

Using AI Tools to Promote Sustainable Tourism Practices: Opportunities and Ethical Consideration in the Post-Pandemic Era

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Abstract

The integration of artificial intelligence (AI) in tourism has accelerated in the post-pandemic era, offering new opportunities to align tourism development with the United Nations Sustainable Development Goals (SDGs). This study examines how AI tools can promote sustainable tourism practices by analyzing three cases—Amsterdam, Singapore, and Taiwan—through a qualitative, multi-case study approach. Findings reveal that AI contributes to enhanced visitor management, optimized resource consumption, environmental protection, and sustainability education. The research identifies key benefits such as operational efficiency and environmental monitoring, as well as challenges including data ethics, stakeholder inclusion, and governance readiness. Despite its promise, AI is not a one-size-fits-all solution and must be implemented within inclusive, ethical, and context-aware frameworks. The study concludes with five policy recommendations to guide the responsible adoption of AI in tourism: developing ethical guidelines, building digital capacity, encouraging public-private collaboration, embedding AI in strategic planning, and integrating sustainability education. These insights aim to support policymakers and destination managers in leveraging AI to create smarter, more resilient, and sustainable tourism ecosystems.

Keywords: Sustainable tourism, Artificial intelligence, Smart tourism, Post-pandemic recovery, Ethical AI, SDGs

1. Introduction

The global tourism industry has experienced unprecedented growth over the last two decades, contributing significantly to economic development, job creation, and cultural exchange. However, this growth has come at a considerable environmental and social cost. Tourism contributes to approximately 8% of global carbon emissions (Gossling & Higham, 2020), while also exerting pressure on local ecosystems, heritage sites, and infrastructure in many destinations. The COVID-19 pandemic has served as a stark reminder of the vulnerabilities inherent in a globalized tourism system. Widespread travel restrictions, declining tourist arrivals, and the closure of hospitality establishments have had a severe economic impact on millions of workers and businesses. At the same time, the pandemic has opened up a unique window of opportunity to reimagine tourism in a more sustainable and resilient way. With the acceleration of digitalization across all sectors, the tourism industry is increasingly adopting artificial intelligence (AI) technologies to adapt to new operational requirements, such as contactless services, health risk monitoring, and remote

engagement. AI tools—ranging from chatbots and virtual assistants to predictive analytics and automated environmental monitoring—are now being positioned not only as recovery solutions but also as catalysts for long-term sustainable transformation.

This paper argues that AI, when deployed thoughtfully and ethically, can significantly support the goals of sustainable tourism by improving operational efficiency, reducing resource consumption, enhancing visitor experiences, and enabling data-driven policy-making. More importantly, AI has the potential to facilitate progress toward several of the United Nations Sustainable Development Goals (SDGs), including Goal 8 (decent work and economic growth), Goal 11 (sustainable cities and communities), Goal 12 (responsible consumption and production), and Goal 13 (climate action). Through a comprehensive literature review and analysis of case studies from different regions, this paper explores the current state of AI applications in tourism, evaluates their contributions to sustainability, and highlights the ethical and policy considerations that must be addressed to ensure equitable outcomes. The goal is to provide a framework for understanding the dual role of AI as both an enabler and a disruptor in the pursuit of sustainable tourism development in the post-pandemic era.

2. Literature Review

2. 1. Sustainable Tourism and the SDGs

Sustainable tourism, as defined by the United Nations World Tourism Organization (UNWTO), addresses the economic, social, and environmental needs of all stakeholders, including visitors, industry operators, host communities, and the environment itself (UNWTO, 2018). This approach is grounded in balancing three core pillars: economic viability, environmental integrity, and socio-cultural responsibility (Hunter, 1997; Bramwell & Lane, 2011; Sharpley, 2009). Economic viability emphasizes long-term financial benefits for local economies, environmental integrity focuses on resource efficiency and ecosystem protection, and socio-cultural responsibility encourages cultural respect and equitable benefit sharing.

