A Conceptual Geospatial Data Management Model for National Parks

Zakri Tarmidi[1*], Noordyana Hassan[2], Suzanna Noor Azmy[3] and Nurul Nadiah Yahya[1]

[1]Department of Geoinformation, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia

[2] Geoscience and Digital Earth Centre (INSTeG), Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia

*zakritarmidi@gmail.com (*Corresponding author's email only)

Abstract: *Effective and integrated geospatial information management plays a critical role in enhancing the administration, natural resource conservation, and sustainable tourism development of national parks. This study proposes a conceptual model for comprehensive geospatial data management, with a specific focus on national parks in Sarawak, Malaysia. The model comprises six core components: core geospatial data, park management information, tourism and activity data, socio-economic and community profiles, GIS infrastructure and technology, and data governance. By integrating these elements, the model aims to support data-driven decision-making, strengthen park administration, and facilitate information sharing among agencies and local communities. The model emphasizes the adoption of spatial data standards, the implementation of digital platforms such as WebGIS, and active involvement of local communities in data collection and updates, such as through participatory mapping or mobile data collection apps. It also addresses the need for multi-layered spatial analysis involving elevation models, buffer zones, and zoning of park attractions, infrastructure, and biodiversity hotspots. The conceptual model developed in this study serves as a foundational framework for establishing a transparent, efficient, and sustainable geospatial information system to support conservation and ecotourism planning in Sarawak's national parks.*

Keywords: Geospatial Data management, Geospatial Data Sharing, National Park, Managing Geospatial Park

Introduction

National parks serve as areas to conserve and protect the natural environment, including flora and fauna (Chung, 2022). They are also established to preserve local heritage, history, and culture. Additionally, national parks function as important locations for recreation ecotourism, education, and research (Hossain and Khanal, 2020).

Malaysia's national parks have become one of the country's key ecotourism resources, offering various major attractions such as rainforests, waterfalls, caves, and more (Diansyah and Sakawi, 2022). Beyond these physical features, unique flora and fauna—some of which are endemic to Malaysia—also serve as significant attractions to these parks (Fauzi, 2017). Many national parks in Malaysia are also home to Indigenous communities (Orang Asli), who preserve and practice distinct cultural and socioeconomic traditions that vary by region

(Diansyah and Sakawi, 2022). These communities play an important role in maintaining local history and heritage.

Despite their potential as sources of local economic development, national parks face several challenges in terms of area management and administration (Vuković, 2022). Information on tourism activities and available tour packages is often fragmented or difficult to access, as it typically exists in silos within each park.

Another concern is the lack of comprehensive geospatial data related to topography, assets, and facilities within the parks (Fauzi, 2017). The absence of standardized, integrated, and accessible data makes it difficult to support local socio-economic development. It also limits the ability to identify, evaluate, and enhance existing facilities, activities, and attractions, as well as to develop appropriate tourism models and packages (Fauzi, 2017).

To cater the issues on geospatial data management, this study aims to develop a conceptual model for managing geospatial and socio-economic data related to national parks, particularly toward achieving sustainable tourism.

To achieve this, three main objectives have been outlined:

1. To identify the key issues and constraints in managing geospatial and socio-economic data within national parks for ecotourism purposes.
2. To determine the required data components and information needs related to park management, activities, and tourism.
3. To design a conceptual model for managing geospatial information in national parks in Sarawak.

Literature Review

A review of multidisciplinary literature reveals a diverse set of approaches, methods, and conceptual frameworks relevant to developing a geospatial information management model for national parks in Malaysia. The studies range from technical geospatial modeling and decision-support systems to governance, community engagement, and tourism integration.

Several works (e.g., Mileti et al., 2022; Lazoglou & Angelides, 2020) emphasize the effectiveness of geospatial decision support systems (SDSS) in enhancing ecotourism and land-use planning. The integration of spatial data, environmental indicators, and stakeholder input enables more informed and context-sensitive decisions, which is directly applicable to managing Malaysia's national parks. The use of SDSS with automated machine learning (AutoML), as discussed by Wen & Li (2022), presents a promising frontier to support adaptive and user-friendly decision-making tools.

