Jurnal Riset & Sains Ekonomi
https://jrse.ekasakti.org/index.php/jrse/

Sustainable Cultural Tourism in the Age of (Green) AI: Opportunities and Challenges for Heritage Sites

Fajar Santoso[1], Bhenu Artha[2]*, Sadath M. Nur[3], Felyanah Dessy Cinthya Putri[1], Adista Ika Julia[2]
[1]Universitas Islam Negeri Raden Mas Said Surakarta, Indonesia
[2]Universitas Widya Mataram, Yogyakarta, Indonesia
[3]STEINU Subang, Indonesia
bhenoz27@gmail.com*

Article Information:
Received Januari 15, 2026
Revised Februari 22, 2026
Accepted Maret 17, 2026

Keywords: *Artificial intelligence, cultural tourism, heritage site, sustainable*

Abstract

Cultural heritage artifacts can be protected and repaired to serve as the foundation for sustainable tourism and related enterprises. Intangible cultural heritage, in particular, stands out as a kind of cultural authenticity, therefore it can be used to generate socioeconomic benefits in the cultural tourism industry. Virtual Reality (VR) and Augmented Reality (AR) are now nearly universally used, resulting in considerable changes in manufacturing and consumption processes. These technologies have found widespread use in marketing, promotion, and even product development. This theoretical overview brings together recent research on how artificial intelligence (AI) is altering sustainable cultural and heritage tourism. It maps key theoretical lenses (socio-technical systems, sustainability/SDG frameworks, cultural heritage theory, experience economy, and technological determinism), identifies major AI-enabled opportunities (interpretation, accessibility, demand management, conservation, community empowerment), and highlights critical challenges (authenticity, equity, data governance, commodification, environmental footprint, skills). AI, AR, VR, and robotics form a tightly coupled technology ecosystem whose combined effect on heritage tourism is simultaneously enabling and disruptive. Thoughtful stewardship, community co-ownership, and interdisciplinary evaluation are essential to harness benefits, enhanced interpretation, conservation efficiency, accessibility while guarding against threats to authenticity, equity, and sustainability. The study concludes with policy and research recommendations for heritage managers, policymakers, and researchers seeking to strike a balance between technological innovation, sustainability, and cultural integrity.

INTRODUCTION

The preservation and restoration of cultural heritage artifacts constitute a fundamental pillar for the development of sustainable tourism and its associated socioeconomic ecosystems. Intangible cultural heritage (ICH), in particular, serves as a primary signifier of cultural authenticity; consequently, it possesses significant potential to catalyze socioeconomic growth within the cultural tourism sector.

How to cite:	Santoso, F., Artha, B., Nur, S, M., Putri, F, D, C., Julia, A, I. (2026). Sustainable Cultural Tourism in the Age of (Green) AI: Opportunities and Challenges for Heritage Sites. *Jurnal Riset & Sains ekonomi*, *3*(1), 17-30.
E-ISSN:	3046-840X
Published by:	The Institute for Research and Community Service

Concurrently, the near-universal adoption of Virtual Reality (VR) and Augmented Reality (AR) has fundamentally restructured the paradigms of both production and consumption, moving from peripheral marketing tools to core components of product development and heritage promotion. The conservation and restoration of cultural artifacts constitute a fundamental prerequisite for the development of sustainable tourism and its associated socioeconomic ecosystems (Cellini, 2011; Chhabra, 2010). Within this framework, intangible cultural heritage (ICH) serves as a primary signifier of cultural authenticity, functioning as a critical catalyst for socioeconomic value within the cultural tourism sector (Esfehani & Albrecht, 2018; Vidal González, 2008). This importance is underscored by UNESCO, which classifies ICH as a vital cultural resource with profound historical and ethnic significance, necessitating international cooperation to ensure its long-term preservation (Blake, 2002; Vecco, 2010).

Concurrently, the proliferation of Virtual Reality (VR) and Augmented Reality (AR) has fundamentally restructured the paradigms of both production and consumption. These technologies have transcended their initial roles, becoming integral to marketing strategies, promotional frameworks, and the simulation of pre-production prototypes (Al-Ansi et al., 2023; Negm, 2024). In the corporate landscape, the integration of AR and VR is increasingly leveraged to foster active user engagement, shifting the consumer role from passive observation to immersive participation (Selmanović et al., 2020; Singh et al., 2024).