Tourism's contribution to the United Nations Sustainable Development Goals (SDGs) has been widely acknowledged. Scheyvens and Hughes (2019) identify meaningful links to several SDGs, particularly Goals 1, 5, 8, 11, 12, and 13. Tourism can reduce poverty, empower women, foster economic opportunities, promote sustainable urban development, and encourage climate-conscious behavior when planned inclusively. Further, Hall (2011), Becken (2017), and Font et al. (2016) stress the importance of good governance, community participation, and measurable indicators for successful sustainable tourism. Effective frameworks must go beyond rhetoric to include actionable strategies and tools such as sustainability indicators and stakeholder engagement to evaluate impact.

Overall, integrating tourism with SDGs requires cross-sector collaboration and consistent evaluation. With clear policies and inclusive planning, tourism can become a powerful catalyst for sustainable development rather than a source of social or ecological strain.

2. 2. AI Technologies in Tourism

Artificial intelligence (AI) technologies are reshaping tourism through automation, personalization, and operational optimization. AI tools such as machine learning, natural language processing (NLP), and computer vision are increasingly applied in demand forecasting, customer service chatbots, smart surveillance, and recommendation systems (Gretzel et al., 2015; Law et al., 2020; Buhalis & Sinarta, 2019). AI also contributes to sustainability goals by improving energy and resource efficiency. Smart hotels use AI to control lighting, heating, and water consumption, while AI-driven mobility platforms reduce congestion and emissions through real-time routing (Ivanov & Webster, 2019; Gretzel & Xiang, 2021). In strategic planning, AI-enabled analytics help tourism boards track visitor flows and design data-informed policies (Zeng et al., 2020).

Beyond operations, AI is being used in mobile guide apps and cultural interpretation systems. These tools deliver real-time, personalized content that enhances the tourist experience and promotes low-carbon travel behaviors (Yoo et al., 2021; Kim & Han, 2022). Academic-industry collaborations have led to the development of route recommendation systems promoting heritage appreciation and sustainable mobility (Wang et al., 2023; Dredge et al., 2021). Additionally, AI supports sustainability education. Apps such as the SDG Academy and GreenStep use gamification and interactive assessments to raise awareness of environmental issues among travelers and students (Sachs et al., 2020; Han et al., 2023). These tools integrate sustainability learning into travel experiences, reinforcing SDG-aligned behavior change.

In summary, AI technologies enhance tourism management and sustainability by streamlining operations, personalizing services, and supporting education. Their application continues to expand as destinations pursue smarter, greener, and more inclusive models of tourism.

2. 3. AI and Sustainability: Intersections

The integration of AI into sustainable tourism practices reveals several promising intersections that can accelerate progress toward the United Nations Sustainable Development Goals (SDGs). These intersections span environmental management, resource optimization, economic inclusivity, and community empowerment.

First, AI supports environmental sustainability by enabling real-time monitoring of tourism-related environmental impacts. For example, AI-powered sensors and IoT devices can track air and water

quality in real time at popular destinations, providing critical data for ecosystem management (Gretzel & Sigala, 2020; Wang et al., 2022; Gössling, 2021).

Second, AI enhances operational efficiency and resource optimization, aligning with SDG 12. Intelligent scheduling and smart building systems reduce energy and material use (Ivanov et al., 2021; Fuchs et al., 2021). Third, AI promotes inclusive economic growth and supports SMEs by democratizing access to analytics and marketing tools (Morosan & DeFranco, 2016; Chatterjee et al., 2022).

AI also facilitates community-based tourism and heritage preservation. Translation and cultural interpretation systems help local voices reach global audiences while preserving authenticity (Zeng et al., 2020; Fernández-Villarán et al., 2023). Additionally, AI-driven platforms for behavior change—such as eco-feedback apps and gamified sustainability lessons—can shape environmentally responsible actions (Tussyadiah et al., 2020; Han et al., 2023).

In short, AI and sustainability intersect in ways that can transform tourism systems. With careful governance, AI can promote innovation and equity while helping destinations meet long-term environmental and cultural goals.

