

Editorial

Application of Remote Sensing and GIS for Promoting Sustainable Geoenvironment

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The continuous growth of Earth's population poses increasingly complex challenges to the physical environment. Over recent decades, urban areas have undergone accelerated growth, leading to significant landscape alterations, heightened demand for natural resources, and increased stress on ecological systems [1]. According to projections by the United Nations, the proportion of the world's population residing in urban areas, which currently exceeds 50%, is expected to rise to nearly 70% by 2050, with the majority of this growth occurring in developing regions of Asia and Africa [2]. These demographic and spatial dynamics are expected to promote continued urban sprawl.

Urban Expansion and Geoenvironmental Consequences

Urban expansion has profoundly transformed the geoenvironment and has been consistently linked to a wide range of detrimental consequences. These include the intensification of energy demand, increased levels of environmental pollution, air, water, and soil degradation, traffic congestion, natural resource depletion, water and soil salinization, biodiversity loss, waste, desertification fires, deforestation, and climate change [3,4]. Over the past decades, the rapid expansion of urban areas has led to new environmental challenges including the development of urban heat islands, increased greenhouse gas emissions from transportation and buildings, and greater pressure on water supply, sewage, and waste management systems [5].

The expansion growth of urban areas has triggered significant modifications in land use practices and coastal morphology [6]. Land use changes can exert significant influences on Earth. Urban sprawl not only has substantial impacts on the climate, but also contributes to ecosystem disruption and environmental degradation [7]. The conversion of naturally vegetated land, such as forests, grasslands, or shrublands, into impervious surfaces intensifies surface runoff and increases the likelihood of flooding [8]. Moreover, coastal regions are projected to experience a 160% increase in urban extent between 2000 and 2030 [9]. In Mediterranean coastal areas, such as Italy, each year, more than 10 km² of natural and agricultural land types are converted into anthropogenic surfaces [10]. In Greece, the coastal areas adjacent to the Athens Metropolitan Area demonstrate that over the past 76 years, artificial land cover has increased by 40% [11]. The loss of natural land due to urbanization is a global phenomenon, potentially exposing many cities to various natural hazards.

Furthermore, it should be noted that urban sprawl has been associated with the amplification of natural hazard occurrences and the exacerbation of disaster impacts on a global scale [12]. The unregulated expansion of built-up areas into flood prone zones has heightened both human and infrastructural vulnerability [13,14]. A global assessment revealed that urban exposure to flooding increased more than fourfold between 1985



Received: 29 September 2025

Accepted: 25 October 2025

Published: 3 November 2025

Citation: Skilodimou, H.D.; Bathrellos, G.D.; Nikolakopoulos, K.G. Application of Remote Sensing and GIS for Promoting Sustainable Geoenvironment. *Sustainability* **2025**, *17*, 9789. <https://doi.org/10.3390/su17219789>

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and 2018, with a significant proportion of new urban development taking place within floodplain areas [15]. Urban expansion also alters topography and increases susceptibility to landslides. In hilly or sloped areas, construction activities frequently destabilize slopes, thereby elevating the likelihood of landslide events [16–19].

Overall, while urbanization continues to serve as a catalyst for economic development and social progress, its uncontrolled expansion presents significant challenges to environmental sustainability and disaster resilience. Consequently, the integration of spatial planning, ecosystem-based management, and climate adaptation policies is imperative to mitigate the adverse geoenvironmental impacts associated with urban growth.

Environmental System Pressures and the Necessity of Continuous Monitoring

Pressures on environmental systems are continuously intensifying as population growth drives extensive land-use and land-cover transformations. These transformations frequently result in irreversible consequences. As human activities reshape the Earth's surface at unprecedented rates, understanding these processes necessitates comprehensive baseline data, continuous environmental monitoring, and the systematic evaluation of spatial and temporal dynamics [20].

Regional-scale assessments are particularly vital, as they enable the identification of localized environmental stresses that may remain undetected at the global scale. Through systematic observation and the use of long-term datasets, researchers can quantify the cumulative impacts of anthropogenic activities on geomorphological processes, hydrological dynamics, and climatic variables [21].