Beyond brand engagement, immersive technologies serve as pivotal instruments for advancing sustainable consumerism and responsible tourism practices. By facilitating high-fidelity virtual encounters with historical sites, these tools mitigate the environmental pressures of excessive foot traffic, thereby aiding in the preservation of vulnerable landmarks (Lampropoulos, 2025). Furthermore, the digitization of cultural assets promotes inclusivity and broader accessibility, aligning with the objectives of Sustainable Development Goal 11 (Sustainable Cities and Communities) by democratizing heritage experiences.

This theoretical overview synthesizes contemporary research regarding the transformative influence of Artificial Intelligence (AI) on sustainable heritage tourism. By situating the discourse within critical conceptual lenses, including socio-technical systems, sustainability (SDG) frameworks, and the Experience Economy, this study maps the burgeoning AI-enabled opportunities for interpretation, accessibility, and community empowerment. However, the integration of AI, AR, VR, and robotics forms a "tightly coupled" technology ecosystem that acts as both a facilitator and a disruptor. To effectively harness the benefits of enhanced conservation while guarding against threats to cultural integrity, the industry must prioritize thoughtful stewardship, community co-ownership, and interdisciplinary evaluation. This study concludes by offering strategic policy and research trajectories intended to assist heritage managers in harmonizing technological innovation with the enduring principles of sustainability.

Artificial Intelligence (AI)

Artificial Intelligence (AI) represents a sophisticated technological paradigm with expansive utility across diverse industrial sectors, primarily aimed at augmenting human cognitive capabilities and operational efficiency (Ahmad et al., 2021, 2022; Kolotylo-Kulkarni et al., 2021). Conceptually, AI involves the computational evaluation and replication of higher-order human neural processes through intellectual simulation and development (Ahmad et al., 2022). At its core, this technology utilizes advanced algorithmic structures designed to emulate the heuristic and analytical functions of the human brain.

By synthesizing principles from engineering and the social sciences, AI facilitates multidimensional applications that yield significant societal dividends. The capacity for systems to interpret human commands and process complex datasets mirrors the nuanced functionality of human cognition. Furthermore, the rapid evolution of contemporary science has catalyzed a surge in the commercial deployment of AI, fundamentally restructuring both labor paradigms and lifestyle patterns (Ran et al., 2020).

In the current economic climate, AI has emerged as a critical driver of innovation, particularly within the e-commerce sector. This burgeoning influence has prompted an intensification of academic and industrial discourse, encouraging researchers to broaden the scope of AI applications and accelerate the pace of technological advancement. As a foundational element of the modern developmental era, AI has transitioned from a supportive tool to an essential infrastructure for complex problem-solving and task execution (Ran et al., 2020).

AI and Tourism

Historically, the tourism sector has served as a primary incubator for Information and Communication Technology (ICT) innovations, leveraging these tools to optimize marketing, operational efficiency, and consumer experiences (Buhalis & Law, 2008; Gretzel et al., 2004). The integration of ICT has been fundamentally linked to sustainability through the automation of reservation systems, inventory management, and customer relationship management (CRM), which collectively enhance operational performance (Li et al., 2019). Modern travelers now exhibit a profound dependency on these digital infrastructures for logistical planning, social networking, and financial transactions (Gössling, 2023).

Despite the success of traditional ICT, Artificial Intelligence (AI) represents a radical departure from conventional data processing. Unlike its predecessors, AI possesses the capacity for pattern recognition, autonomous decision-making, and iterative adaptation to dynamic data inputs. In the tourism domain, these capabilities manifest through chatbots, virtual assistants, real-time language translation, and high-precision dynamic pricing (Doborjeh et al., 2021; Tussyadiah et al., 2020). Current industry analysis suggests that AI not only elevates service efficiency but also offers significant potential for heritage preservation, environmental monitoring, and the enhancement of resident quality of life (Almasi et al., 2023; Majid et al., 2023).

