REVISTA INVECOM
ISSN en línea: 2739-0063

Applications of artificial intelligence in the management of sustainable tourist destinations: a systematic review

Aplicaciones de la inteligencia artificial en la gestión de destinos turísticos sostenibles: una revisión sistemática

Received: 08/08/2025 - **Accepted:** 05/11/2025

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Abstract

The study aimed to systematically analyze the applications, benefits, challenges, and future trends of artificial intelligence (AI) in the management of sustainable tourist destinations. To this end, a literature review was conducted following the PRISMA protocol, which included scientific studies published between 2020 and 2024 in databases such as Web of Science, Scopus, SciELO, and PubMed. The article selection process was carried out in two stages: first, a screening of titles and abstracts; then, a detailed evaluation of the full text. The final analysis was based on 25 scientific publications, which represented the body of this research. The results showed that AI contributes positively to sustainability through environmental monitoring, energy optimization, tourism flow prediction, and waste management. However, there are significant challenges, such as high initial investment, digital divides, and the lack of ethical frameworks and standardized metrics to assess the impact of AI. This research offers a comprehensive framework to guide managers and policymakers, while highlighting areas that require further attention in future research.

Keywords: tourism management, sustainability, emerging technologies

Resumen

El estudio tuvo como objetivo analizar, de manera sistemática, las aplicaciones, beneficios, desafíos y tendencias futuras de la inteligencia artificial (IA) en la gestión de destinos turísticos sostenibles. Para ello, se llevó a cabo una revisión de la literatura siguiendo el protocolo PRISMA, que incluyó estudios científicos publicados entre 2020 y 2024 en bases de datos como Web of Science, Scopus, SciELO y PubMed. El proceso de selección de artículos se realizó en dos etapas: primero, un cribado de títulos y resúmenes; posteriormente, una evaluación detallada del texto completo. El análisis final se basó en 25 publicaciones científicas, que representaron el cuerpo de esta investigación. Los resultados mostraron que la IA contribuye de manera positiva a la sostenibilidad mediante el monitoreo ambiental, la optimización energética, la predicción de flujos turísticos y la gestión de residuos. Sin embargo, existen desafíos significativos, como la elevada inversión inicial, las brechas digitales y la falta de marcos éticos y métricas estandarizadas para evaluar el impacto de la IA. Esta investigación ofrece un marco integral para guiar a gestores y responsables políticos, al tiempo que resalta las áreas que requieren mayor atención en futuras investigaciones.

Palabras clave: gestión turística, sostenibilidad, tecnologías emergentes

Introduction

Artificial intelligence (AI) has recently emerged as a set of technologies poised to revolutionize the tourism industry (Al-Romeedy & Alharethi, 2024). In a global context where tourist destinations face pressures from over-tourism, climate change, and the increasing demand for authentic and responsible experiences, the search for sustainable management models has become an undeniable necessity (Yeh et al., 2020). Sustainability in tourism encompasses a balanced approach to economic, social, and environmental dimensions and presents challenges of unprecedented complexity (Goralski & Tan, 2020). It is at this intersection where the urgent need for sustainability meets the ongoing technological revolution (Schwaeke et al., 2025).

Traditional management of tourist destinations has struggled with the challenge of making decisions based on incomplete or excessively abundant and heterogeneous data (Bairachna & Krupitsa, 2024). Managers grapple with dynamic and multifaceted phenomena, such as visitor flows, the carrying capacity of ecosystems, tourist satisfaction, and the carbon footprint of activities, all of which are intrinsically difficult to measure using conventional methods (Mishra et al., 2024). AI, with its capability to process large volumes of data, offers tools for comprehending these dynamics with a greater level of detail and foresight (Doborjeh et al., 2022).

The concept of intelligent tourist destinations has gained increasing relevance, progressing from the digitalization of services towards a more integrative understanding in which intelligence, provided by technologies such as machine learning or natural language processing, is employed to enhance sustainability (Leong et al., 2024). This paradigm suggests the existence of a data ecosystem that feeds AI models to optimize resources (Archi et al., 2023). For instance, forecasting algorithms can predict surges in visitor numbers weeks in advance, enabling managers to implement measures to prevent overcrowding and its negative impacts (Mishra et al., 2024).

