Geoai-Driven Tourism Planning: A Framework And Educational Implications

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Abstract
The integration of Geographic Information Systems (GIS) and Artificial Intelligence (AI) has created transformative opportunities for tourism destination planning. This paper presents the GeoAI Tourism Intelligence Framework (GTIF), a conceptual framework integrating geospatial big data, AI algorithms, and spatial analytics to support evidence-based destination planning and management. Drawing upon advances in GeoAI, machine learning, and spatial data science, the framework synthesizes diverse geospatial data sources including satellite imagery, GPS trajectories, and social media data to enable tourist flow prediction, demand forecasting, hotspot analysis, and destination resilience assessment. The paper reviews the evolution of GIS applications in tourism, examines Spatial Decision Support Systems, and evaluates AI integration in tourism research. Additionally, the paper addresses the educational implications of GeoAI for geography and tourism education, proposing curriculum development strategies and pedagogical approaches for preparing the next generation of tourism professionals. The GTIF is structured around three interconnected layers: an Input Layer comprising multi-source geospatial big data, a GeoAI Engine Layer incorporating deep learning and ensemble methods, and a Spatial Analytics and Decision Support Layer delivering actionable intelligence. The paper articulates a future research agenda encompassing explainable AI, privacy-preserving analytics, and human-AI collaboration. The proposed framework contributes to GeoAI by providing a structured approach to intelligent tourism destination planning that balances economic development with environmental sustainability and educational capacity building.

Keywords: geographic information systems, geoai, tourism destination planning, spatial decision support systems, geography education, machine learning

1. Introduction

The global tourism industry has experienced unprecedented growth over recent decades, emerging as a significant driver of economic development and employment generation [1]. However, this growth has been accompanied by mounting challenges including overtourism, environmental degradation, infrastructure strain, and socio-cultural impacts that threaten the long-term sustainability of destinations [2]. The COVID-19 pandemic further exposed the vulnerability of tourism-dependent economies and underscored the urgent need for more resilient, adaptive, and data-driven destination planning approaches [3].

Concurrently, the proliferation of geospatial data from satellite constellations, unmanned aerial vehicles, mobile positioning systems, Internet of Things sensors, and location-enabled social media platforms has created unprecedented opportunities for understanding and managing tourism phenomena at scale [4].

Geographic Information Systems have long served as essential tools for tourism planning, enabling the mapping, analysis, and visualization of spatial relationships between tourists, attractions, infrastructure, and environmental resources [5]. Traditional GIS approaches, however, have been constrained by their reliance on static data, manual interpretation, and conventional statistical methods that struggle to capture the dynamic and nonlinear nature of tourist behavior and destination systems [6].

The emergence of Artificial Intelligence, particularly machine learning and deep learning, has opened new frontiers in spatial analysis by enabling automated pattern recognition, predictive modeling, and adaptive decision-making from massive and heterogeneous geospatial datasets [7]. Geographic Artificial Intelligence represents the integration of these computational advances with GIS, creating a powerful analytical framework for addressing complex spatial problems across multiple domains [8]. Within the tourism context, GeoAI offers transformative potential for destination planning through tourist flow prediction, demand forecasting, sentiment analysis, and optimization of infrastructure and services.

Despite these promising developments, the integration of GeoAI into tourism destination planning remains fragmented and under-theorized. Existing studies have primarily focused on isolated applications of specific AI techniques to particular tourism problems, lacking a comprehensive framework that synthesizes the full spectrum of GeoAI capabilities for holistic destination planning [9]. Moreover, the translation of technical GeoAI research into practical planning tools and decision-support systems remains a significant gap, particularly in contexts where data availability and institutional structures vary considerably.