However, the influence of AI on the Sustainable Development Goals (SDGs) is dualistic. While it can accelerate target achievement, it also introduces systemic risks across economic, geopolitical, and technological spheres (World Economic Forum, 2024). This research responds to critical calls for a more nuanced understanding of AI's role in shaping the future of sustainable tourism by rigorously evaluating its inherent benefits against these emerging threats (Hall & Cooper, 2025). Furthermore, the literature has increasingly focused on the impact of Augmented Reality (AR) and Virtual Reality (VR) within "smart" destination frameworks (Sousa et al., 2024; Sharma et al., 2021). These immersive technologies enhance the visitor experience by providing high-fidelity sensory stimulation via specialized hardware (Huang et al., 2021). Today, AI-enhanced ecosystems seamlessly integrate these tools with geospatial data, such as Google Maps, and 3D visualizations of transport and accommodation, creating a comprehensive digital interface for the modern traveler.

Robotics and AI

In the wake of the COVID-19 pandemic, the travel and hospitality sectors have accelerated the deployment of robotics and Artificial Intelligence (AI) to bolster institutional competitiveness and ensure sanitary safety for both consumers and personnel (Gaur et al., 2021; Koo et al., 2021). These "service agents" manifest in diverse configurations, ranging from disembodied voice assistants to tangible humanoid robots, and are increasingly utilized to augment staff capabilities or directly facilitate guest interactions (Chi et al., 2020).

From a guest-centric viewpoint, robotic integration is frequently associated with heightened engagement, satisfaction, and brand loyalty (Prentice et al., 2020; Zhang et al., 2022). By transforming routine service encounters into memorable, interactive experiences, robots can significantly elevate the perceived value of a stay (Mariani & Borghi, 2021). However, this technological shift is not without friction. Extensive research suggests that a "devaluation" of the service experience may occur when guests feel coerced into digital-only interactions, potentially leading to a breakdown in the traditional host-guest relationship (Gursoy et al., 2019; Samala et al., 2020). Furthermore, the design of these agents remains a point of scholarly contention; while human-like features can enhance empathy, they may also trigger skepticism or the "uncanny valley" effect, where overly realistic appearances become disconcerting to the user (Akdim et al., 2021; Pillai & Sivathanu, 2020).
For tourism enterprises, the primary drivers for automation include enhanced productivity, cost reduction, and the mitigation of staff burnout (Collins, 2020; Kong et al., 2021). Industry stakeholders increasingly view robotics as a strategic solution to chronic labor shortages and a means to maximize profitability (Morosan & Bowen, 2022). Conversely, the impact on the internal workforce is deeply nuanced. The potential for AI to displace lower-skilled, repetitive roles has catalyzed significant job insecurity among employees, which negatively correlates with workplace loyalty and psychological well-being (Li et al., 2023; Tang et al., 2020). While automation promises substantial socioeconomic dividends, the literature maintains a consensus that peak service performance and high-touch hospitality will continue to necessitate a fundamental human element (Wong et al., 2023).

Life Cycle Assessment of AI

While Artificial Intelligence (AI) serves as a transformative catalyst across industries, its environmental ramifications necessitate rigorous scrutiny through Life Cycle Assessment (LCA). This methodology provides a comprehensive framework for evaluating ecological impacts across the entire technological continuum, from hardware fabrication to model deployment (Salla et al., 2025). Current empirical evidence highlights the energy-intensive nature of AI model training, which typically requires high-performance computing clusters that contribute substantially to greenhouse gas emissions. Specifically, generative AI services have been shown to consume vast quantities of electricity, resulting in significant carbon footprints when subjected to LCA protocols (Berthelot et al., 2024).

The integration of machine learning with LCA methodologies has enhanced the precision of environmental forecasting, allowing researchers to simulate complex scenarios involving energy consumption, thermal management requirements, and hardware lifecycles (Salla et al., 2025). This intersection is critical given that AI ecosystems are tethered to intricate global supply chains for semiconductors and the operation of hyper-scale data centers (Berthelot et al., 2024).

The literature suggests that AI-enabled LCA frameworks fulfill a dual role: they serve as both a metric for assessing AI's own ecological footprint and a mechanism for improving sustainability assessments across diverse sectors (Romeiko et al., 2024). This duality underscores the necessity for interdisciplinary synergy between computer science, environmental engineering, and policy studies to ensure that technological advancement does not come at the expense of ecological integrity.