From an environmental standpoint, the potential contributions of AI are significant. Continuous and non-invasive monitoring of the health of sensitive ecosystems, such as coral reefs, forests, or coastal areas, can be achieved through image analysis captured by drones equipped with computer vision algorithms that detect subtle changes indicative of stress or degradation (Bibri et al., 2024). Intelligent energy management systems in hotel infrastructures can reduce consumption and emissions (Fan et al., 2023). Furthermore, waste management can be transformed through dynamic, AI-driven sensors (Wang et al., 2024). These applications aim to minimize the ecological footprint of tourism activities via more efficient management.

From a socioeconomic perspective, AI serves as a valuable tool for listening to and understanding the perceptions of residents and visitors (Marigliano, 2023). Sentiment analysis applied to reviews and comments on social media can capture real-time opinions and expectations regarding tourism development (Tuo et al., 2025). This feedback is invaluable for managers as it allows them to identify issues like overtourism in specific locations. Far from being a cold and impersonal technology, AI, when properly oriented, can help center attention on people (Rane et al., 2023).

However, this promising landscape is not without challenges. The implementation of AI solutions in sustainable destination management raises unavoidable ethical questions concerning the potential existence of algorithmic biases that could perpetuate inequalities (Al-kfairy et al., 2024). Transparency in the development and use of algorithms is essential for a genuinely positive technological transformation (Insirat et al., 2025).

The objective of this study was to systematically analyze the applications, benefits, challenges, and trends of AI in the management of sustainable tourist destinations, synthesizing current knowledge to identify opportunities and limitations that contribute to a more effective and responsible integration of AI in the sustainable development of tourism.

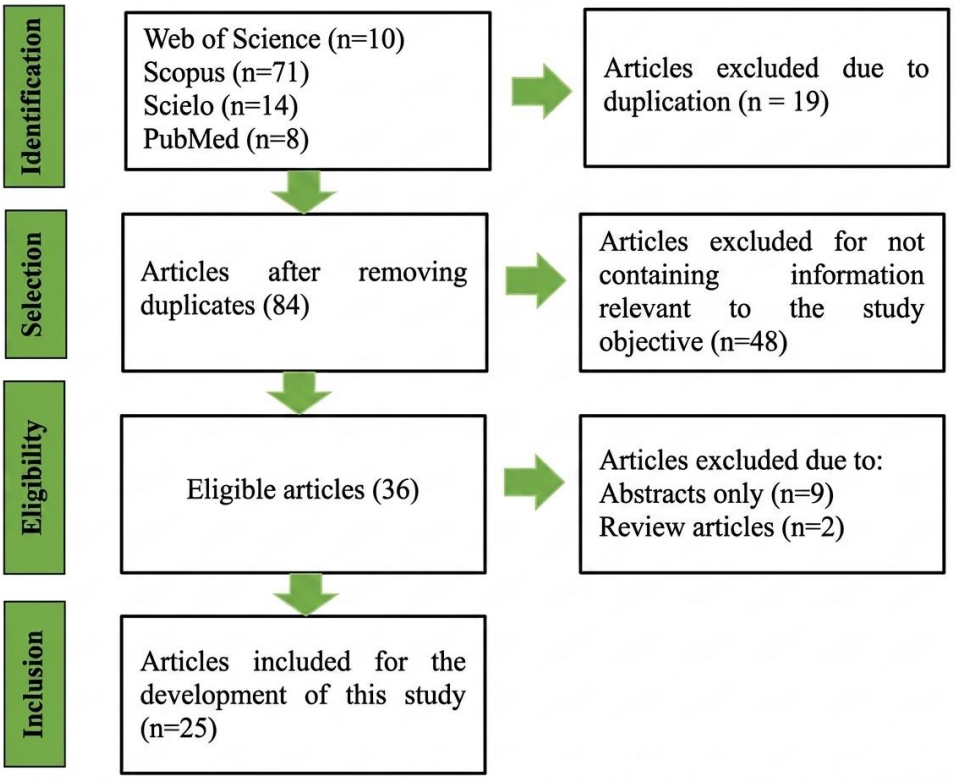
Methodology

This study followed a systematic literature review approach, adhering to the guidelines of the PRISMA protocol (Miller et al., 2025; Rethlefsen et al., 2021). It included scientific studies published between 2020 and 2024, aiming to identify, analyze, and synthesize evidence concerning AI applications in sustainable tourist destination management. Research searches were conducted in internationally recognized databases (Web of Science, Scopus, SciELO, and PubMed), using a combination of keywords in both English and Spanish (*artificial intelligence, sustainable tourism, AI applications, and tourism sustainability*). Additionally, search strings were constructed by combining keywords with Boolean operators (AND, OR).