This paper addresses these gaps by proposing the GeoAI Tourism Intelligence Framework, a novel conceptual framework that systematically integrates geospatial big data, AI algorithms, and spatial analytics to support intelligent and sustainable tourism destination planning. Additionally, this paper addresses the significant educational implications of GeoAI for geography and tourism education, proposing curriculum development strategies and pedagogical approaches for preparing the next generation of tourism professionals. The remainder of this paper is organized as follows: Section 2 presents a systematic literature review covering GIS in tourism, Spatial Decision Support Systems, AI in tourism, and GeoAI. Section 3 establishes the theoretical foundations underpinning the proposed framework. Section 4 introduces the GeoAI Tourism Intelligence Framework in detail. Section 5 discusses the framework's applications across various tourism domains. Section 6 addresses the educational implications of GeoAI. Section 7 examines research implications and limitations. Section 8 articulates a future research agenda. Section 9 offers concluding remarks on the transformative potential of GeoAI for intelligent tourism destination planning.

Geographic Information Systems in Tourism

Geographic Information Systems have been integral to tourism research and planning for over three decades, providing essential capabilities for mapping, analyzing, and visualizing the spatial dimensions of tourism phenomena [5, 10]. Early applications of GIS in tourism focused primarily on resource inventory and mapping, including the identification and classification of tourist attractions, accommodation facilities, and transportation networks [11]. As GIS technology matured, its applications expanded to encompass visitor flow analysis, carrying capacity assessment, site suitability analysis, and route optimization [12].

The utility of GIS in tourism planning derives from its capacity to integrate diverse spatial datasets, perform sophisticated spatial analyses, and communicate complex geographic information through intuitive visualizations [13]. Key GIS techniques employed in tourism research include overlay analysis for suitability mapping, network analysis for accessibility assessment and route planning, buffer analysis for impact assessment, and interpolation for demand surface modeling [14]. Recent research has demonstrated the value of GIS for regional tourism disparity analysis, destination competitiveness assessment, and identification of priority areas for infrastructure investment.

Recent research has demonstrated the value of integrating GIS with multi-criteria decision analysis for ecotourism site selection. For example, a study on ecotourism suitability mapping demonstrated that GIS-based spatial modeling, combined with environmental variables and expert knowledge, provides an effective decision-support tool for sustainable tourism site selection [15]. Similarly, GIS-based accessibility analysis has been applied to geosite evaluation and route optimization in rural regions [16].

However, traditional GIS approaches face inherent limitations when applied to dynamic tourism systems. The reliance on static data sources and predefined analytical workflows constrains the ability to capture temporal dynamics, adapt to changing conditions, and generate predictive insights [6]. Furthermore, conventional GIS analyses often require substantial manual intervention, limiting scalability and responsiveness in data-rich environments. These limitations have motivated the integration of AI techniques with GIS to create more intelligent, adaptive, and automated analytical frameworks.

Spatial Decision Support Systems

Spatial Decision Support Systems represent an evolution of GIS toward more analytical and decision-oriented applications, integrating spatial data, analytical models, and user interfaces to support complex decision-making processes [17]. SDSS in tourism planning have been developed for applications including destination selection, route planning, carrying capacity management, and impact assessment [18]. These systems typically incorporate multi-criteria evaluation, optimization algorithms, and scenario analysis capabilities to assist planners in evaluating trade-offs and identifying preferred alternatives [19].

The STESY framework provides a notable example of a data-driven and interpretative model to support tourism destination planning, classifying and interpreting tourism destinations based on georeferenced data, spatial relationships, and thematic value chains [20]. Despite their analytical sophistication, many SDSS have been constrained by limited capacity for real-time data integration, adaptive learning, and predictive analytics [21]. The emergence of AI techniques offers opportunities to enhance SDSS with predictive modeling, pattern recognition, and automated decision-support capabilities that can respond dynamically to changing conditions and user needs.

Artificial Intelligence in Tourism

Artificial Intelligence has been increasingly applied to diverse tourism and hospitality challenges, encompassing areas including demand forecasting, personalization, sentiment analysis, recommendation systems, and operational optimization [22]. Machine learning techniques have demonstrated particular value for tourism demand forecasting, where algorithms such as Random Forest, Gradient Boosting, and Support Vector Machines have often outperformed traditional time-series methods in capturing complex nonlinear relationships [23].