2. 4. Ethical Considerations and Responsible AI

While artificial intelligence offers transformative potential for sustainable tourism, it also introduces ethical challenges that require careful oversight. These concerns include data privacy, algorithmic bias, workforce displacement, surveillance, and unequal access to digital infrastructure.

Firstly, data privacy remains a critical issue. Many AI tools rely on real-time collection of personal and behavioral data. Without clear regulation, misuse or data breaches may occur. Tourists increasingly demand transparency regarding how their information is gathered and used (Tussyadiah & Miller, 2019; Buhalis et al., 2020). Secondly, algorithmic bias is another concern. AI models trained on incomplete or skewed data may marginalize underrepresented groups or reinforce dominant preferences in tourism platforms (Cows & Floridi, 2018; Eubanks, 2018). Equitable AI requires diverse datasets, human oversight, and frequent system audits. Thirdly, AI adoption may also displace jobs in hospitality and travel services. While AI creates new opportunities in digital tourism, inclusive reskilling and support programs are needed to reduce disruption (Ivanov & Webster, 2017; OECD, 2021). Fourthly, surveillance technologies like facial recognition and smart cameras raise concerns about mass monitoring and civil liberties. Clear policies and community consultation are essential for ethical deployment (Zuboff, 2019; Lupton, 2021). Finally, the digital divide limits access to AI benefits for marginalized destinations and

communities. Investment in infrastructure and digital literacy is necessary to promote inclusive participation (Scheerder et al., 2017; Graham, 2020).

To foster trust and accountability, AI systems in tourism should follow explainable and transparent frameworks (Doshi-Velez & Kim, 2017). Responsible AI must balance innovation with fairness, inclusion, and respect for individual rights.

3. Research Method

This study adopts a qualitative multiple-case study methodology to examine how artificial intelligence (AI) is applied to promote sustainable tourism practices and support the Sustainable Development Goals (SDGs). The methodology is designed to allow in-depth exploration of different AI-driven tourism models across diverse sociocultural and governance contexts.

Research Design. A qualitative research design was selected to gain contextualized, interpretative insights into real-world applications of AI in sustainable tourism. The case study approach enables the analysis of dynamic, complex interactions between AI tools, tourism stakeholders, and sustainability outcomes. Three cases were purposively selected for their innovative use of AI in sustainable tourism: Amsterdam (Netherlands), Singapore, and Taiwan. Each case represents a different regional model of smart tourism implementation, emphasizing environmental sustainability, urban mobility, or ecotourism education.

In **Amsterdam**, the city government has implemented AI-enabled real-time visitor management systems to address over-tourism and protect heritage zones. These systems use predictive analytics and sensor data to guide tourist flows, distribute visitation across the city, and reduce congestion in iconic sites such as the Anne Frank House and the Red Light District. AI tools also assist in monitoring environmental impacts, such as air quality and noise pollution, reinforcing the city's commitment to SDG 11 (sustainable cities) and SDG 13 (climate action).

In **Singapore**, the Tourism Analytics Network (STAN) leverages AI to integrate multi-agency datasets for urban mobility planning, sustainability policy evaluation, and hotel energy optimization. For example, AI-driven models are used to simulate visitor demand and inform transportation and infrastructure design. These innovations support Singapore's Smart Nation initiative and demonstrate how urban AI ecosystems can support Goals 9 (industry and infrastructure), 11, and 12 (responsible consumption).

In **Taiwan**, national parks and local ecotourism initiatives employ AI for environmental education and biodiversity monitoring. The Alishan National Scenic Area uses AI-powered image recognition for tracking wildlife activity and analyzing tourist interactions with natural environments. Additionally, mobile apps provide visitors with SDG-aligned eco-guides and

gamified learning experiences about conservation and local culture. These approaches foster awareness and behavior change aligned with SDG 4 (quality education) and SDG 15 (life on land).

