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A GEOSPATIAL-BASED EDUCATION MANAGEMENT MODEL AS A WEIGHTED DECISION SUPPORT SYSTEM FOR SUSTAINABLE TOURISM VILLAGES

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Abstract: This study aims to develop and operationalize a geospatial-based education management model as a weighted Decision Support System (DSS) framework for sustainable tourism villages. A qualitative case study approach was employed in Panglipuran Village, Bali, Indonesia. Data were collected through semi-structured interviews, field observations, and document analysis involving traditional leaders, village government officials, religious leaders, administrators, and community representatives. To demonstrate the model's operational feasibility, a simplified weighted overlay approach was applied by integrating three principal components: infrastructure accessibility, land-use suitability, and education management capacity. Education capacity was operationalized through a normalized Educational Spatial Index (ESI) derived from the student–teacher ratio (STR) and student–school ratio (SSR). The spatial evaluation compared two scenarios: one based on infrastructure accessibility and land-use suitability, and another incorporating the additional education management layer. The results indicate that integrating education management variables altered spatial prioritization patterns. The proportion of high-priority zones decreased from 48% to 36%, while moderate-priority zones increased from 32% to 40% and low-priority zones rose from 20% to 24%. These changes demonstrate that incorporating educational and institutional capacity can modify conventional infrastructure-oriented spatial suitability assessments. The findings highlight the importance of considering human capital readiness and institutional capacity alongside physical accessibility and land-use conditions in sustainable tourism planning. The proposed geospatial education DSS extends conventional GIS-based decision-support approaches by operationalizing education management as a spatially explicit governance component. Rather than treating education solely as a social outcome of tourism development, the model positions educational capacity as a factor in territorial prioritization and development planning. Although the empirical application is limited to Panglipuran Village, the model offers a transferable framework that can be adapted to other tourism village contexts. Further research should validate the framework across multiple locations and employ empirically derived weighting schemes to strengthen its analytical robustness and practical applicability.

Keywords: sustainable tourism villages, geospatial analysis, education management, Decision Support System (DSS), spatial suitability, tourism governance

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INTRODUCTION

Sustainable tourism villages have increasingly been positioned as strategic instruments for balanced regional development, integrating economic diversification, cultural heritage preservation, and environmental stewardship at the local scale. Within this framework, villages are not merely tourism destinations but complex spatial systems in which social, economic, environmental, and institutional processes interact dynamically. The sustainability of tourism villages therefore depends not only on physical resource management but also on governance capacity capable of coordinating spatial assets and human capital (Gao et al., 2024; Romão & Neuts, 2017; Shen et al., 2025).

Geospatial technologies and Geographic Information Systems (GIS) have become central tools in tourism planning and territorial governance. Prior studies demonstrate the effectiveness of GIS-based approaches in identifying tourism potential, evaluating accessibility, mapping environmental sensitivity, and supporting land-use decisions (Acharya et al., 2022; Bandt et al., 2022). GIS-driven Decision Support Systems (DSS) further enable the integration of spatial data with analytical procedures to assess development alternatives and policy scenarios (Aghvamimoghadam & Madani, 2025; Daud et al., 2024; Deressa et al., 2025; Mileti et al., 2022; Priatmoko et al., 2026; Zubiaga De la Cal et al., 2026). However, most

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existing applications prioritize environmental suitability and infrastructural indicators, while governance-related dimensions are frequently treated descriptively rather than embedded within spatial analytical frameworks.

Parallel to these developments, human capital and education management have been recognized as fundamental pillars of sustainable tourism governance. Education enhances service quality, entrepreneurial capacity, and community participation, thereby strengthening long-term resilience in village-based tourism destinations (Bachri et al., 2024; Sholeha & Sumarmi, 2025). Empirical evidence from Panglipuran Village in Bali highlights how tourism spaces can function as "learnscapes," simultaneously supporting cultural preservation, economic development, and educational engagement (Widodo et al., 2024). Additional studies indicate that geospatial analysis can reveal spatial disparities in educational access and institutional capacity, supporting more equitable governance strategies (Widodo et al., 2025).

Similar structural challenges are observable in other developing regions. In rural coastal destinations in West Africa, such as Kafountine in Senegal, tourism development reflects a spatial paradox: high tourism potential coexists with fragile socio-ecological systems and limited human capital capacity. Spatially uneven infrastructure distribution, climate vulnerability (including coastal erosion and salinization), and insufficient vocational training aligned with tourism market demands illustrate the persistent misalignment between tourism planning and education management systems. In many developing countries, tourism education and local capacity-building mechanisms remain weakly integrated into spatial governance frameworks. The United Nations World Tourism Organization emphasizes that sustainable rural tourism requires community empowerment, institutional capacity building, and integrated territorial governance rather than infrastructure-led expansion alone. These conditions underscore the importance of embedding geospatial intelligence within education management architectures to promote spatial justice and sustainable territorial governance (Nunkoo, 2017).