From a technological standpoint, Prince et al. (2020) and Rajabifard et al. (2021) demonstrate how advanced techniques such as object-based image analysis (OBIA), LiDAR, and 3D land administration systems can improve accuracy and data richness, especially in mapping terrain, soil properties, and land governance. These methods are crucial for national parks characterized by diverse topography and land tenure complexity.

In terms of tourism planning, Peterson et al. (2020) and Cai et al. (2023) offer insights into understanding visitor behavior and integrating stakeholder values using GPS and participatory mapping. These approaches support sustainable tourism by aligning spatial planning with real-world usage and local perceptions.

Community and cultural integration are also critical dimensions. Studies like Diansyah et al. (2022) and Hossain & Khanal (2020) highlight the role of indigenous knowledge and socio-cultural factors in sustainable forest and park management. The presence of Orang Asli communities in Malaysian national parks aligns well with these findings, indicating the need to incorporate socio-economic datasets and participatory governance mechanisms.

Furthermore, governance and policy frameworks are discussed in works such as Chung (2022) and Fauzi (2017). These emphasize the necessity of cross-agency collaboration, clearly defined data ownership, and standardized metadata protocols for effective GIS deployment. Issues like fragmented data sharing, limited interoperability, and lack of technical training are recurrent themes that must be addressed in the Malaysian context.

Lastly, studies such as Williams & McHenry (2020) and Ballesteros et al. (2022) stress the importance of using GIS tools not only for spatial analysis but also as platforms for communication, education, and public engagement. This is particularly important for promoting environmental awareness and facilitating research and policy-making in protected areas.

Discussion

Synthesizing across these studies, several key themes emerge that should inform the conceptual model for geospatial information management in Malaysian national parks:

a. The Need for Integrated, Multi-Domain Data Frameworks

The synthesis of studies such as those by Ballesteros et al. (2022) and Fauzi (2017) reveals the importance of integrating diverse datasets into a unified geospatial information system. Effective national park management involves more than environmental data; it requires integrating core geospatial datasets (topography, boundaries, biodiversity zones), administrative data (SOPs, staffing, infrastructure), tourism-related information, and socioeconomic variables from surrounding communities.

For instance, the Courel Mountains UNESCO Global Geopark (UGGp) example demonstrates a GIS platform that compiles multi-thematic data validated by scientific teams. This kind of thematic layering is essential in Malaysia where national parks often encompass biodiversity hotspots, indigenous territories, and tourism zones. It suggests that modular and multi-source GIS architecture is a foundational requirement.

b. Spatial Decision Support Systems (SDSS) and Automation for Adaptive Management

Several studies (Mileti et al., 2022; Wen & Li, 2022; Lazoglou & Angelides, 2020) highlight the evolution from static GIS systems to more interactive Spatial Decision Support Systems (SDSS), enabling park managers to perform scenario analysis, monitor ecological indicators, and support real-time decision-making. Importantly, Wen & Li's (2022) work on integrating Automated Machine Learning (AutoML) into SDSS underlines the potential for predictive analytics, data-driven policy-making, and user-centered design that reduces the barrier to use among non-technical stakeholders.

In the context of Malaysian parks, this allows for real-time feedback on visitor flows, weather-related risks, wildlife movement, and even forest degradation alerts, improving resilience and responsiveness in management.

c. Role of Remote Sensing and AI-Based Mapping in Environmental Intelligence

The technical capacity to monitor and analyze spatial environments has been transformed through tools such as LiDAR, OBIA (Object-Based Image Analysis), and AI-based classification algorithms, as illustrated by Prince et al. (2020) and Ahmad et al. (2020). The high-resolution mapping of soil parent materials, forest canopy, and terrain conditions offers direct applications in zoning, ecological sensitivity assessments, and land suitability analysis within park boundaries.