Article selection occurred in two stages. First, titles and abstracts of the identified studies were reviewed to discard those that did not align with the review's objectives. In the second stage, a detailed assessment of the full texts of preselected articles was performed. Inclusion criteria considered research published in the last five years, peer-reviewed articles, studies addressing the application of AI in destination management, and those incorporating dimensions of environmental, social, or economic sustainability. Works that did not address the central theme, systematic reviews, duplicated studies, opinion pieces, and conference abstracts were excluded.

Data extraction was conducted using a matrix that allowed for the collection of relevant information from each selected study, including authorship, publication year, type of AI application, main results, and identified limitations. Information synthesis was performed qualitatively, grouping findings into thematic categories related to the benefits, challenges, emerging trends, and research gaps in the application of AI for tourism sustainability. To ensure transparency and reproducibility of the selection process, each stage was documented, and a PRISMA diagram was created (Figure 1) (Forteza-Martínez & Alonso-López, 2024). Finally, the results were analyzed and interpreted according to the research objectives, providing an updated perspective on the future prospects of AI in the sustainable management of tourist destinations.

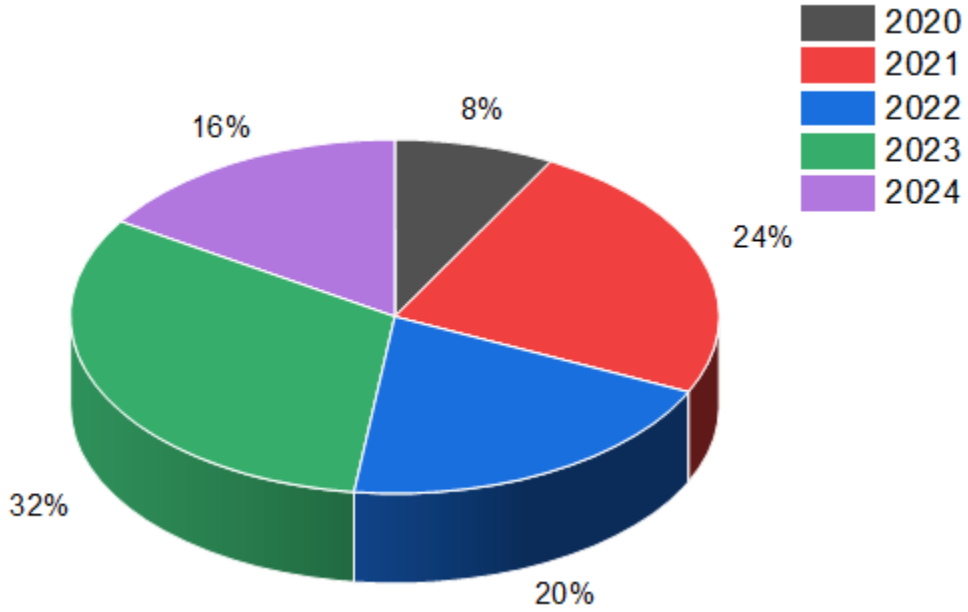
Figure 1
PRISMA diagram



Results and discussion

A total of 103 scientific studies were identified for this research. The selection process concluded with the inclusion of 25 articles that met the criteria for analysis. The year 2020 recorded the lowest number of publications, representing only 8% of the total articles included, indicating that the field of study was at an early stage. Conversely, the research witnessed significant growth in subsequent years, culminating in 2023, which accounted for 32% of the studies (Figure 2).