Recent studies highlight the growing importance of sustainable and innovation-driven approaches in tourism development. For example, Safarov et al. (2024) emphasize the role of agrotourism in supporting regional economic diversification, cultural heritage preservation, and sustainable rural livelihoods. At the same time, Manurung et al. (2025) underline the importance of digital capability, green innovation, and environmental adaptability in enhancing performance in dynamic contexts. These perspectives suggest the need for integrative frameworks that combine spatial analysis, governance, and adaptive capacity in tourism planning. Despite these advancements, a conceptual and methodological gap persists. While GIS-based DSS models are widely applied in tourism planning, the integration of education management as a spatially operationalized governance variable remains underdeveloped. Human capital capacity is rarely treated as a measurable and locationally embedded component within territorial decision architectures. This separation limits the ability of policymakers to align spatial development priorities with education-based community strengthening strategies.

To address this gap, this study develops and operationalizes a geospatial-based education management model embedded within a GIS-driven Decision Support System (DSS) for sustainable tourism villages. Beyond conceptual integration, the study demonstrates simplified computational feasibility through weighted spatial integration of infrastructure, land suitability, and education management indicators. By operationalizing education management as a spatial governance variable, the framework integrates human capital capacity into territorial evaluation processes.

The proposed model offers a transferable semi-operational decision structure adaptable to diverse tourism village contexts and strengthens the alignment between spatial planning and human capital development.

MATERIALS AND METHODS

This study adopts a qualitative framework-development approach aimed at constructing a geospatial-based education management model as a weighted Decision Support System (DSS) for sustainable tourism villages. The methodological framework and the sequence of research steps are illustrated in Figure 1.

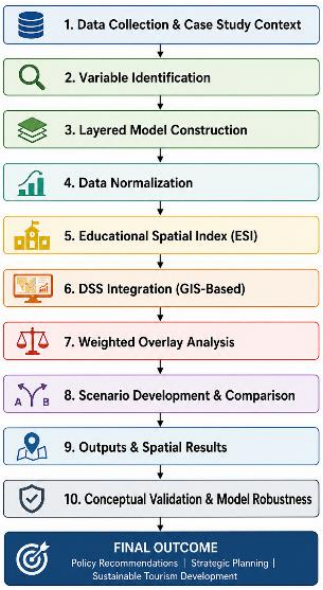


Figure 1. Flowchart of Methodology Steps

Although grounded in qualitative case validation, the study operationalizes the proposed framework through simplified quantitative spatial modelling to demonstrate decision feasibility. By synthesizing perspectives from tourism geography, education management, and GIS-based decision science, the study maintains an integrated view of spatial and governance interactions (Yin, 2018). A case study design was employed to demonstrate the applicability of the proposed model within a real-world governance context. Panglipuran Village, Bali Province, Indonesia, was selected as the reference case due to its established reputation as a cultural tourism village and its documented role as a tourism-based "learnscape" (Widodo et al., 2024). Case study methodology allows in-depth examination of complex phenomena embedded within specific socio-spatial settings, particularly when boundaries between context and process are interrelated (Baxter & Jack, 2008; Flyvbjerg, 2006).

Study Area and Time Frame

Panglipuran Village was selected for its distinctive integration of cultural heritage preservation, tourism management, and community-based governance structures. Its spatial configuration, institutional organization, and tourism dynamics provide a relevant context for examining the integration of education management within territorial planning systems. The traditional spatial layout of Panglipuran Village, including its structured settlement patterns and cultural zoning, is illustrated in Figure 2. Data collection was conducted from February to October 2024, allowing sufficient temporal scope to observe governance practices, educational activities, and spatial organization patterns. The selection of time and place follows qualitative research principles emphasizing contextual depth, research objectives, and ethical considerations (Robson & McCartan, 2016).



Figure 2. Traditional spatial layout of Panglipuran Village reflecting structured settlement patterns and cultural zoning (Source: Authors' documentation, photographed by BSW on 5 July 2024 in Panglipuran Village, Bali, Indonesia)

The study draws upon multiple data sources to support model development and contextual validation. Secondary materials include peer-reviewed international journal articles addressing geospatial analysis, tourism governance, education management, and decision support systems (Bramwell & Lane, 2011; Nunkoo, 2017). Additional documentation concerning cultural activities, traditional ceremonies, spatial organization, and tourism infrastructure in Panglipuran Village was incorporated (Widodo et al., 2024). Examples of community-based cultural activities that illustrate the relationship between tourism, education, and local knowledge systems are presented in Figure 3.