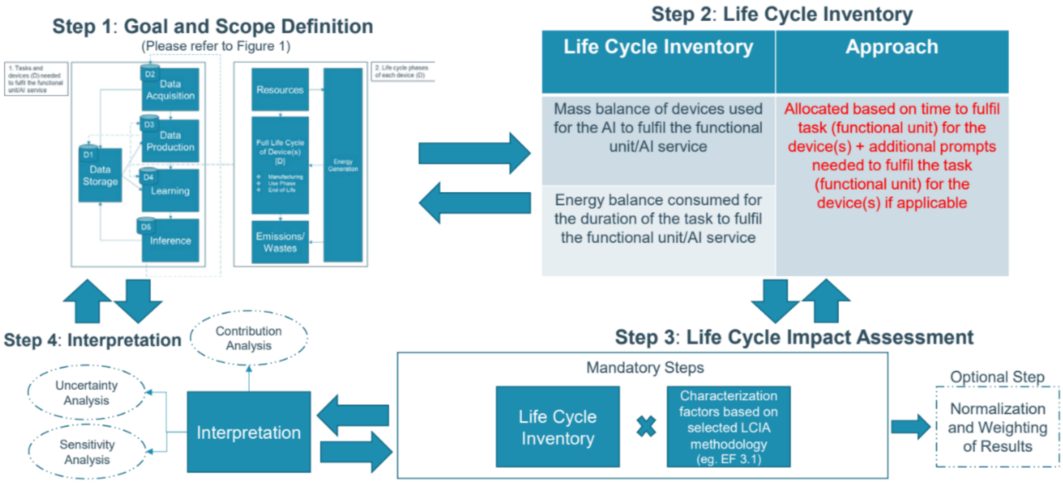

Figure: 1. Life Cycle Assessment of AI (Plociennik et al., 2025)

Shifting to Green AI

The environmental discourse concerning Artificial Intelligence has catalyzed a significant paradigm shift from "Red AI"—characterized by the pursuit of state-of-the-art accuracy through massive, unconstrained computational power—toward "Green AI." This emerging framework treats energy efficiency as a fundamental performance metric co-equal with predictive accuracy. For AI to achieve genuine sustainability, it is imperative that research methodologies prioritize the attainment of novel results without a corresponding inflation of computational overhead (Schwartz et al., 2020).

Green AI initiatives aim to minimize the "physical footprint" of digital systems by optimizing energy demand during both the developmental training phase and real-world inference (Rojahn & Grum, 2025). This transition is a direct response to the unsustainable trajectory of modern machine learning, where the computational resources required for frontier models have doubled approximately every 3.4 months since 2012. A central tenet of the Green AI discourse is that substantial reductions in energy consumption can be achieved through software-level optimization, independent of hardware advancements (Dash, 2025; Rajput et al., 2025). The following mechanisms represent the primary methodological pillars for reconciling computational performance with ecological responsibility:

- Model Quantization: This technique involves reducing the numerical precision of model parameters, for instance, transitioning from 32-bit floating-point representations to 8-bit integers, thereby diminishing memory overhead and computational intensity. Empirical evidence suggests that when quantization is integrated with complementary optimization strategies, energy consumption can be reduced by up to 94.6% while retaining approximately 96% of the original model's F1 score (Pawar et al., 2025). This demonstrates that sustainability and high-fidelity performance are not mutually exclusive.
- Knowledge Distillation: This process facilitates the training of compact "student" models designed to replicate the predictive behavior of expansive "teacher" architectures. By enabling the deployment of lightweight AI on edge devices, knowledge distillation democratizes access to sophisticated computational tools while significantly lowering the associated carbon footprint.

- Neural Network Pruning: By identifying and eliminating redundant weights and connections within a neural network, researchers can develop "sparse" models. These architectures require fewer operations to generate outputs, directly translating into reduced energy requirements during the inference phase.