In Malaysia's diverse terrain, where elevation gradients and hydrological features influence biodiversity and tourism potential, such detailed spatial modeling supports more nuanced park zoning and conservation planning.

d. Tourism and Visitor Dynamics: Spatial-Temporal Insights for Smart Management

Visitor management is a critical issue for national parks, especially where over-tourism or environmental degradation threatens sustainability. Peterson et al. (2020) and Cai et al. (2023) emphasize the importance of incorporating spatiotemporal visitor movement data, obtained through GPS trackers and participatory mapping.

These data help managers not only understand high-traffic areas and peak times but also design location-based services, improve resource allocation, and minimize human-wildlife conflict. In Malaysia, this could inform smart ecotourism packages, guide the placement of infrastructure, and ensure visitor safety in remote areas.

e. Community Integration and Socioeconomic Data as a Pillar of Park Sustainability

In line with Diansyah et al. (2022) and Hossain & Khanal (2020), the literature reveals that park sustainability is deeply interlinked with the wellbeing and participation of surrounding communities. Socioeconomic data—such as local income sources, tourism-based livelihoods, cultural practices, and community conservation roles—are crucial for inclusive planning.

Models that exclude local populations risk marginalization and conflict. Conversely, integrating community profiles and participatory data layers ensures that national parks become engines of local development, not just isolated conservation zones. This aligns with Malaysia's goal of empowering Orang Asli communities in conservation and tourism initiatives.

f. Governance, Policy, and Institutional Collaboration

Effective data management systems require robust governance structures, as outlined in Chung (2022) and Fauzi (2017). Key challenges include unclear data ownership, lack of metadata standards, restricted inter-agency data flows, and limited technical capacity. Rajabifard et al. (2021) further demonstrate how Land Administration Domain Model (LADM) principles can improve interoperability and land data standardization—an idea applicable to the layered land uses within national parks.

In Malaysia, where responsibilities for park management are often fragmented across state governments, federal agencies, NGOs, and community groups, a centralized and transparent geospatial data governance model is imperative.

g. GIS for Communication, Education, and Public Engagement

Lastly, the function of GIS as a communication and engagement tool must not be overlooked. As per Williams & McHenry (2020), many geospatial tools aid not just in analysis but also in visualizing and communicating conservation priorities. This is particularly effective for education, awareness campaigns, and citizen science initiatives. Using WebGIS, interactive dashboards, or mobile apps, park authorities can share data with the public, receive citizen inputs, and increase transparency—creating a sense of shared responsibility over national parks.

Table 1: The synthesis summary.

Dimension	**Insights from Literature**	**Implications for National Parks in Malaysia**
Data Integration	Multi-domain GIS frameworks (Ballesteros et al., Fauzi)	Develop modular geospatial systems for ecology, tourism, and communities
Decision Support	SDSS and AutoML (Wen & Li; Mileti)	Enable dynamic, real-time, and predictive management systems
Remote Sensing	LiDAR, OBIA (Prince, Ahmad)	High-resolution environmental mapping for zoning & monitoring
Tourism Analytics	Visitor GPS data, 3D modeling (Peterson, Cai)	Smart tourism, improved safety, and resource planning
Community Involvement	Indigenous & local socioeconomics (Diansyah, Hossain)	Community-based planning and benefit-sharing mechanisms
Data Governance	Policy & standards (Chung, Rajabifard, Fauzi)	Unified, transparent data ownership and access protocols
Outreach	GIS for communication (Williams)	Public engagement, education, and participatory decision-making

Literature Synthesis to Key Components of Geospatial Data Management for National Parks

Building upon the synthesis of international and local studies, it becomes clear that a robust model for managing geospatial information in national parks must be comprehensive, inclusive, and technologically responsive. To this end, the following six components emerge as foundational pillars of the conceptual model as shown in Figure 1.