Deep learning approaches, particularly Convolutional Neural Networks and Recurrent Neural Networks, have been applied to tourism image analysis, sentiment classification, and spatiotemporal prediction [24]. Natural Language Processing techniques have been used to extract insights from user-generated content such as online reviews and social media posts [25]. Recent research has demonstrated the potential of Large Language Models for smart destination planning by providing comprehensive recommendations across multiple dimensions of destination management [26].

The integration of AI with GIS has emerged as a particularly promising direction, enabling the combination of spatial analytical capabilities with predictive modeling and automated pattern recognition. Recent research on smart tourism systems has demonstrated the value of integrating AI assistants with web-based GIS platforms to enhance tourist experiences through accurate information, personalized recommendations, and intuitive visualizations [27].

Despite the demonstrated potential of AI in tourism, its application has also raised important concerns regarding data privacy, algorithmic bias, interpretability, and the ethical implications of automated decision-making [28]. These concerns are particularly acute in the context of geospatial data, where location information may reveal sensitive information about individuals and communities [29]. Addressing these challenges requires careful consideration of governance frameworks, transparency mechanisms, and stakeholder engagement processes.

Geographic Artificial Intelligence

GeoAI represents the convergence of AI and geospatial science, encompassing the application of machine learning, deep learning, and other AI techniques to geographic problems [30]. The field has grown rapidly with advances in computational power, the availability of large-scale geospatial datasets, and the development of specialized algorithms for spatial data [31]. Key GeoAI techniques include Convolutional Neural Networks for satellite image analysis and land cover classification, Recurrent Neural Networks for spatiotemporal prediction, Graph Neural Networks for spatial network analysis, and ensemble methods for spatial classification and regression [32].

In the tourism context, GeoAI has been applied to tourist flow prediction, destination image analysis, sentiment mapping, and accessibility assessment [9]. A recent study demonstrated GeoAI-enabled assessment of forest dynamics for regenerative tourism, showing how machine learning classification models can support spatial strategies combining ecological preservation with local tourism development [33]. Despite the demonstrated potential, systematic application of GeoAI to tourism destination planning remains limited, with most studies focusing on isolated applications of specific techniques [9].

2.Theoretical Background

The proposed GeoAI Tourism Intelligence Framework draws upon several theoretical traditions that collectively inform the integration of GIS, AI, and tourism planning.

Complexity Theory and Tourism Systems

Tourism destinations are complex adaptive systems characterized by nonlinear interactions, feedback loops, emergence, and path dependence [34]. The behavior of tourists, businesses, residents, and institutions within a destination emerges from the interactions among these actors and their environment, producing patterns and dynamics that cannot be fully understood through reductionist approaches [35]. Complexity theory provides a lens for understanding how tourism systems evolve, adapt, and respond to perturbations, emphasizing the importance of context and contingency in shaping outcomes.

The complexity perspective has important implications for tourism planning, suggesting that deterministic, top-down approaches are unlikely to succeed in capturing the full range of possible futures [36]. Instead, planning should be adaptive, iterative, and responsive to emergent patterns and feedback. This perspective aligns with the capabilities of GeoAI, which can detect emergent patterns in large-scale data, model nonlinear relationships, and generate scenario-based projections that account for uncertainty and contingency [37].

Spatial Data Science and the Fourth Paradigm

Spatial data science represents the application of data science principles and methods to geographic problems, integrating spatial statistics, machine learning, and visualization [38]. The emergence of spatial data science reflects the broader shift toward the fourth paradigm of data-intensive scientific discovery, in which data-intensive approaches complement theory, experimentation, and simulation [39]. This paradigm emphasizes the value of exploratory data analysis, pattern discovery, and hypothesis generation from large-scale, heterogeneous datasets.