Data Collection. Data were collected from multiple sources to ensure triangulation and validity. Sources included: (1) Government reports, tourism board strategy documents, and white papers (2019–2024); (2) Peer-reviewed journal articles and case study publications; (3) Publicly available datasets and dashboards related to smart tourism projects; (4) Semi-structured expert interviews with tourism planners, AI developers, and sustainability professionals (n=12)

Interviewees were selected using purposive sampling based on their direct involvement in AI-related tourism planning, digital transformation projects, or sustainability initiatives within Amsterdam, Singapore, and Taiwan. The participant group included senior officials from national tourism organizations, project managers overseeing AI deployment in smart tourism initiatives, software engineers from AI development firms, and academics specializing in sustainable tourism or AI ethics. Efforts were made to ensure representation from both public and private sectors, as well as from institutions involved in policy development and community engagement.

Each interview lasted approximately 45–60 minutes and was conducted via secure video conferencing platforms (Zoom or Microsoft Teams) between January and March 2025. Interviews were semi-structured, allowing for guided discussion while enabling interviewees to elaborate on their unique perspectives. Interview protocols were designed around themes such as perceived benefits of AI for sustainability, implementation challenges, ethical concerns, and stakeholder collaboration. All interviews were audio recorded with informed consent, transcribed verbatim, and anonymized for confidentiality.

Data Analysis. Thematic analysis was employed to examine collected data from expert interviews, policy documents, and case study materials. Transcripts and documents were coded using NVivo software, following Braun and Clarke’s (2006) six-step framework: (1) familiarization with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the final report. This process enabled the identification of repeated ideas and underlying patterns across the three case study contexts.

The initial coding focused on key constructs such as the types of AI applications used (e.g., mobility management, energy efficiency, cultural engagement), sustainability outcomes (e.g., reduced emissions, education enhancement), stakeholder roles and collaboration, ethical issues (e.g., data privacy, surveillance), and alignment with relevant SDG goals. Codes were then aggregated into broader categories such as “AI for visitor management,” “AI for conservation,” “barriers to adoption,” and “ethical concerns.”

A cross-case comparison approach was conducted after individual case analyses were complete. This comparative analysis enabled the research team to identify convergent and divergent themes across Amsterdam, Singapore, and Taiwan. For instance, while all three cases used AI to reduce environmental pressures, the specific tools and institutional mechanisms varied depending on national priorities and technological readiness.

Special attention was given to the influence of governance frameworks, public-private partnerships, and local community involvement in shaping AI outcomes. Governance-related codes were further disaggregated into sub-themes related to digital infrastructure, regulatory clarity, stakeholder engagement, and public trust. This allowed the study to link micro-level practices (e.g., app features or monitoring devices) with macro-level policy implications. The final themes were validated through iterative re-coding and cross-verification among the research team.

Limitations. This study has several limitations. First, the purposive case selection may overrepresent successful implementations, limiting generalizability to less-developed regions. Second, the relatively small number of interviews (n=12) may not capture the full spectrum of stakeholder perspectives. Third, the rapid pace of AI development may render some findings less applicable over time. Despite these constraints, the multi-source and cross-case design provides a robust basis for qualitative insight into AI-supported sustainable tourism.

4. Finding and Discussion

This section presents the key findings from the case studies and expert interviews, organized into four main thematic categories: (1) perceived benefits of AI for sustainable tourism, (2) implementation enablers and barriers, (3) ethical and governance challenges, and (4) alignment with SDG targets. Findings from Amsterdam, Singapore, and Taiwan are synthesized and discussed comparatively.

4.1 Perceived Benefits of AI for Sustainable Tourism

Across all three case studies, AI was broadly recognized as a tool to improve sustainability performance in tourism. Experts emphasized that AI technologies helped destinations enhance operational efficiency, reduce environmental pressures, and improve tourist experiences. These observations align with findings from Gretzel et al. (2015) on smart tourism, Ivanov and Webster (2019) on AI and resource efficiency, and Reisinger and Hanna (2022) on AI-enhanced environmental learning.