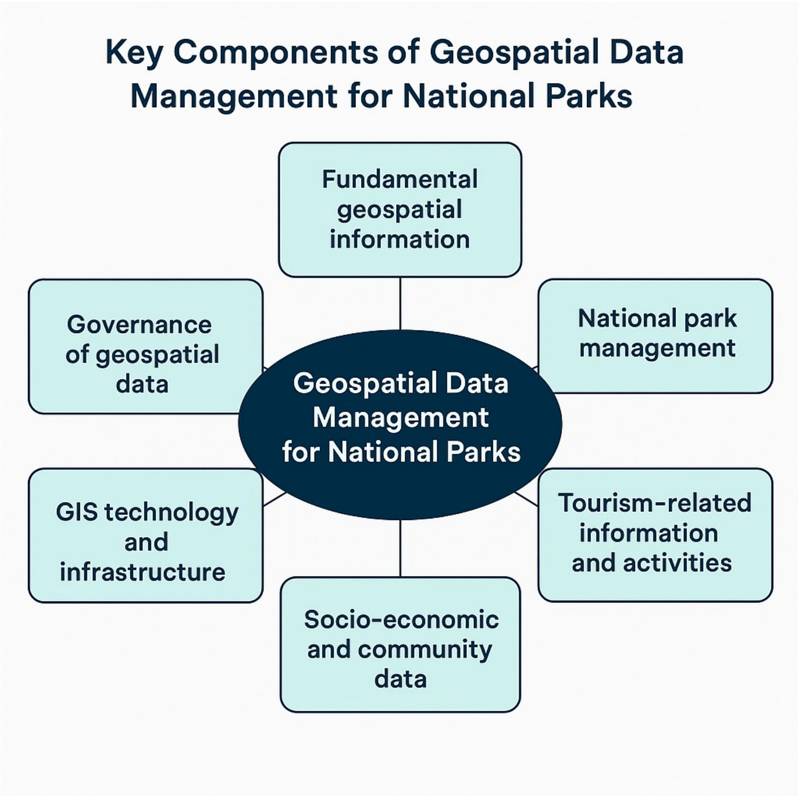

Figure 1: Six components emerge as foundational pillars for conceptual model.

1. Fundamental Geospatial Information

At the core of any national park management system is the availability and accuracy of base geospatial data. This includes topography, hydrology, vegetation cover, land use/land cover (LULC), park boundaries, and protected zones. Studies by Prince et al. (2020) and Phua & Minowa (2000) show how remote sensing and high-resolution spatial datasets can provide essential environmental layers that underpin all spatial planning activities. Without such fundamental data, zoning, conservation, and infrastructure planning remain fragmented and reactive.

Furthermore, Ahmad et al. (2020) demonstrate how 3D geoinformatics modeling can enhance the spatial realism of park environments, offering an interactive base for visualizing and analyzing key ecological and terrain elements.

2. National Park Management Information

National parks are dynamic entities requiring active and informed management. Literature such as Ballesteros et al. (2022) and Rajabifard et al. (2021) underscores the value of integrating management-related spatial datasets—including ranger patrol areas, infrastructure maintenance schedules, species monitoring zones, and incident reports—into a central geodatabase.

A spatial decision support system (SDSS) tailored to park management enables adaptive responses to threats such as illegal encroachment, wildlife conflicts, and climate-related disturbances. The system should also include administrative boundaries, legal designations, and management zones, which are critical for aligning park operations with national and international regulations.

3. Tourism-Related Information and Activities

Tourism is both a major opportunity and a management challenge. Studies by Peterson et al. (2020) and Mileti et al. (2022) illustrate how visitor movement data, spatial behavior patterns, and tourist hotspots can be captured using GPS tracking, participatory GIS, and web mapping interfaces. Integrating these layers into geospatial systems allows managers to optimize trail designs, signage placement, crowd control, and amenity planning.

Additionally, information such as tourism zones, visitor centers, campgrounds, and eco-lodges must be spatially represented. This data also supports tourism marketing, heritage interpretation, and ecosystem carrying capacity analysis. Malaysia's unique ecotourism appeal—especially in national parks like Taman Negara or Kinabalu Park—requires a geospatial backbone to balance promotion with protection.

4. Socio-Economic and Community Data

As emphasized in the works of Diansyah et al. (2022) and Hossain & Khanal (2020), the communities living in and around national parks play a pivotal role in shaping the success of conservation efforts. Geospatial systems must integrate socio-economic datasets—including population distribution, local livelihoods, land use patterns, cultural sites, and community-conserved areas.