The fourth paradigm has particular relevance to tourism research, where the proliferation of digital data from multiple sources has created unprecedented opportunities for understanding tourist behavior, destination dynamics, and industry performance [4]. Spatial data science provides a framework for exploiting these opportunities through the systematic integration of diverse data sources, rigorous analytical methods, and reproducible workflows. GeoAI represents a natural extension of spatial data science, bringing advanced AI techniques to bear on geographic problems and enabling new forms of analysis that transcend the limitations of traditional statistical approaches [8].

Decision Support and Planning Theory

Planning theory provides a foundation for understanding the role of analytical tools in supporting planning processes. Communicative planning theory emphasizes the importance of dialogue, negotiation, and stakeholder participation in planning decision-making [40]. This perspective suggests that planning tools should not simply provide answers but should facilitate deliberation, illuminate trade-offs, and support collective learning.

The concept of decision support aligns with this theoretical perspective, emphasizing the role of analytical tools in informing rather than replacing human judgment. Effective decision support systems should be transparent, interactive, and adaptable, enabling users to explore scenarios, interrogate assumptions, and apply their domain expertise in interpreting outputs [41]. These principles inform the design of the proposed framework, which emphasizes explainability, user engagement, and the integration of AI outputs with human judgment.

3. Methodology

This paper presents a conceptual framework rather than reporting empirical findings. The methodology employed follows the established approach for developing conceptual frameworks in the social sciences and geography [42]. The framework development process consisted of three interrelated phases.

Phase 1: Systematic Literature Review

A systematic literature review was conducted to identify and synthesize existing research on GIS, GeoAI, and tourism destination planning. The review followed established guidelines for systematic reviews [43]. Searches were conducted in academic databases including Scopus, Web of Science, and Google Scholar using keywords including geographic information systems, geoai, tourism destination planning, spatial decision support systems, and machine learning. Articles published between 2005 and 2026 were considered. The review identified 85 relevant articles, which were analyzed to identify key themes, methodological approaches, research gaps, and theoretical foundations.

Phase 2: Framework Synthesis

Drawing upon the literature review findings, the framework synthesis phase integrated concepts, techniques, and approaches from multiple disciplines including geography, computer science, tourism studies, and urban planning. The synthesis followed the integrative framework development approach

[44], which involves identifying core components, defining relationships among components, and establishing operational principles. The framework was iteratively refined through consideration of diverse tourism contexts including urban tourism, ecotourism, geotourism, and crisis management.

Phase 3: Educational Implications Analysis

The educational implications analysis examined the curriculum development, pedagogical, and competency implications of GeoAI for geography and tourism education. This analysis drew upon educational theory, curriculum development literature, and professional competency frameworks [45]. Recommendations were developed for incorporating GeoAI into geography and tourism education at secondary, undergraduate, and graduate levels, as well as for professional development.

Proposed GeoAI Tourism Intelligence Framework

This section presents the GeoAI Tourism Intelligence Framework, a comprehensive conceptual framework designed to integrate geospatial big data, AI algorithms, and spatial analytics for intelligent and sustainable tourism destination planning. The framework is structured around three interconnected layers: Input Layer, GeoAI Engine Layer, and Spatial Analytics and Decision Support Layer.

Input Layer: Geospatial Big Data Sources

The Input Layer encompasses the diverse geospatial big data sources that feed into the GeoAI engine. Drawing upon the tourism intelligence literature [4], these data sources include remote sensing data from satellite platforms and UAVs, location-based data from GPS trajectories and mobile devices, user-generated content from social media platforms, open geospatial data from OpenStreetMap, IoT and sensor data for real-time monitoring, and administrative and economic data from official statistics.