Figure 2
Distribution of the 25 studies evaluated for inclusion by year



Environmental monitoring, aided by the Internet of Things (IoT) and big data, facilitates the immediate collection and analysis of environmental data, thereby reducing ecological impact and optimizing the management of tourist destination loads (Majid et al., 2023; Suanpang & Pothipassa, 2024). The enhancement of energy resources through machine learning increases operational efficiency, achieving energy consumption aligned with demand (Rane et al., 2023; Siddik et al., 2025).

Smart waste management, developed from AI algorithms, optimizes collection routes and promotes a circular economy (Rane et al., 2023; Zhao, 2025). Personalizing tourist experiences, thanks to technologies such as natural language processing, generative AI (Gen AI), and augmented/virtual reality (AR/VR), enhances satisfaction and accessibility, enabling tourists to receive personalized recommendations and engage in inclusive experiences through virtual tours (Loureiro & Nascimento, 2021; Knani et al., 2022; Samara et al., 2020). Predicting tourist flows using predictive analytics contributes to alleviating congestion at destinations and effectively planning infrastructure (Filieri et al., 2021; Wang & Zhang, 2025; Tuo et al., 2025).

In the realm of heritage, AI and AR allow for the monitoring of the status of cultural and natural assets while also offering educational and immersive experiences (Iah et al., 2023). Supply chain management, supported by blockchain and Gen AI, ensures traceability and equitably distributes economic benefits, fostering social justice and transparency (Rane et al., 2023; Kulkov et al., 2024). Sustainable marketing, driven by big data and AI, strengthens engagement with environmentally conscious tourists (Majid et al., 2023; Tuo et al., 2025).

Crisis management and resilience utilize AI to provide responses to unforeseen situations, thereby increasing the adaptability of tourist destinations (Zhao, 2025). Additionally, assessing the ecological footprint using AI and big data offers precise metrics for calculating environmental impact (Kulkov et al., 2024; Liu et al., 2022).

Recent literature emphasizes that integrating AI with blockchain or AR amplifies its positive impact on sustainability, underscoring the need for an ethical and collaborative governance model to maximize benefits while minimizing risks. Moreover, AI emerges as an essential driver of efficiency and sustainability in the management of tourist destinations (Grundner & Neuhofer, 2021; Tiwari et al., 2022).

Table 1
Uses of AI and associated technologies in the sustainable management of tourist destinations

Applications	Associated technology	Type of destination	Result	Reference
Environmental Monitoring	IoT, Big Data	Heritage	Sensors for crowd control	(Liu et al., 2022; Iah et al., 2023; Suanpang & Pothipassa, 2024)
Optimization of Energy Resources	Machine Learning	Urban	Prediction of electricity demand	(Rane et al., 2023; Siddik et al., 2023)
Smart Waste Management	AI, Big Data	Urban and Natural	Optimal collection routes	(Samara et al., 2020)
Experience Personalization	NLP, Gen AI, AR/VR	Heritage and Urban	Multilingual virtual assistants	(Knani et al., 2022; Loureiro & Nascimento, 2021)
Tourist Flow Prediction	Predictive Analytics	Urban and Natural	Visitor prediction models	(Tuo et al., 2025; Wang & Zhang, 2025)
Heritage Conservation	AI, AR/VR, IoT	Heritage	Virtual tours, monitoring	(Liu et al., 2022; Iah et al., 2023)
Supply Chain Management	Gen AI, Blockchain	Urban and Regional	Traceability of local products	(Kulkov et al., 2024; Wang & Zhang, 2025)
Sustainable Marketing	Big Data, AI	Urban, Natural, and Heritage	Segmentation of sustainable tourists	(Filieri et al., 2021; Knani et al., 2022; Tuo et al., 2023)
Crisis Management and Resilience	AI, Big Data	Urban, Natural, and Heritage	Post-COVID response models	(Knani et al., 2022; Zhao, 2025)
Ecological Footprint Assessment	AI, Big Data	Natural and Heritage	Calculation of footprint and capacity	(Liu et al., 2022; Loureiro & Nascimento, 2021; Kulkov et al., 2024)

Applications	Associated technology	Type of destination	Result	Reference
Heritage Tourism	AI, IoT, Big Data	Urban and Regional	Footprint calculation	(Grundner & Neuhofer, 2021; Tiwari et al., 2022)

In the environmental realm, the use of big data, machine learning, and the implementation of sensors has significantly advanced emissions reduction and energy efficiency (Iah et al., 2023; Zhao, 2023). However, difficulties in standardizing impact metrics continue to limit ongoing improvements in sustainability. Initial challenges in securing funding and the high costs associated with technological infrastructure present common barriers for small tourism accommodation businesses (Rane et al., 2023; Samara et al., 2020; Siddik et al., 2025).