Moreover, Cai et al. (2023) highlight the importance of integrating social values and local knowledge into spatial decision-making. For Malaysia, this means including the voices of Orang Asli and rural communities in spatial planning through participatory GIS, ensuring that conservation does not occur at the cost of social exclusion.

5. GIS Technology and Infrastructure

Effective geospatial information management depends not only on data but also on technological infrastructure, including GIS platforms, software, cloud storage, and field data collection tools. Wen & Li (2022) and Williams & McHenry (2020) emphasize that adopting user-friendly, automated, and scalable GIS tools can significantly enhance data usability across different levels of stakeholders—from policymakers to on-the-ground rangers.

This component also entails capacity-building, ensuring that national park staff have the skills, equipment, and technical support to utilize and update geospatial systems. Fauzi (2017) noted that limitations in infrastructure and technical training continue to hinder effective GIS implementation in Malaysia, suggesting a pressing need for long-term digital investments.

6. Governance of Geospatial Data

The sixth and arguably most critical component is governance—the policies, standards, responsibilities, and coordination mechanisms that underpin the system. As highlighted by Chung (2022) and Rajabifard et al. (2021), poor data governance can result in data silos, overlapping responsibilities, and restricted data access, ultimately stalling progress.

In the Malaysian context, where both federal and state authorities share jurisdiction over national parks, a centralized yet flexible data governance framework is essential. This includes agreements on data sharing, metadata standards, privacy protocols, and mechanisms for stakeholder coordination.

The integration of national land policies, environmental regulations, and indigenous rights frameworks into the governance layer ensures that the geospatial system operates with legitimacy, accountability, and inclusivity.

The Conceptual Model

For the development of this conceptual model, several key criteria must be considered for effective geospatial data management in managing national parks. The first involves fundamental geospatial information; the second relates to national park management; the third covers tourism-related information and activities; the fourth focuses on socio-economic and community data; the fifth concerns GIS technology and infrastructure; and lastly, the governance of geospatial data. The figure 2 below illustrates the main criteria for this conceptual model.

The development of an effective conceptual model for managing geospatial and socioeconomic data within national parks requires a structured and comprehensive framework. This framework must consider multiple interrelated components to ensure a holistic approach to planning, monitoring, and decision-making. The proposed model is structured around six major components, each of which plays a vital role in supporting sustainable ecotourism, environmental conservation, and efficient park governance.