In Amsterdam, the use of predictive analytics allowed local authorities to manage tourist flows proactively, redirecting visitors to less congested areas. This reduced stress on cultural heritage zones while encouraging exploration of lesser-known neighborhoods, thereby distributing

economic benefits more equitably. Tourism officials highlighted that AI-driven traffic and air quality sensors also supported environmental monitoring and regulatory enforcement.

In Singapore, stakeholders praised AI's contribution to resource optimization. For example, the STAN platform facilitated efficient allocation of transportation services based on predicted demand, contributing to reduced urban congestion and emissions. Hotel operators reported significant reductions in electricity and water use through AI-enabled energy management systems.

In Taiwan, AI was seen as particularly valuable for education and conservation. Park administrators noted how AI-supported biodiversity tracking tools allowed for early detection of ecological disturbances. The integration of SDG-themed content into visitor mobile apps was also credited with increasing public awareness of sustainability issues (Sachs et al., 2020).

4.2 Enablers and Barriers to AI Implementation

Interviewees identified strong government leadership, inter-agency data integration, and public-private partnerships as critical enablers of AI adoption. These factors have also been emphasized in prior research (Hall, 2011; Dredge et al., 2021; Buhalis & Sinarta, 2019). In Singapore, centralized digital infrastructure and a clear national vision for smart governance created favorable conditions for cross-sectoral AI integration. Amsterdam benefited from long-term investment in open data platforms and citizen participation frameworks.

Conversely, several barriers were noted. In all three cases, challenges around data interoperability, stakeholder resistance, and high implementation costs were reported. In Taiwan, experts cited limited technical capacity among some regional tourism bureaus as a constraint on scaling AI initiatives. Concerns about data sharing between private and public entities also emerged in both Amsterdam and Singapore, despite supportive policies (Scheerder et al., 2017; Cows & Floridi, 2018).

4.3 Ethical and Governance Challenges

Ethical issues raised in the interviews reflected concerns detailed in the literature. Data privacy emerged as a key topic, with interviewees emphasizing the need for greater transparency in how AI systems collect, process, and store user data. Algorithmic fairness was also frequently discussed. These concerns align with findings from Mittelstadt et al. (2016), Tussyadiah and Miller (2019), and Floridi (2021), who highlight the importance of fairness, consent, and explainability in AI ethics.

In Amsterdam, one stakeholder noted that AI-based route suggestions had inadvertently disadvantaged businesses located outside high-traffic areas. Governance frameworks varied in maturity. Singapore was noted for its structured AI ethics guidelines and risk assessment protocols. In contrast, stakeholders in Taiwan and Amsterdam called for more explicit guidelines on ethical AI use in tourism, especially in relation to surveillance and data consent.

4.4 Contributions to the SDGs

Participants across the three cases agreed that AI applications contributed directly to multiple SDGs. Commonly referenced goals included:

SDG 11 (Sustainable Cities and Communities): through improved urban mobility, reduced congestion, and protection of cultural sites.

SDG 12 (Responsible Consumption and Production): by optimizing energy, food, and water usage in tourism operations.

SDG 13 (Climate Action): via reduced emissions and enhanced environmental monitoring.

SDG 4 (Quality Education) and SDG 15 (Life on Land): particularly in Taiwan, where AI was used to promote ecological literacy and protect biodiversity.

The contributions identified here echo prior research linking tourism, sustainability, and AI to SDG progress (Scheyvens & Hughes, 2019; Font et al., 2016; Sachs et al., 2020). Despite these positive contributions, interviewees emphasized that AI is not a silver bullet. The extent to which AI supports SDG progress depends heavily on policy alignment, stakeholder collaboration, and inclusive design processes.

In summary, the findings suggest that while AI holds great promise for supporting sustainable tourism, its effectiveness depends on local governance structures, data ecosystem maturity, and ethical implementation strategies. These insights inform the policy recommendations presented in the following section.