In the social dimension, AI facilitates the personalization of experiences and the inclusion of tourists with diverse needs, thereby improving access and satisfaction (Suanpang & Pothipassa, 2024). Nonetheless, the digital divide and concerns regarding privacy and data protection may exclude certain groups. Resistance to change among both local stakeholders and tourists underscores the importance of awareness-raising and continuous training to promote the adoption of new technologies (Tuo et al., 2025; Zhang & Cheng, 2024).

From an economic perspective, improvements in equity throughout the value chain and responsible promotion are apparent, as AI favors a more just distribution of benefits (Knani et al., 2022; Kulkov et al., 2024; Wang & Zhang, 2025). However, inequality in access to technology and information overload can hinder the participation of small and medium-sized enterprises, as well as local agents.

Resilience in crisis situations demonstrates AI's capacity to model scenarios amid uncertainty. Nevertheless, the lack of specific protocols remains a challenge when AI takes on a significant role in sustainable tourism (Knani et al., 2022; Loureiro & Nascimento, 2021).

The literature highlights the importance of technological training, the development of robust indicators, and multi-sector collaboration as determining factors for the success of AI in tourism sustainability (Liu et al., 2022; Siddik et al., 2025; Tussyadiah, 2020). Additionally, while AI offers benefits such as resource optimization, innovation, and personalization, it also faces technical, ethical, and adoption challenges (García-Madurga & Grilló-Méndez, 2023; Go & Kang, 2023).

Table 2

Benefits, challenges, and critical success factors of AI in tourism sustainability

Benefit	Main challenge	Success factor	Reference
Reduction of Emissions	Lack of Data	Integration of Sensors and Analytics	(Iah et al., 2023; Liu et al., 2022; Zhao, 2025)
Energy Efficiency	High Initial Investment	Institutional Support and Funding	(Rane et al., 2023; Samara et al., 2020; Siddik et al., 2025)
Personalization and Inclusion	Privacy and Data Protection	Community Engagement	(Suanpang & Pothipassa, 2024; Wang & Zhang, 2023)
Decongestion of Destinations	Resistance to Change	Awareness-Raising and Training	(Kulkov et al., 2024; Tuo et al., 2023)
Heritage Protection	Lack of Standards	Multi-Sector Collaboration	(Knani et al., 2022; Liu et al., 2022)

Benefit	Main challenge	Success factor	Reference
Equity in the Value Chain	Inequality in Access to Technology	Inclusion of SMEs and Local Stakeholders	(Rane et al., 2023; Wang & Zhang, 2025)
Responsible Promotion	Information Overload	Ethical Marketing Strategies	(Filieri et al., 2021; Tuo et al., 2025)
Crisis Resilience	Lack of AI Protocols	Scenario Planning and Simulation	(Loureiro & Nascimento, 2021; Zhao, 2025)
Environmental Impact Measurement	Difficulty in Standardized Metrics	Development of Robust Indicators	(Liu et al., 2022; Kulkov et al., 2024)
Fostering Sustainability	Lack of Environmental Data	Technological Training	(García-Madurga & Grilló-Méndez, 2023; Go & Kang, 2023)

The conjunction of AI with IoT and blockchain has yielded advances that could transform destination management models and foster the emergence of intelligent ecosystems, optimizing the use of available resources while strengthening traceability and transparency throughout the value chain (Kulkov et al., 2024; Suanpang & Pothipassa, 2024). However, a significant gap remains in quantifying the environmental effects of technological implementations, as the most accurate methodological combination for measuring the average impact of AI on sustainability has yet to be established.

The use of collaborative platforms and co-creation with local communities, alongside the promotion of participatory governance and social ownership, constitutes particularly relevant trends (Iah et al., 2023; Tussyadiah, 2020). Nonetheless, the availability of participatory models and ethical frameworks for co-creating value remains insufficient. Immersive experiences, such as AR/VR, are transforming how tourists experience and relate to their surroundings (Rane et al., 2023).