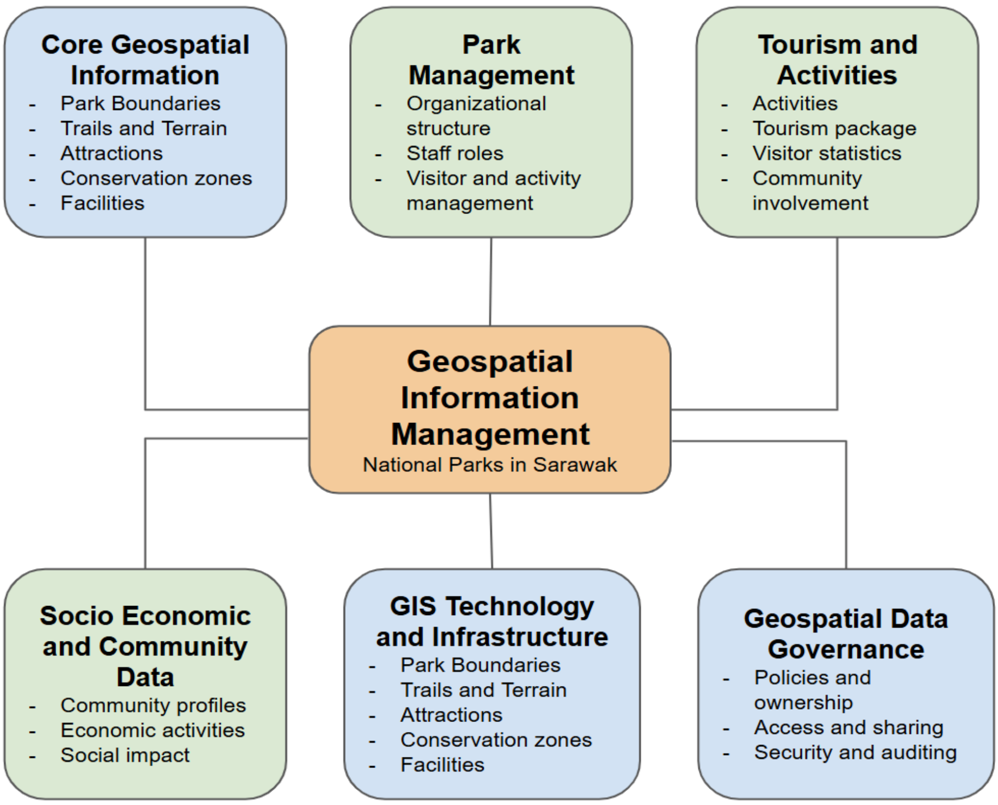

Figure 2. Concept Model for Geospatial Information Management in National Park.

1. Core Geospatial Information Component

At the heart of the model is the geospatial information component, which serves as the foundation for spatial analysis and mapping. This includes the delineation of national park boundaries, road networks, and hiking trails, as well as topographic data such as elevation and slope derived from Digital Elevation Models (DEMs). In addition, the spatial distribution of natural attractions—such as waterfalls, caves, and scenic viewpoints—is essential for visitor navigation and planning. Critical biodiversity zones and conservation areas must also be identified and monitored. This component further encompasses the location of physical assets including resorts, cabins, restrooms, halls, and observation huts, all of which support tourism infrastructure and park operations.

2. National Park Management Component

This component focuses on the administrative and operational structures that govern national parks. It includes the organizational hierarchy, roles and responsibilities of personnel—such as park managers, rangers, nature guides, and volunteers—as well as protocols for visitor management and activity regulation. Proper documentation of Standard Operating Procedures (SOPs) and integration of visitor data management systems are necessary to ensure compliance, efficiency, and coordination among stakeholders.

3. Tourism and Activity Component

Tourism forms a significant pillar of national park function. This component encompasses the classification of ecotourism activities such as hiking, camping, birdwatching, and canopy walks. The model integrates the development of tour packages tailored to park zones and natural attractions, as well as the compilation of statistics related to visitor numbers, seasonal patterns, and accommodation usage. Importantly, local community-based tourism activities—such as eco-guiding, homestays, and the production of traditional crafts—are included to enhance community engagement and diversify income opportunities.

4. Socioeconomic and Community Data Component

Understanding the demographic and economic landscape of communities surrounding the park is essential for fostering inclusive development. This component captures data on population profiles, employment, tourism-related income-generating activities, and the socio-cultural impacts of tourism. The model also emphasizes the role of local communities in conservation efforts, recognizing their indigenous knowledge, participation in eco-tourism, and co-management of natural resources.

5. GIS Technology and Infrastructure Component

The effective application of GIS technologies underpins the model's spatial data infrastructure. This includes the establishment of a centralized geodatabase, adherence to national and international metadata standards (e.g., MS1759, ISO 19115), and the development of interactive applications such as dashboards, WebGIS portals, and mobile apps. These platforms facilitate real-time monitoring, spatial querying, and visualization. Integration with emerging technologies such as IoT devices, sensors, and digital reservation systems enhances the model's adaptability and responsiveness.

6. Data Governance Component

Robust data governance is critical to ensure the integrity, security, and interoperability of the system. This component addresses issues of data ownership, access rights, and inter-agency data sharing policies. It also includes provisions for data security, transparency, and periodic audits. Evaluating the effectiveness of data governance mechanisms is necessary to maintain accountability and support evidence-based policy-making.

Together, these components form a multi-dimensional framework aimed at enhancing the management of national parks, supporting sustainable tourism development, and promoting community participation through the efficient use of geospatial data and technologies.