The integration of these diverse data sources presents significant technical challenges related to data heterogeneity, quality, and scale. The framework addresses these challenges through preprocessing workflows that standardize, validate, and harmonize data from multiple sources. Key preprocessing steps include data cleaning to remove errors and inconsistencies, georeferencing to ensure spatial alignment, temporal alignment to synchronize data from different time periods, and feature engineering to extract relevant variables for analysis.

GeoAI Engine Layer

The GeoAI Engine Layer comprises the core analytical capabilities of the framework, organized into four functional categories. Deep Learning Architectures including Convolutional Neural Networks for image analysis and feature extraction, U-Net for semantic segmentation, Recurrent Neural Networks for spatiotemporal prediction, and Transformer architectures for attention-based modeling enable automated feature extraction, pattern recognition, and predictive modeling from geospatial data [32]. Machine Learning Algorithms including Random Forest, Gradient Boosting, XGBoost, and Support Vector Machines for classification and regression tasks provide robust, interpretable alternatives to deep learning for many tourism analytics applications [23]. Large Language Models including applications for natural language interaction and automated report creation enhance the accessibility and usability of GeoAI for non-technical stakeholders [26]. Computer Vision including object detection, semantic segmentation, and change detection from satellite and UAV imagery enable automated infrastructure mapping, environmental monitoring, and impact assessment [31].

Table 1 presents the GeoAI algorithms and their primary tourism applications.

Table 1

GeoAI Algorithms and Their Tourism Applications

Algorithm Category	Specific Methods	Primary Tourism Applications
Convolutional Neural Networks	CNN, U-Net, ResNet	Land cover classification, infrastructure detection, environmental monitoring
Recurrent Neural Networks	RNN, LSTM, GRU	Tourist flow prediction, demand forecasting, time-series analysis
Transformer Models	Transformer, BERT	Sentiment analysis, spatiotemporal prediction, text understanding
Ensemble Methods	RF, XGBoost, GBDT	Suitability mapping, classification, regression prediction
Unsupervised Learning	K-Means, DBSCAN	Segmentation, hotspot detection, pattern discovery
Large Language Models	ChatGPT, LLAMA	Natural language interaction, recommendations, reporting
Object Detection	YOLO, Mask R-CNN	Infrastructure mapping, asset detection, change monitoring

Spatial Analytics and Decision Support Layer

The Spatial Analytics and Decision Support Layer translates the outputs of the GeoAI Engine into actionable intelligence for tourism planning and management. Key analytical modules include tourist flow prediction using spatiotemporal models to forecast visitor movements and congestion patterns, demand forecasting combining economic indicators and historical patterns to predict tourism demand, hotspot analysis identifying concentrations of tourist activity through spatial clustering, accessibility assessment evaluating physical and digital accessibility of attractions, suitability analysis integrating multi-criteria evaluation to identify optimal locations for tourism development, destination resilience assessment evaluating capacity to absorb and adapt to shocks, and environmental impact assessment monitoring ecological consequences of tourism activities [9, 15, 16].

Table 2

presents the spatial analytics modules and their decision support applications.

Table 2

Spatial Analytics Modules and Decision Support Applications

Analytics Module	Primary Input Data	Decision Support Applications
Tourist Flow Prediction	GPS trajectories, mobile data, bookings	Capacity management, congestion mitigation, experience optimization

Demand Forecasting	Historical data, bookings, economic indicators	Infrastructure planningg, investment decisions, marketing
Hotspot Analysis	Social media, GPS data, occupancy	Overtourism management, targeted interventions
Accessibility Assessment	Transport networks, elevation, facilities	Inclusive planning, infrastructure prioritization
Suitability Analysis	Environmental, infrastructural, socio-economic	Site selection, development planning, impact mitigation
Resilience Assessment	Climate data, historical events, infrastructure	Disaster preparedness, climate adaptation
Environmental Impact	Remote sensing, biodiversity, land use	Conservation planning, carrying capacity management

Applications

This section discusses the application of the framework across diverse tourism contexts, illustrating its versatility and practical value.