AI's application in crisis management has highlighted its role in enhancing the adaptability of tourist destinations. Nevertheless, the absence of specific protocols and strategies continues to pose a challenge (Zhao, 2025). Additionally, personalized and sustainable marketing associated with AI algorithms raises ethical concerns regarding segmentation and privacy (Filieri et al., 2021).

Optimizing mobility and transportation through AI can contribute to reducing indirect emissions, but it requires effective integration with urban and transportation policies (Samara et al., 2020). Moreover, intelligent management of both tangible and intangible heritage, as well as universal accessibility, are emerging areas needing greater attention and development of inclusive solutions (Suanpang & Pothipassa, 2024).

The automation of tourism services raises questions about employment; thus, establishing labor transition policies to protect workers is essential (Kulkov et al., 2024; Rane et al., 2023). Lastly, incorporating AI into sustainable tourism training is crucial for preparing professionals to meet the demands of the sector's digital transformation (Neophytou et al., 2025).

Research gaps persist concerning social, ethical, and regulatory impacts, along with evaluating the long-term effects of AI on tourist destinations (Esteve-Selma et al., 2022; Gaur et al., 2021; Saydam et al., 2022).

Table 3
Emerging trends and research gaps in AI applications for tourism sustainability

Emerging trend	Research gap	Recommendation	Reference
Integration of AI, IoT, and Blockchain	Quantitative assessment of environmental impact	Longitudinal studies and standardized metrics	(Suanpang & Pothipassa, 2024; Rane et al., 2023)
Collaborative Platforms and Co-Creation	Community participation and ethical governance	Participatory models and ethical frameworks	(Ateş et al., 2024; Tussyadiah, 2020)
Immersive Experiences (AR/VR)	Measurement of long-term social outcomes	Social and cultural impact assessment	(Kulkov et al., 2024; Rane et al., 2023)
AI in Crisis Management (Post-COVID)	Adaptability and resilience in crisis situations	AI-based response strategies	(Knani et al., 2022; Zhao, 2025)
Personalized and Sustainable Marketing	Lack of ethical segmentation	Development of responsible algorithms	(Filieri et al., 2021; Samara et al., 2020)
Mobility and Transportation Optimization	Impact on indirect emissions	Integration with urban policies	(Knani et al., 2022; Siddik et al., 2023)
Smart Heritage Management	Inclusion of intangible heritage	Digitization of cultural resources	(Iah et al., 2023; Liu et al., 2022; Rane et al., 2023)
AI for Universal Accessibility	Lack of studies in inclusive tourism	Universal design in AI platforms	(Siddik et al., 2023; Knani et al., 2022)
Automation of Tourism Services	Impact on employment and labor relations	Labor transition policies	(Iah et al., 2023; Liu et al., 2022)
AI in Education for Sustainable Tourism	Scarcity of training programs	Integrate AI into educational curricula	(Samara et al., 2020; Suanpang & Pothipassa, 2024)
AI in Tourist Destinations	Lack of studies in inclusive tourism	Design AI-enabled platforms	(Esteve-Selma et al., 2022; Gaur et al., 2021; Saydam et al., 2022)

Conclusions

The results of this systematic review demonstrate that AI has effectively optimized resource management, personalized visitor experiences, increased accessibility, fostered cultural heritage conservation, and facilitated data-driven decision-making by incorporating technologies such as IoT, big data, blockchain, augmented reality, and virtual reality. These applications have shown positive effects on operational efficiency, reduction of

environmental footprints, as well as economic equity and crisis resilience, thus contributing to the sustainable growth of tourism. The literature highlights persistent issues such as initial investment costs, the digital divide, technical barriers, data protection, and the need for ethical governance frameworks. Coupled with the lack of standardized metrics for assessing the environmental and social impacts of AI, as well as limited community and tourist involvement in solution design, these gaps must be addressed in future research. This study provides a comprehensive framework to guide managers, policymakers, and industry stakeholders on how to leverage AI for advancing toward more sustainable, intelligent, and inclusive tourist destinations while identifying priority areas for future research and technological development.

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