5. Conclusion

This study explored the potential of artificial intelligence (AI) to support sustainable tourism practices in alignment with the United Nations Sustainable Development Goals (SDGs). Through a qualitative analysis of three leading destinations—Amsterdam, Singapore, and Taiwan—findings revealed that AI technologies are increasingly deployed to manage visitor flows, optimize resource consumption, support environmental conservation, and enhance sustainability education.

International Conference of Organizational Innovation 2025

Proceedings

ICOI

2025

e-ISSN: 3064-6030
FMI, Vol 2
15-17 July 2025

AI was shown to contribute significantly to SDG 11 (Sustainable Cities), SDG 12 (Responsible Consumption), SDG 13 (Climate Action), SDG 4 (Quality Education), and SDG 15 (Life on Land). These contributions echo prior analyses by Scheyvens and Hughes (2019), Sachs et al. (2020), and Gretzel et al. (2015), who noted that the integration of smart technologies in tourism can improve both environmental and social sustainability outcomes.

However, the study also identified challenges related to ethical implementation, governance structures, and digital capacity (Cowls & Floridi, 2018; Mittelstadt et al., 2016). These issues underscore the need for deliberate, inclusive, and context-sensitive approaches to AI deployment in tourism systems.

While AI is not a universal solution, its integration—when aligned with strong governance and community engagement—can accelerate tourism’s transformation toward more resilient and sustainable models (Font et al., 2016).

Based on the findings, the following recommendations are proposed for policymakers, destination managers, and technology developers: (1) Establish Clear Ethical Guidelines for AI in Tourism Governments and tourism authorities should co-develop ethical AI frameworks that ensure transparency, fairness, and data protection. These guidelines should address algorithmic accountability and be adapted to local legal and cultural contexts (Doshi-Velez & Kim, 2017; Cowls & Floridi, 2018); (2) Promote Inclusive Digital Capacity Building Investments in training programs and digital infrastructure should prioritize underrepresented communities, small tourism enterprises, and local government units. Capacity-building efforts will reduce inequality in AI adoption and foster more inclusive innovation ecosystems (Scheerder et al., 2017; Chatterjee et al., 2022); (3) Incentivize Public-Private Collaboration Policy instruments such as innovation grants, regulatory sandboxes, and cross-sector working groups can encourage collaborative development of AI applications that align with sustainability goals (Dredge et al., 2021; Buhalis & Sinarta, 2019). Collaborative governance models will enhance trust, innovation, and shared responsibility; (4) Integrate AI into National and Local Tourism Strategies. AI tools should be embedded in broader tourism development plans that emphasize SDG alignment (Hall, 2011; UNWTO, 2018). Strategic integration ensures that AI technologies contribute not only to operational goals but also to environmental protection, cultural preservation, and equitable economic development; (5) Embed Sustainability Education into AI-Driven Platforms

AI-powered apps and interpretation systems should include educational modules that promote awareness of environmental and cultural sustainability. This will enhance tourists’ capacity to act as responsible travelers and contribute to behavior change aligned with SDG principles (Sachs et al., 2020; Reisinger & Hanna, 2022).

International Conference of Organizational Innovation 2025

Proceedings

ICOI

2025

e-ISSN: 3064-6030
FMI, Vol 2
15-17 July 2025

These recommendations support a future-oriented approach to AI in tourism—one that prioritizes innovation, sustainability, and social responsibility. As AI technologies continue to evolve, their ethical and strategic deployment will be critical in shaping tourism's contribution to a more sustainable and equitable world. As the tourism industry navigates an era defined by both technological acceleration and environmental urgency, this study affirms that the thoughtful integration of AI can serve as a catalyst for change. By aligning innovation with ethical governance and sustainable development objectives, destinations can redefine how tourism contributes to people, planet, and prosperity. The path forward requires not only technical solutions but also collective vision and interdisciplinary collaboration to ensure tourism remains a force for good in the digital age.

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International Conference of Organizational Innovation 2025

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2025

e-ISSN: 3064-6030
FMI, Vol 2
15-17 July 2025

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