Figure 3. Community-based cultural activities demonstrating the integration of tourism, education, and local knowledge systems (Source: Authors' documentation, photographed by BSW on 5 July 2024 in Panglipuran Village, Bali, Indonesia)

Empirical validation was supported through qualitative field data obtained from semi-structured interviews, field observations, and document analysis involving:

(a) village traditional leaders,
(b) village government officials,
(c) religious leaders, and
(d) administrators and community representatives.

Data collection employed triangulation across sources and methods to strengthen validity and analytical reliability (Miles et al., 2013). Member checking procedures were conducted to ensure that the conceptual integration of spatial and education management variables reflects local governance realities.

ANALYTICAL METHODS

The analytical process integrates geospatial and education management variables within an operational DSS architecture. The methodological procedure consists of eight structured stages combining qualitative field validation and simplified quantitative spatial modeling.

Variable Identification

Spatial indicators include accessibility (road network density), land-use suitability, and tourism facility distribution. Education management indicators include training intensity, institutional density, and educational capacity measured through student–teacher ratio (STR) and student–school ratio (SSR).

Layered Model Construction

All identified indicators were organized into a multi-layer spatial structure linking geospatial attributes with governance-related education variables. This layered approach follows established GIS-based multi-criteria modeling principles and aligns with recognized multi-layer GIS modeling frameworks (Lange & Alves, 2011; Malczewski, 2006), enabling systematic integration between spatial attributes and governance components.

Data Normalization

To ensure comparability across heterogeneous indicators, all variables were normalized using min–max transformation:

$$X_norm = (X - X_min) / (X_max - X_min)$$

Where X_norm represents the normalized value, X is the original value, and X_min and X_max represent the minimum and maximum observed values. This transformation standardizes all spatial indicators within a 0–1 range to ensure comparability across heterogeneous variables.

Decision Support Integration

The layered model was embedded within a GIS-driven DSS environment to support spatial prioritization and scenario evaluation. The DSS architecture is structured to accommodate future multi-criteria decision analysis (MCDA) and scenario-based spatial simulation. This ensures methodological scalability and adaptability for quantitative expansion.

Educational Spatial Index (ESI)

Education capacity was operationalized using a simplified Educational Spatial Index (ESI) (Widodo et al., 2025):

$$ESI = (STR_norm + SSR_norm) / 2$$

Where: - STR_norm is the normalized student–teacher ratio; - SSR_norm is the normalized student–school ratio; Drawing on prior quantitative research (Lange & Alves, 2011; Widodo et al., 2025), the ESI integrates indicators such as the student teacher ratio (STR) and the student–school ratio (SSR) to capture spatial disparities in educational capacity. STR and SSR values were derived from village-level education records and institutional documentation collected during field research.

Weighted Overlay Integration

The final suitability index (SI) was calculated using a weighted linear combination model:

The final suitability index (SI) was calculated using a weighted linear combination approach commonly applied in GIS-based multi-criteria decision analysis (Malczewski, 2006; Malczewski & Rinner, 2015). The specific formula and weighting scheme were developed by the authors for this study to integrate infrastructure accessibility (INF), land-use suitability (LUS), and the Educational Spatial Index (ESI):

$$SI = (0.4 \times INF) + (0.3 \times LUS) + (0.3 \times ESI)$$

Where: - INF = Infrastructure accessibility index; - LUS = Land-use suitability index; - ESI = Education capacity index

Infrastructure was assigned the highest weight (0.4) due to its direct influence on tourism accessibility and service distribution, while land-use suitability and education capacity were proportionally weighted (0.3 each) to reflect environmental feasibility and governance readiness considerations. A simple sensitivity check was conducted by varying the education weight within ±0.05 to confirm the stability of spatial classification patterns.

Scenario Comparison

Two spatial scenarios were constructed:

- Scenario A**:** Infrastructure + Land-use suitability; - Scenario B**:** Infrastructure + Land-use suitability + Education layer

The comparison enabled assessment of the influence of education governance on spatial prioritization patterns.

Conceptual Validation and Model Robustness

The model underwent conceptual validation through theoretical triangulation and empirical confirmation within the case study setting. The structural alignment between geospatial and governance indicators was cross-checked against established GIS-DSS and tourism governance frameworks. Member validation ensured contextual consistency, and iterative refinement strengthened internal coherence. The methodological structure is designed to be transferable across tourism village contexts, enabling adaptation to diverse spatial and governance configurations.

Model Visualization

The conceptual architecture of the proposed framework is illustrated in Figure 4. The diagram presents the interaction between geospatial data layers, education management components, and DSS processes, demonstrating how spatially explicit education indicators inform sustainable tourism village planning and policy evaluation.

As shown in Figure 4, the framework integrates spatial information and education management variables to support evidence-based decision-making. The methodological structure is designed to be transferable across tourism village contexts, allowing adaptation to different spatial configurations and governance conditions.