Urban Tourism Planning

Urban destinations face complex challenges including visitor concentration, infrastructure strain, and competition for space between tourists and residents [46]. The framework supports urban tourism planning through real-time visitor monitoring using mobile positioning data and IoT sensors to track visitor distribution and movement patterns, predictive modeling of tourism demand at intra-urban scales supporting dynamic pricing and infrastructure planning, accessibility analysis identifying underserved areas and optimizing the location of visitor services, and sentiment mapping using social media data to understand visitor perceptions and identify areas requiring improvement [9].

Ecotourism and Nature-Based Tourism

Ecotourism requires careful balancing of visitor experiences with environmental conservation [47]. The framework supports these objectives through suitability mapping identifying optimal locations for low-impact tourism infrastructure based on environmental sensitivity and accessibility, carrying capacity assessment integrating visitor flow data and ecological indicators to determine sustainable visitation levels, ecological sensitivity zoning using remote sensing and machine learning to identify areas requiring conservation priority, and visitor behavior monitoring using GPS trajectories to understand spatial use patterns and potential environmental impacts [15, 33].

Geotourism and Geopark Planning

Geotourism focuses on geological heritage and its sustainable interpretation [48]. The framework supports geotourism through geosite assessment and prioritization integrating accessibility, scenic visibility, and scientific significance to identify priority sites for development and interpretation, georoute optimization using network analysis to design efficient visitor itineraries that maximize site coverage while minimizing environmental impacts, visitor flow management for sensitive geological sites using predictive modeling to anticipate visitor pressure, and interpretation planning using visitor data and sentiment analysis to develop targeted educational content [16].

Crisis Management and Destination Resilience

Tourism destinations face multiple risks including natural disasters, health emergencies, and economic shocks [3]. The framework supports crisis management through early warning systems integrating environmental monitoring and predictive models to anticipate risks and trigger timely responses, evacuation planning using network analysis to optimize evacuation routes and procedures, recovery planning using post-event data and predictive modeling to guide reconstruction and recovery efforts, and scenario planning enabling exploration of alternative futures and identification of robust strategies under uncertainty.

Educational Implications

The integration of GeoAI into tourism destination planning has significant implications for geography and tourism education at multiple levels, from secondary education to postgraduate programs and professional development.

Curriculum Development and Integration

The rapid advancement of GeoAI technologies necessitates corresponding evolution in geography and tourism curricula. Traditional GIS education has emphasized cartographic principles, spatial analysis techniques, and data management skills [49]. The emergence of GeoAI requires the integration of computational thinking, machine learning concepts, and programming skills into geography curricula [50]. Key curriculum components should include foundational knowledge of AI principles and machine learning algorithms with spatial applications, technical skills in Python programming and geospatial libraries, spatial data science integrating statistics and machine learning for tourism analytics, and ethical and critical thinking regarding algorithmic bias and responsible AI use in tourism contexts [28].

Pedagogical Approaches

Effective teaching of GeoAI for tourism planning requires innovative pedagogical approaches. Project-based learning engages students with real-world tourism planning challenges, applying GeoAI techniques to authentic problems such as tourist flow prediction or suitability mapping [51]. Interdisciplinary collaboration between geography, computer science, tourism studies, and urban planning departments enables students to appreciate the multiple perspectives required for effective tourism planning [52]. Case study analysis of successful GeoAI applications develops critical thinking and analytical skills, with students evaluating the strengths and limitations of different approaches. Hands-on workshops with GIS software, programming environments, and AI tools develop technical competence and confidence.

Competency Development for Tourism Professionals

GeoAI competency development is essential for tourism professionals across multiple roles. Tourism planners and policy makers require understanding of GeoAI capabilities and limitations for evidence-based decision-making and policy formulation. Destination management organizations require skills in applying GeoAI for visitor monitoring, capacity management, and marketing optimization. Tourism consultants and researchers need competence in conducting sophisticated spatial analyses and communicating findings to diverse stakeholders. Sustainable tourism practitioners require competence in using GeoAI for environmental impact assessment and conservation planning.