Furthermore, the continuous monitoring of environmental parameters provides critical feedback to policymakers and stakeholders, facilitating the development of adaptive, evidence-based management strategies. Such approaches form the cornerstone of sustainable geoenvironmental management, ensuring that development policies respect ecological thresholds and promote long-term environmental resilience [22]. Ultimately, the systematic observation and analysis of environmental data are essential for maintaining a balance between human development and the sustainability of the geoenvironment.

Remote Sensing and GIS in Geoenvironmental Research

Over the past several decades, the proliferation of advanced remote sensing (RS) technologies has facilitated the acquisition of high-resolution, multi-sensor, and multi-temporal geospatial datasets. Simultaneously, geographical information systems (GIS) have evolved into sophisticated computational platforms for the integration, management, and quantitative analysis of heterogeneous geospatial data. The synergistic fusion of RS and GIS enables the generation of multi-dimensional, dynamic datasets that are critical for systematic environmental monitoring, change detection, and predictive modeling [14–16].

The advancement of modern RS technologies has allowed researchers to obtain highly detailed data regarding land cover characteristics, vegetation dynamics, hydrological patterns, urban expansion, and environmental degradation at unprecedented spatial and temporal scales [23–26]. The use of high-resolution satellite imagery, synthetic aperture radar (SAR), and LiDAR technologies now permits the identification of subtle environmental changes that were previously undetectable through conventional field-based techniques.

Simultaneously, geographical information systems (GIS) have evolved into sophisticated computational platforms capable of integrating, managing, and quantitatively analyzing heterogeneous geospatial datasets. Modern GIS supports advanced modeling, statistical analysis, and scenario-based simulations of environmental processes, enhancing visualization and spatial querying capabilities [27,28].

The integration of remote sensing (RS) and geographic information systems (GIS) significantly improves the capacity to analyze spatial and temporal variations in environmental systems. This combined approach offers essential insights for policymakers,

resource managers, and stakeholders, facilitating data-driven decision-making in sustainable land-use planning, environmental protection, and geoenvironmental management.

The application of RS and GIS spans a wide spectrum of geoenvironmental studies. These include but are not limited to:

- Precise geological and geomorphological mapping for understanding terrain evolution [29,30];
- Quantitative assessment of natural resources such as soil, water, vegetation, and mineral deposits [31–33];
- Evaluation of contaminant dispersal and environmental hazard assessment [34,35];
- Ecosystem and ecological vulnerability assessment [36,37];
- Modeling of natural hazard susceptibility and identification of vulnerable communities [13–19];
- Urbanization and climate changes [38,39];
- Land-use planning and resource management for sustainable development [40–42].

RS and GIS allow for the integration of remotely acquired data with in situ measurements, supporting predictive modeling and decision-making in both applied and theoretical geosciences. These technologies enhance the precision and efficiency of environmental assessments and provide the foundation for adaptive, data-driven strategies in sustainable geoenvironmental management. Consequently, such capabilities ensure that geoenvironmental management remains responsive and evidence-based, effectively addressing the complex challenges arising from rapid environmental change and urbanization.

Consequently, RS and GIS constitute indispensable methodological tools in contemporary geoenvironmental research. They underpin the quantitative analysis of human–environment interactions and support the sustainable management of geological, ecological, and socio-environmental systems [8,27,43–47]. The continuous advancement of sensor technologies, data analytics, and spatial modeling algorithms further underscores their critical role in addressing complex environmental challenges in an era of rapid global change [9,22,48–50]. By integrating high-resolution geospatial data, real-time monitoring, and predictive modeling, RS and GIS provide essential tools for mitigating environmental degradation, reducing disaster risk, and promoting resilient and sustainable geoenvironmental management.

The main aim of this Special Issue is to emphasize the wide-ranging applications of RS and GIS in advancing sustainable geoenvironmental research. It encompasses systematic monitoring, evaluation, and the spatiotemporal analysis of environmental conditions. The Issue also addresses strategies for enhancing the long-term sustainability of geoenvironmental systems, reducing anthropogenic impacts, and supporting the preservation of high-quality human life. Additionally, natural hazard assessment and prevention are presented.

Conflicts of Interest: The authors declare no conflict of interest.

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