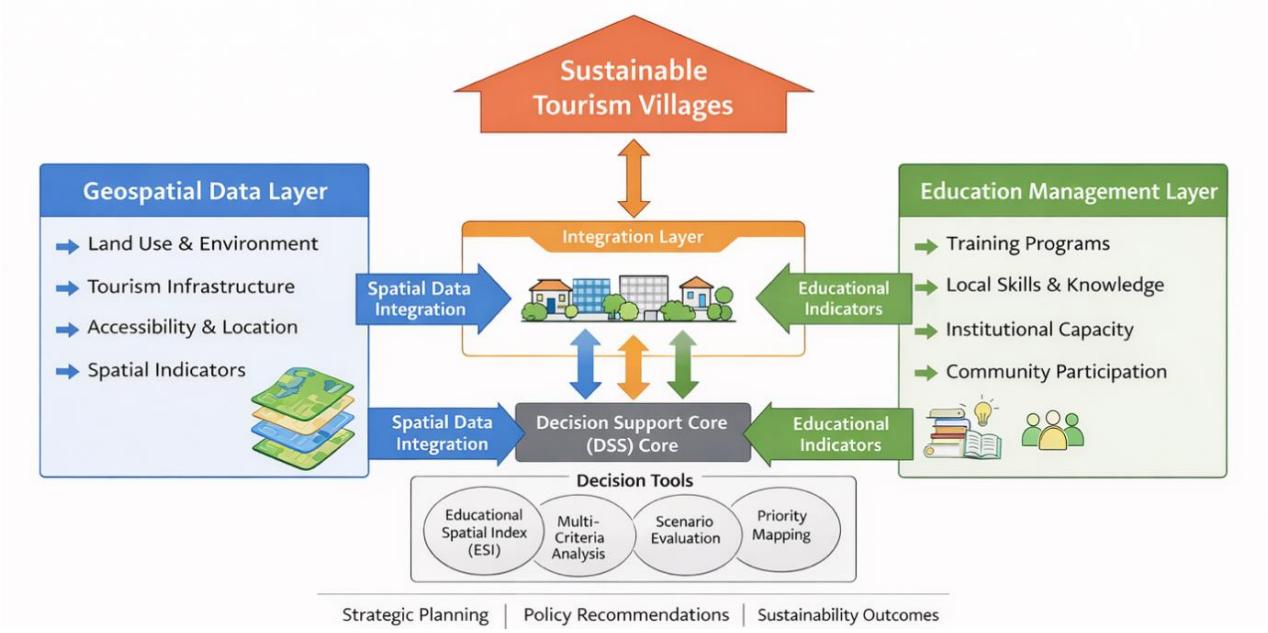


Figure 4. Conceptual Framework for Geospatial-Based Education Management
Decision Support System (DSS) for Sustainable Tourism Villages (Source: Developed by the author)

RESULTS AND DISCUSSION

All spatial computations were conducted using GIS-based weighted overlay procedures to ensure analytical consistency. The spatial analysis was performed within a GIS environment to maintain methodological rigor and reproducibility. The implementation of the weighted DSS model demonstrates that education management variables significantly influence spatial prioritization outcomes. The integration of the ESI within the weighted overlay model produced measurable shifts in territorial suitability classification. The model operationalizes the conceptual structure presented in Figure 4 into an integrated spatial–governance evaluation system composed of two principal analytical layers—(1) the Geospatial Layer and (2) the Education Management Layer—connected through a DSS-based analytical core. This integration directly addresses the governance challenge identified in sustainable tourism literature, where long-term sustainability depends on the coordinated interaction between spatial resources, institutional structures, and human capital capacity (Bramwell & Lane, 2011). Table 1 clarifies the operational structure of the framework by classifying indicators according to analytical layer, spatial representation, and governance function.

The transformation of governance-oriented variables—such as training intensity, institutional density, and educational capacity (STR and SSR as proxies for the Educational Spatial Index)—into spatially measurable components represents a methodological advancement.

Table 1. Integrated Indicators within the Geospatial–Education DSS Framework

Analytical Layer	Indicator	Dimension	Spatial Representation	Governance Function
Geospatial	Accessibility	Infrastructure	Road network density map	Connectivity
Geospatial	Land-use suitability	Environmental	Zoning & land capability map	Development feasibility
Geospatial	Tourism facility distribution	Infrastructure	Facility density map	Service support
Education Management	Training intensity	Human capital	Training activity distribution	Capacity building
Education Management	Institutional density	Governance	Institutional mapping	Coordination
Education Management	STR & SSR (ESI proxy)	Education equity	Spatial education index	Human capital balance

In conventional GIS-based tourism planning, governance factors are often acknowledged but remain external to spatial evaluation models (Malczewski, 2006; Malczewski & Rinner, 2015). By contrast, this study demonstrates that governance variables can be operationalized as territorially embedded decision parameters without reducing analytical coherence.