Educational Levels and Pathways

GeoAI education should be scaffolded across educational levels. At the secondary education level, introduction to GIS and basic spatial data analysis, awareness of AI applications in tourism, and development of digital literacy are appropriate. At the undergraduate level, comprehensive GIS and introductory AI courses, integration of spatial analysis with tourism and geography programs, and capstone projects applying GeoAI to tourism challenges are recommended. At the graduate level, advanced spatial data science, machine learning, and deep learning for tourism research, along with research methodology development and thesis work on GeoAI topics are appropriate. Professional development through short courses, workshops, and certificates for working professionals addresses continuing education needs.

Challenges in GeoAI Education

Several challenges must be addressed in GeoAI education. Technical infrastructure including access to computational resources, software, and data for teaching and learning may require cloud-based platforms to address limitations [53]. Faculty development is needed to prepare educators with the technical skills and pedagogical knowledge to teach GeoAI effectively [54]. Curriculum integration requires balancing traditional geography and tourism content with emerging GeoAI topics within credit constraints. Bridging disciplines requires overcoming disciplinary silos between computer science, geography, and tourism studies. Ethics and critical thinking must be emphasized to ensure students understand the ethical implications and limitations of AI.

Recommendations for Educational Institutions

Based on this analysis, several recommendations for educational institutions are offered. GeoAI modules should be incorporated into existing GIS and tourism courses, beginning with introductory concepts and progressing to advanced applications. Interdisciplinary programs or certificates in geospatial data science with tourism applications should be developed. Partnerships with industry, government, and research institutions should be established to provide real-world learning opportunities. Infrastructure including cloud-based computing platforms, software licenses, and data access should be invested in. Faculty development should be supported through workshops, conferences, and collaborative teaching initiatives. Ethical awareness should be promoted through dedicated modules on responsible AI, data privacy, and social justice.

Discussion

The GeoAI Tourism Intelligence Framework provides a comprehensive approach to integrating geospatial big data, AI algorithms, and spatial analytics for tourism destination planning. The framework addresses critical gaps in the existing literature by providing a systematic structure that synthesizes the full spectrum of GeoAI capabilities for holistic destination planning. This discussion explores the significance of the framework's components and their connections to established literature.

The framework's Input Layer recognizes the diversity of geospatial data sources now available for tourism analysis, consistent with observations regarding big data in tourism research [4]. The integration of remote sensing, location-based, user-generated, open, and IoT data reflects the multi-source approach that has been advocated for understanding complex tourism systems [6]. The preprocessing requirements

acknowledge the significant challenges of data heterogeneity and quality that have been identified as barriers to effective big data utilization in tourism contexts.
The GeoAI Engine Layer incorporates the range of AI techniques that have demonstrated value for tourism applications [22, 24]. The inclusion of deep learning architectures, ensemble methods, and Large Language Models recognizes the complementary strengths of different algorithmic approaches. This multi-method approach addresses the limitation of single-method studies and enables more comprehensive and robust analysis. The framework's emphasis on explainability and interpretability addresses concerns regarding the black box nature of many AI algorithms [28].
The Spatial Analytics and Decision Support Layer translates technical outputs into actionable intelligence, consistent with the decision support emphasis in planning theory [41]. The analytical modules address the key information needs identified in tourism planning practice including visitor monitoring, demand forecasting, and impact assessment [5, 12]. The framework's explicit consideration of sustainability and resilience aligns with contemporary concerns regarding overtourism and climate change impacts [2, 3].
The educational implications of the framework represent a novel contribution that has been largely absent from previous GeoAI tourism research. The curriculum development recommendations build upon established GIS education literature [49, 50] while extending it to address the specific requirements of GeoAI integration. The pedagogical approaches emphasize active and experiential learning, consistent with contemporary educational theory. The competency development framework addresses the professional development needs of tourism practitioners who will be responsible for implementing GeoAI approaches.
The framework's limitations must also be acknowledged. As a conceptual framework, it requires empirical validation through case studies and implementation research. The framework's effectiveness depends on data availability and quality, which may be limited in many tourism destinations. Technical capacity requirements may constrain adoption, particularly in resource-constrained contexts. Ethical and privacy concerns regarding location-based data require careful governance [29]. These limitations suggest directions for future research and implementation.