Conclusion

The integration of diverse yet interconnected components in the proposed conceptual model underscores the complexity and multidimensional nature of managing geospatial and socioeconomic data in national parks. By addressing core elements such as geospatial information, park management structures, tourism activities, community data, GIS infrastructure, and data governance, the model provides a comprehensive and systematic framework to support sustainable ecotourism and conservation efforts.

Each component plays a distinct yet complementary role in ensuring that decision-making processes are data-driven, transparent, and inclusive. The model not only facilitates better spatial planning and resource allocation but also promotes community involvement and cross-agency collaboration. Ultimately, the adoption of this conceptual model is expected to enhance the efficiency, resilience, and long-term sustainability of national parks, particularly in regions such as Sarawak where ecological, cultural, and tourism values are deeply intertwined.

Future work may include piloting this model in selected national parks in Sarawak to validate its operational feasibility and refine data workflows.

Acknowledgement

This research is funded by Jabatan Tanah dan Survei Sarawak, Vot R.J130000.7352.1R051, and partially funded by Ministry of Higher Education (MOHE), Fundamental Research Grant Scheme, Vot R.J130000.7852.5F685.

References

Paul, M., Negahban-Azar, M., Shirmohammadi, A., & Montas, H. J. (2020). Assessment of agricultural land suitability for irrigation with reclaimed water using geospatial multi-criteria decision analysis. Agricultural Water Management, 231, 105987. https://doi.org/10.1016/J.AGWAT.2019.105987

Mileti, F. A., Miranda, P., Langella, G., Pacciarelli, M., De Michele, C., Manna, P., Bancheri, M., & Terribile, F. (2022). A geospatial decision support system for ecotourism: a case study in the Campania region of Italy. Land Use Policy, 118, 106131. https://doi.org/10.1016/j.landusepol.2022.106131

Prince, A., Franssen, J., Lapierre, J.-F., & Maranger, R. (2020). High-resolution broad-scale mapping of soil parent material using object-based image analysis (OBIA) of LiDAR elevation data. Catena, 188, 104422. https://doi.org/10.1016/J.CATENA.2019.104422

Peterson, B. A., Brownlee, M. T. J., Hallo, J. C., Beeco, J. A., White, D., Sharp, R. L., & Cribbs, T. W. (2020). Spatiotemporal variables to understand visitor travel patterns: A management-centric approach. Journal of Outdoor Recreation and Tourism, 31, 100316. https://doi.org/10.1016/J.JORT.2020.100316

Salunke, V. S., Lagad, S. J., Bhagat, R. S., & Kudnar, N. S. (2021). A Geospatial Approach to Enhance Point of the Interest and Tourism Potential Centers in Parner Tehsil in Maharashtra, India. International Journal of Scientific Research in Science, Engineering and Technology, 8(1), 186–196. https://doi.org/10.32628/IJSRSET218136

Chung, J. W. (2022). A proposed governance model for the adoption of geoparks in Australia. International Journal of Geoheritage and Parks, 10(1), 160–172. https://doi.org/10.1016/j.ijgeop.2021.12.001

Lazoglou, M., & Angelides, D. C. (2020). Development of a spatial decision support system for land-use suitability assessment: The case of complex tourism accommodation in Greece. 2, 100022. https://doi.org/10.1016/J.RESGLO.2020.100022

Rajabifard, A., Atazadeh, B., Kalantari, M., Olfat, H., Shojaei, D., & Badiee, F. (2021). Design and development of an LADM-driven 3D Land administration system: Lessons learned in Malaysia. Land Use Policy, 102(102), 105252. https://doi.org/10.1016/J.LANDUSEPOL.2020.105252

