (GMES) illustrate this further, by providing open-access satellite data for use in policy and planning.

Regarding technological advancement, the review aligns with Zhou et al. (2013) in underlining the rapid evolution of sensor types and data analysis methodologies. New tools like LiDAR and high-resolution optical satellites offer detailed and timely information, enabling planners to better understand complex spatial dynamics. This theme of innovation is also echoed in Qiao et al., (2022), who emphasized machine learning's increasing role in remote sensing classification and interpretation.

Contextual Disparities

Despite broad alignment, the literature also reveals significant differences in the implementation of remote sensing between developed and developing nations. Shah and Patel (2020) documented infrastructural and educational constraints that impede remote sensing adoption in rural regions of developing countries. These constraints contrast sharply with the structured and well-funded planning systems in developed nations, where integration of satellite data is both routine and institutionalized.

Additionally, while countries like Germany and Sweden are implementing comprehensive data-sharing frameworks and regulatory structures (Paršova et al., 2018), many developing countries lack access to open data repositories or sufficient technical expertise. This disparity reinforces the findings of this study that policy frameworks and technological infrastructure are often the dividing lines between effective and ineffective utilization of remote sensing in planning.

Systemic Factors and Institutional Barriers

The analysis of systemic barriers offers a nuanced understanding of why remote sensing is underutilized in some contexts. Institutional fragmentation and lack of inter-agency coordination often hinder the effective deployment of remote sensing technology. While some literature, like Bruno et al. (2019), focuses on the environmental outcomes of satellite monitoring, there is a need for more targeted studies investigating the role of institutional design in the adoption of geospatial technologies.

Data bureaucracy is another recurrent theme. Remote sensing data often traverse multiple administrative layers before reaching the hands of local planners. These bureaucratic hurdles delay real-time applications and reduce the utility of otherwise valuable satellite information. Although Kumar et al. (2021) emphasized the success of satellite platforms like IRS-1C in urban mapping, they did not address how procedural complexities can undermine these successes.

Moreover, the shortage of skilled human resources is a pervasive problem. Technical personnel capable of interpreting geospatial data are often concentrated in urban centers, leaving regional or rural planning offices under-resourced. This finding is reinforced by Ekmen and Kocaman (2023), who highlighted the need for widespread capacity-building initiatives. The lack of relevant educational programs and professional training limits both the adoption and the sophistication of remote sensing use in policy-making.

Policy-Driven Solutions and Best Practices

This study also identifies several policy-based solutions that could address the implementation gap. Strengthening data infrastructure is paramount. Creating centralized geospatial data repositories can facilitate interdepartmental coordination and ensure that local and regional planners have timely access to relevant data. Studies have shown that when governments invest in digital infrastructure, the efficiency of spatial planning improves significantly (Zhou et al., 2013).

Another key recommendation is expanding training and education. Remote sensing is a technically demanding field, and widespread adoption hinges on the availability of skilled personnel. Governments and institutions should invest in higher education curricula and professional training programs focusing on geospatial technologies. The evidence suggests that training not only increases technical capability but also fosters a culture of data-driven decision-making.

Evidence-based policy is another cornerstone for expanding remote sensing use. Integrating satellite data into planning legislation and governance models ensures that the information is not merely available but also actionable. Policies that mandate the use of remote sensing for land use change detection or environmental impact assessments have proven effective in enhancing the credibility and utility of planning decisions.

Furthermore, multistakeholder engagement is critical. Coordination among government agencies, academic institutions, civil society, and the private sector ensures that the multiple facets of

spatial planning are addressed. Successful case studies from countries with inclusive governance structures demonstrate that collective ownership of geospatial data enhances its application and fosters greater accountability.

Implications for Developing Nations

The implications of these findings are particularly relevant for developing countries. In contexts marked by rapid urbanization, deforestation, and vulnerability to climate change, remote sensing offers a cost-effective tool for proactive governance. By strengthening local capacities and investing in open-data platforms, these countries can build resilience into their planning systems.

Moreover, local adaptation of remote sensing technology ensures that its application is sensitive to community needs and ecological contexts. The inclusion of local stakeholders in data interpretation and planning processes promotes more equitable and sustainable outcomes.

Finally, the use of remote sensing can play a transformative role in disaster risk reduction, food security, and water resource management—critical issues for developing nations. Evidence-based planning informed by satellite data can reduce the margin for error in resource allocation and improve responsiveness during crises.

Limitations and Future Research

While the present review consolidates a wide range of evidence, it also underscores significant research gaps. Many studies focus on the technical or environmental aspects of remote sensing while neglecting institutional and socio-political dimensions. There is a pressing need for interdisciplinary studies that examine how governance structures, legal frameworks, and social norms influence the deployment of geospatial technologies.

Additionally, most available literature originates from or focuses on the Global North. This geographic bias limits the generalizability of findings and underrepresents the innovative adaptations occurring in the Global South. Future research should aim to diversify both the regions studied and the disciplinary perspectives employed.

The rapid evolution of artificial intelligence and big data analytics offers another promising frontier. Exploring how these technologies can be integrated with remote sensing to enhance predictive capabilities and real-time planning will be essential.

In sum, the discussion affirms that while remote sensing has transformative potential for regional planning, its full benefits can only be realized through systemic reforms, policy innovations, and inclusive capacity-building strategies.

CONCLUSION

This narrative review highlights the multifaceted roles of remote sensing technology in supporting regional planning. The findings confirm that while developed countries have successfully integrated remote sensing due to strong institutional support, technological infrastructure, and collaborative policy frameworks, developing countries still face significant barriers including limited access to data, lack of skilled human resources, and bureaucratic constraints. The study underscores that social, economic, and policy dimensions deeply influence the adoption and effectiveness of remote sensing technologies. Notably, training and public awareness programs, combined with international collaborations, were found to significantly enhance implementation outcomes. Furthermore, technological innovation, particularly the integration of LiDAR and satellite-based data, has enabled more precise and efficient land use analysis. To address systemic constraints, it is imperative to improve institutional capacity, streamline data protocols, and invest in human capital development. Policymakers are encouraged to develop inclusive, data-driven planning frameworks and cross-sectoral partnerships. Future research should focus on longitudinal analyses to examine the long-term effectiveness of remote sensing interventions across diverse geographic and socioeconomic contexts(Dahy et al., 2024). Emphasizing remote sensing as a strategic tool for informed spatial decision-making can help bridge the gap between environmental monitoring and sustainable regional development.

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