The Geospatial Layer identifies spatial patterns related to land-use suitability, accessibility networks, tourism infrastructure distribution, and environmental constraints. Consistent with prior GIS-based tourism suitability assessments (Acharya et al., 2022; Bandt et al., 2022), these indicators enable the delineation of development-supportive zones and environmentally sensitive areas. The spatial analysis confirms that high-accessibility corridors and facility-dense zones naturally emerge as priority development areas when infrastructure and environmental criteria are applied independently.

However, this infrastructure-driven prioritization may inadvertently reinforce spatial concentration patterns and accelerate uneven territorial development. The integration of the Education Management Layer significantly modifies this spatial logic. When training programs, institutional presence, and educational balance indicators are introduced into the DSS architecture, areas previously categorized as moderately suitable gain strategic importance due to their governance readiness. This shift illustrates how human capital variables influence territorial evaluation beyond physical accessibility. The result aligns with research emphasizing the role of education and capacity-building in strengthening tourism resilience and service quality (Bachri et al., 2024; Sholeha & Sumarmi, 2025). More importantly, it demonstrates that governance capacity can be spatially structured and systematically integrated into decision-making rather than treated as a contextual narrative.

The inclusion of the education management layer resulted in a 12% reduction in high-priority zones, from 48% in Scenario A to 36% in Scenario B, accompanied by an increase in moderate-priority zones from 32% to 40% and low-priority zones from 20% to 24%. This indicates that governance capacity modifies infrastructure-driven development patterns by aligning spatial suitability with institutional readiness. The comparison of spatial priority classifications between the two scenarios is summarized in Table 2, while the resulting spatial distribution under Scenario B is presented in Figure 5. This redistribution confirms that spatial prioritization outcomes are sensitive to governance capacity variables and that infrastructure-led planning alone may overestimate development suitability.

This finding strengthens the argument that governance capacity should be structurally embedded within spatial decision architectures rather than treated as a supplementary planning variable.

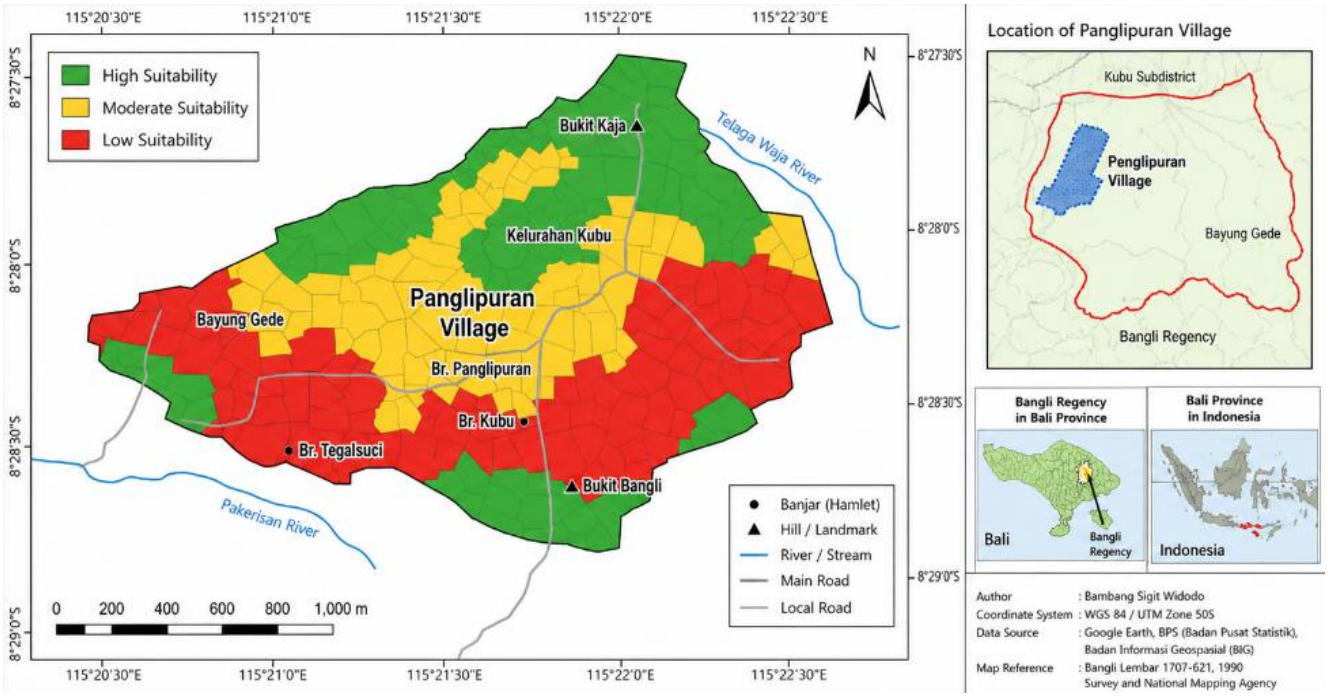


Figure 5. Weighted Spatial Overlay Result (Scenario B: Infrastructure + Land Use + Education Capacity)