Hossain, M. I., & Khanal, B. P. (2020). SWOT Analysis of Forest Protected Area Based Sustainable Tourism Development: A Case Study in the Lawachara National Park, Bangladesh. Journal of Tourism and Hospitality, 10, 71–89. https://doi.org/10.3126/JTHE.V10I0.28734
Williams, M. A., & McHenry, M. (2020). The increasing need for Geographical Information Technology (GIT) tools in Geoconservation and Geotourism. 3(1), 17–32. https://doi.org/10.30486/GCR.2020.1901102.1019
Ballesteros, D., Caldevilla, P., Sanchez Vila, R., Barros, X. C., Rodríguez-Rodríguez, L., García-Ávila, M., Sahuquillo, E., Llorente, M., Diez, J. B., Fuertes-Fuente, M., Timón-Sánchez, S., de Lombera-Hermida, A., Álvarez, I., Pérez-Cáceres, I., Acebo, M., Orche Amaré, P., García, J., Martín-González, F., & Alemparte, M. (2022). A GIS-supported Multidisciplinary Database for the Management of UNESCO Global Geoparks: the Courel Mountains Geopark (Spain). Geoheritage, 14(2). https://doi.org/10.1007/s12371-022-00654-3
Long, C.-C., Lu, S., & Zhu, Y. (2022). Research on Popular Science Tourism Based on SWOT-AHP Model: A Case Study of Koktokay World Geopark in China. Sustainability, 14(15), 8974. https://doi.org/10.3390/su14158974
Wen, R., & Li, S. (2022). Spatial Decision Support Systems with Automated Machine Learning: A Review. 12(1), 12. https://doi.org/10.3390/ijgi12010012
Ahmad, M. A., Tvoroshenko, I., Baker, J. H., Kochura, L., & Lyashenko, V. (2020). Interactive Geoinformation Three-Dimensional Model of a Landscape Park Using Geoinformatics Tools. International Journal on Advanced Science, Engineering and Information Technology, 10(5), 2005–2013. https://doi.org/10.18517/IJASEIT.10.5.11298
Cai, C., van Riper, C. J., Johnson, D. N., Stewart, W., Raymond, C. M., Andrade, R., Goodson, D., & Keller, R. (2023). Integrating social values with GPS tracks through Denali National Park and Preserve. Applied Geography, 155, 102958. https://doi.org/10.1016/j.apgeog.2023.102958
Diansyah, M. W., Abas, A., & Sakawi, Z. (2022). Exploring the relevance of engaging the Orang Asli in Malaysia's forest management. Frontiers in Forests and Global Change, 5. https://doi.org/10.3389/ffgc.2022.1019994
Nettles, J. M., Brownlee, M. T. J., Sharp, R. L., & Verbos, R. I. (2021). The utilization distribution: wildlife research methods as a tool for understanding visitor use in remote parks and protected areas. Human Dimensions of Wildlife, 1–13. https://doi.org/10.1080/10871209.2021.1885766
Cakir, S., Hecht, R., Krellenberg, K., & Krellenberg, K. (2021). Sensitivity analysis in multi-criteria evaluation of the suitability of urban green spaces for recreational activities. 2, 1–8. https://doi.org/10.5194/AGILE-GISS-2-22-2021
Vuković, M. (2022). The application of GIS in sustainable tourism management. Economics of Sustainable Development, 6(2), 53–62. https://doi.org/10.5937/esd2202053v
Spatial Decision Support Systems with Automated Machine Learning: A Review. (2022). https://doi.org/10.20944/preprints202209.0465.v1
Fauzi, N. S. M., & Misni, A. (2022). The Impact of Geopark Recognition on Kilim Karst Geoforest Park, Langkawi. International Review for Spatial Planning and Sustainable Development, 10(4), 209–222. https://doi.org/10.14246/irspsd.10.4_209
Fauzi, R. (2017). Isu, cabaran dan prospek aplikasi dan perlaksanaan Sistem Maklumat Geografi di Malaysia: Satu pengamatan (Issues, challenges and prospects of application and

implementation of Geographic Information System in Malaysia: An observation). Geografia: Malaysian Journal of Society and Space, 11(2). https://ejournal.ukm.my/gmjss/article/view/18495

Phua, M. H., & Minowa, M. (2000). Evaluation of environmental functions of tropical forest in Kinabalu Park, Sabah, Malaysia using GIS and remote sensing techniques: Implications to forest conservation planning. Journal of Forest Research, 5(3), 123–131. https://doi.org/10.1007/BF02762390