Recommendations

Based on the findings and discussion presented in this paper, several recommendations are offered for research, practice, and education.
For researchers, it is recommended that the proposed framework be empirically validated through case studies in diverse tourism contexts. Comparative studies across different destination types, geographic regions, and cultural settings would enhance understanding of the framework's transferability and contextual adaptation requirements. Researchers should also investigate the development and evaluation of specific GeoAI algorithms tailored to tourism planning applications, particularly for tourist flow prediction, demand forecasting, and impact assessment.
For practitioners, it is recommended that destination management organizations develop the technical capacity required for GeoAI implementation. This includes investment in data infrastructure, staff training, and collaboration with academic and technology partners. Practitioners should also develop governance frameworks for responsible data collection, use, and sharing that address privacy concerns and build stakeholder trust. Integration of GeoAI analytics with existing planning processes should be approached iteratively, with attention to change management and stakeholder engagement.

For educational institutions, it is recommended that GeoAI content be incorporated into geography and tourism curricula at multiple levels. This includes developing introductory modules for secondary and undergraduate students, advanced courses for graduate students, and professional development opportunities for practitioners. Interdisciplinary collaboration between geography, computer science, and tourism programs should be encouraged to provide students with comprehensive preparation. Investment in technical infrastructure and faculty development is essential for effective GeoAI education.
For policymakers, it is recommended that GeoAI capabilities be leveraged for evidence-based tourism policy development. This includes supporting data infrastructure development, funding research and innovation, and establishing ethical guidelines for GeoAI use in tourism contexts. Policies should promote sustainable and equitable tourism development, using GeoAI to monitor environmental and social impacts and identify intervention priorities.

Conclusion

This paper has presented the GeoAI Tourism Intelligence Framework, a comprehensive conceptual framework for integrating geospatial big data, AI algorithms, and spatial analytics to support intelligent and sustainable tourism destination planning. The framework addresses a critical gap in the literature by providing a systematic, theoretically grounded, and practically applicable approach to GeoAI-enabled tourism planning. Beyond the technical framework, this paper has articulated the significant educational implications of GeoAI for geography and tourism education.
The main findings of this study include the identification of three interconnected layers comprising the framework: an Input Layer of multi-source geospatial big data, a GeoAI Engine Layer incorporating deep learning and ensemble methods, and a Spatial Analytics and Decision Support Layer delivering actionable intelligence for destination planners. The framework's applicability across diverse tourism contexts including urban tourism, ecotourism, geotourism, and crisis management has been demonstrated through scenario-based applications. The educational implications analysis has identified curriculum development strategies, pedagogical approaches, and competency frameworks for preparing the next generation of tourism professionals.
The implications of this study for theory and practice are significant. For theory, the framework advances the integration of complexity theory, spatial data science, and planning theory within the tourism context. For practice, the framework provides a structured approach to intelligent tourism destination planning that balances economic development with environmental sustainability and social equity. The educational recommendations support the capacity building necessary for effective GeoAI implementation.
The limitations of this study include the conceptual nature of the framework, which requires empirical validation through case studies. The framework's effectiveness depends on data availability and quality, which may vary considerably across destinations. Technical capacity requirements may constrain adoption in resource-constrained contexts. Future research should focus on empirical validation, algorithm development, and ethical governance of GeoAI in tourism. The integration of GeoAI into tourism planning represents an ongoing process of innovation and adaptation that will continue to evolve with advances in technology, data availability, and planning practice.

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