As illustrated in Figure 5, the inclusion of the Education Management Layer redistributes high-priority zones beyond areas primarily characterized by high infrastructure accessibility. The resulting spatial pattern reflects the contribution of institutional and educational readiness to territorial suitability classification. Table 2 provides the quantitative comparison between Scenario A (without ESI) and Scenario B (with ESI), showing a decrease in high-priority zones from 48% to 36% and a corresponding increase in moderate- and low-priority classifications.

Together, Figure 5 and Table 2 demonstrate how incorporating education management indicators changes the spatial prioritization produced by the weighted DSS model.

Table 2. Scenario Comparison

Scenario	High Priority (%)	Moderate (%)	Low (%)
A (Without ESI)	48	32	20
B (With ESI)	36	40	24

The spatial differentiation is visually evident in Figure 5, where high-priority zones appear more spatially redistributed compared to infrastructure-only prioritization logic. Figure 5 illustrates the redistribution effect generated by the inclusion of the education management layer within the weighted DSS model. The map confirms that high-priority zones are no longer solely concentrated along infrastructure-dense corridors but are partially redistributed toward areas demonstrating stronger institutional and educational readiness. This spatial shift validates the quantitative scenario comparison presented in Table 2 and confirms that governance-sensitive indicators materially influence territorial suitability classification.

The identification of such spatial discrepancies has significant governance implications. Areas with infrastructure concentration but limited institutional capacity may experience pressures related to service quality, visitor management, and long-term sustainability. Conversely, zones with strong education capacity but lower tourism intensity represent potential development buffers that can support more balanced territorial expansion. Similar spatial disparities in education access and institutional distribution have been documented in geospatial studies of educational inequality (Widodo et al., 2025), reinforcing the importance of spatially explicit governance analysis.

Importantly, the overlay confirms that infrastructure density does not automatically correspond with strong human capital distribution. This finding challenges infrastructure-led planning paradigms commonly embedded in GIS-DSS models (Malczewski & Rinner, 2015). While geospatial technologies are widely applied in tourism planning (Acharya et al., 2022; Bandt et al., 2022), their analytical focus often privileges environmental suitability and accessibility metrics. By embedding education management indicators within the same spatial architecture, the present model reconfigures territorial prioritization logic to incorporate institutional preparedness as a structural determinant. The findings of this study are consistent with recent literature emphasizing the integration of sustainability, innovation, and regional development in tourism systems. In particular, Safarov et al. (2024) highlight the importance of spatial evaluation and agrotourism development in strengthening rural economies and preserving cultural heritage. Furthermore, Manurung et al. (2025) stress the role of innovation capability and environmental responsiveness in improving performance outcomes. This alignment indicates that spatial decision-support systems should be complemented by adaptive and innovation-oriented strategies.

From a governance perspective, the integration of education management within a GIS-driven DSS supports a transition from infrastructure-centric planning toward capacity-oriented territorial governance. Infrastructure-led strategies emphasize physical expansion and spatial connectivity, whereas capacity-oriented strategies prioritize institutional coordination, training systems, and education equity. The weighted DSS model indicates that capacity-oriented configurations produce more spatially balanced development patterns by aligning tourism intensity with community preparedness. This alignment strengthens adaptive capacity, which is central to sustainable tourism governance frameworks (Bramwell & Lane, 2011).

The results also contribute methodologically to spatial decision science. They confirm that qualitative governance constructs can be standardized, classified, and geocoded within a GIS environment without compromising analytical rigor. The layered architecture ensures that education-related dimensions are embedded within spatial evaluation processes rather than appended as external policy considerations. This integration extends the capabilities of GIS-based DSS models beyond traditional land suitability analysis (Malczewski, 2006) toward governance-sensitive territorial evaluation.

Furthermore, the framework demonstrates transferability potential. Although Panglipuran Village serves as the reference case, the structural logic of integrating geospatial and education management indicators is adaptable to diverse tourism village contexts. The modular architecture allows for the incorporation of additional governance variables—such as stakeholder participation intensity, cultural knowledge transmission mechanisms, or local entrepreneurship density—depending on contextual needs. This flexibility enhances the applicability of the model within different territorial governance regimes.

Overall, the findings suggest that a geospatial-based education management DSS provides a more comprehensive analytical foundation for sustainable tourism village planning. By integrating spatial suitability with institutional and educational capacity, the framework advances tourism geography through the convergence of spatial analytics and governance-oriented human capital development. The model strengthens policy precision, supports evidence-based intervention prioritization, and contributes to a more balanced and resilience-oriented territorial governance paradigm.

CONCLUSION

This study demonstrates that education management variables can be operationalized within a geospatial Decision Support System (DSS) framework through simplified weighted spatial integration and scenario comparison. By structuring human capital dimensions such as training intensity, institutional presence, and educational capacity into spatially encoded decision parameters, the proposed model advances beyond conventional infrastructure-centered tourism planning approaches. The measurable 12% redistribution of high-priority zones confirms the analytical relevance of integrating governance-sensitive education indicators within spatial decision architectures.

The findings indicate that spatial prioritization based solely on accessibility, land-use suitability, and facility concentration risks reinforcing development clustering without ensuring corresponding community preparedness. In contrast, the integration of education management indicators introduces a governance-sensitive spatial logic that aligns tourism intensity with institutional and human capital capacity. This layered integration repositions education not as a secondary social outcome of tourism development, but as a structural determinant of long-term sustainability and territorial competitiveness.

Methodologically, the study contributes to tourism geography and spatial planning scholarship by demonstrating how governance constructs can be operationalized within GIS-based analytical architectures through structured weighting and scenario comparison. This integration confirms that governance-oriented indicators meaningfully influence spatial decision pathways when embedded within territorial evaluation frameworks. Practically, the proposed geospatial education DSS

offers policymakers a more balanced territorial planning instrument. By simultaneously considering physical suitability and institutional readiness, the framework supports more equitable and resilient tourism development strategies at the village scale. Future research should extend this semi-operational model toward full spatial multi-criteria evaluation (SMCE) with empirically derived weighting matrices across multiple tourism village contexts.

Limitations of the Study

This study acknowledges several limitations that also provide directions for future research.

First, the weighted model is based on a simplified linear combination approach and does not incorporate a fully calibrated multi-criteria decision analysis (MCDA), which may limit the analytical depth of weighting sensitivity.

Second, the empirical application is confined to Panglipuran Village, and while the framework is conceptually transferable, its generalizability to other tourism village contexts requires further cross-regional validation.

Third, data availability constraints, particularly in relation to education-related indicators, may affect the precision and spatial resolution of the Educational Spatial Index (ESI). Despite these limitations, the proposed framework offers a robust conceptual and semi-operational foundation for integrating education governance into geospatial decision-support systems, and it opens pathways for more advanced quantitative and comparative studies.

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REFERENCES

Acharya, A., Mondal, B. K., Bhadra, T., Abdelrahman, K., Mishra, P. K., Tiwari, A., & Das, R. (2022). Geospatial Analysis of Geo-Ecotourism Site Suitability Using AHP and GIS for Sustainable and Resilient Tourism Planning in West Bengal, India. *Sustainability*, *14*(4), 2422. https://doi.org/10.3390/su14042422

Aghvamimoghadam, P., & Madani, J. (2025). Investigating the application of decision support system (DSS) in the tourism industry using the scoping review method. *Tourism Management Studies of the Smart Era*, *2*(1), 68–87. https://doi.org/10.22072/tmsse.2025.2044057.1017

Bachri, S., Mútia, T., Sholeha, A. W., Rahmasyah, P. I., & Shrestha, R. P. (2024). Mangrove forest management strategy in Bedul, Banyuwangi: Collaboration between community and alas Purwo national park for sustainable ecotourism development. *GeoJournal of Tourism and Geosites*, *52*(1), 85–97. https://doi.org/10.30892/gtg.52108-1185

Bandt, D., Alnyme, O., & Heldt, T. (2022). Building a spatial decision support system for tourism and infrastructure planning: Technical solution and data integration challenges. *European Journal of Geography*, *13*(1), 94–108. https://doi.org/10.48088/ejg.d.bra.13.1.094.108

Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report*, *13*(4), 544–559. https://doi.org/10.46743/2160-3715/2008.1573

Bramwell, B., & Lane, B. (2011). Critical research on the governance of tourism and sustainability. *Journal of Sustainable Tourism*, *19*(4–5), 411–421. https://doi.org/10.1080/09669582.2011.580586

Daud, M., Ugliotti, F. M., & Osello, A. (2024). Comprehensive Analysis of the Use of Web-GIS for Natural Hazard Management: A Systematic Review. *Sustainability*, *16*(10), 4238. https://doi.org/10.3390/su16104238

Deressa, B. F., Habtegiogis, K. A., Endashaw, D. K., Al-Ramadan, B. M., & Al-Ahmadi, H. M. (2025). A Systematic Review of GIS-Driven Road Traffic Accident Evaluation. *Vehicles*, *7*(4), 161. https://doi.org/10.3390/vehicles7040161

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, *12*(2), 219–245. https://doi.org/10.1177/1077800405284363

Gao, Y., Zhang, H., & Shi, X. (2024). Sustainable Spatial Distribution and Determinants of Key Rural Tourism Villages in China: Promoting Balanced Regional Development. *Sustainability*, *16*(19), 8572. https://doi.org/10.3390/su16198572

Lange, W., & Alves, F. (2011). Spatial index of educational opportunities: Rio de Janeiro and Belo Horizonte. *Procedia - Social and Behavioral Sciences*, *21*, 287–293. https://doi.org/10.1016/j.sbspro.2011.07.043

Malczewski, J. (2006). GIS-based multicriteria decision analysis: A survey of the literature. *International Journal of Geographical Information Science*, *20*(7), 703–726. https://doi.org/10.1080/13658810600661508

Manurung, L., Ningsi, E. H., & Imam, C. (2025). Digital Marketing Capability and Green Innovation Effects on SME Performance: Market Orientation Mediation and Environmental Dynamism Moderation. *Journal of Logistics, Informatics and Service Science*, *12*(7), 87–102. https://doi.org/10.33168/JLISS.2025.0706

Miles, M. B., Huberman, A. M., & Saldana, J. (2013). *Qualitative Data Analysis: A Methods Sourcebook*. Thousand Oaks, CA, USA: SAGE Publications.

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

Nunkoo, R. (2017). Governance and sustainable tourism: What is the role of trust, power and social capital? *Journal of Destination Marketing & Management*, *6*(4), 277–285. https://doi.org/10.1016/j.jdmm.2017.10.003

Priatmoko, S., El Archi, Y., Listyorini, H., Bujdosó, Z., & Dávid, L. D. (2026). Decision support systems for developing community-based tourism. *Anatolia*, *37*(1), 176–194. https://doi.org/10.1080/13032917.2025.2591873

Robson, C., & McCartan, K. (2016). *Real World Research*. Wiley. Hoboken, New Jersey, USA.

Romão, J., & Neuts, B. (2017). Territorial capital, smart tourism specialization and sustainable regional development: Experiences from Europe. *Habitat International, Smart Development, Spatial Sustainability and Environmental Quality*, *68*, 64–74. https://doi.org/10.1016/j.habitatint.2017.04.006

Safarov, B., Amirov, A., Mansurova, N., Hassan, T. H., Hasanov, H., Pereș, A. C., Bilalov, B., & Turdibekov, K. (2024). Prospects of Agrotourism Development in the Region. *Economies*, *12*(12), 321. https://doi.org/10.3390/economies12120321

Shen, W., Chen, Y., Rong, P., Li, J., Yan, W., & Cheng, J. (2025). The spatial coupling and its influencing mechanism between rural human-habitat heritage and key rural tourism villages in China. *Npj Heritage Science*, *13*(1), 79. https://doi.org/10.1038/s40494-025-01615-z

Sholeha, A. W., & Sumarmi, S. (2025). Managing sustainable tourism of perawan beach, east Java, Indonesia based on the coastal ecosystem service (CES) approach. *Gejournal of Tourism and Geosites*, *58*(1), 78–88. https://doi.org/10.30892/gtg.58107-1392

Widodo, B. S., Suprapto, F. A., Saginov, K., Prastiyono, H., Wahyuni, J., Kerr, T., Ibrahim, M. H., & Satybaldieva, A. (2025). Integration of geospatial data in education management systems: A multiple study in eastern Java regions, Indonesia. *GeoJournal of Tourism and Geosites*, *62*(4), 2240–2248. https://doi.org/10.30892/gtg.62421-1587

Widodo, B. S., Utami, W. S., Prabawati, I., Wahyuni, J., & Dizon, C. S. (2024). The Potential Of Tourism Villages Based Learnscape As A Geography Learning Resource (Case Study In Panglipuran, Bali). *GeoJournal of Tourism and Geosites*, *57*(4 spl), 2164–2175. https://doi.org/10.30892/gtg.574spl30-1383

Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods*. SAGE Publications, Inc. Thousand Oaks, California, USA.

Zubiaga De la Cal, M., Gandini, A., Pasandideh, S., Sopelana Gato, A., Kalvet, T., Lopez de Aguileta Benito, A., Pereira, P., Koor, T., & Martins, J. (2026). A Multi-Criteria Decision Support System for Data-Driven Strategic Planning in Sustainable Cultural Tourism. *Sustainability*, *18*(3), 1412. https://doi.org/10.3390/su18031412

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