Beyond static model compression, the development of Dynamic Trade-Off Control Algorithms represents a sophisticated approach to sustainable AI. These algorithms dynamically calibrate the equilibrium between energy conservation and accuracy retention throughout training iterations. By maintaining performance degradation within strictly defined tolerances, such frameworks ensure that environmental objectives do not compromise the functional efficacy of the AI system.

METHOD

This research adopts a conceptual research strategy grounded in an extensive critical review of existing literature. Departing from primary empirical investigation, the study synthesizes contemporary scholarly discourse to construct a robust theoretical framework. This framework is designed to elucidate the transformative influence of Artificial Intelligence (AI) on the cultural tourism landscape in Indonesia. A conceptual orientation was deemed most appropriate given that AI-driven interventions at heritage sites represent a nascent and underexplored phenomenon within current academic literature. By utilizing conceptual analysis, this study integrates disparate theoretical domains, including digital marketing, open innovation, the Computer as Social Actors (CASA) paradigm, and cultural studies, into a unified model (Skrzek-Lubasińska & Szaban, 2019; Vasiljeva et al., 2017). This methodological trajectory is particularly efficacious in contexts where empirical data remains scarce, yet where theoretical development is urgently required to guide future research and practical application. Consequently, this study serves to map the critical interconnections and generate hypotheses that will inform subsequent empirical inquiries.

RESULT AND DISCUSSION

In this conceptual research, we proposed that artificial intelligence affects augmented reality, virtual reality, robotic; and augmented reality, virtual reality, robotic affect tourism of heritage sites.

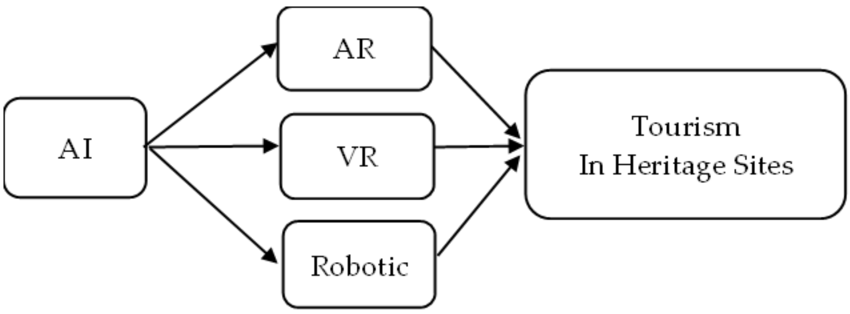

Figure: 1. Research Framework (Researchers, 2026)

Within the context of heritage management, Artificial Intelligence (AI) functions as the essential cognitive and functional architecture that augments the capabilities of Augmented Reality (AR), Virtual Reality (VR), and robotic systems. Through sophisticated Machine Learning (ML) models, raw environmental data, including LiDAR scans, high-resolution imagery, and visitor telemetry, are synthesized into semantically structured outputs. These processes facilitate precise object recognition, the semantic segmentation of architectural surfaces, and the generation of automated natural-language narratives.

The integration of AI outputs transforms static digital assets into adaptive, scalable interpretive systems capable of near real-time synchronization with emerging data. This synergy yields three primary outcomes:

- Adaptive Interpretation (AR/VR): Rather than providing a uniform experience, AI allows AR/VR systems to deliver context-aware overlays and personalized informational layers tailored to individual visitor profiles.
- Proactive Conservation (Robotics/AI): Autonomous robotics, powered by predictive modeling, facilitate the early detection of structural or material deterioration. This continuous monitoring optimizes the allocation of scarce conservation resources by reducing the need for invasive physical inspections.
- Enhanced Engagement (AI Interactivity): AI-mediated interfaces, such as conversational agents and recommendation engines, significantly increase visitor engagement and pedagogical impact by fostering meaningful dialogue and discovery.

Ultimately, this technological nexus shifts the paradigm from passive digital replicas to active, interactive environments that evolve alongside the physical sites they represent. The integration of Augmented Reality (AR), Virtual Reality (VR), and robotics fundamentally alters tourism dynamics by restructuring both consumer demand and on-site behavioral patterns. These technologies move beyond mere digital supplements, acting as catalysts for a more sophisticated engagement with heritage sites.

The relationship between Artificial Intelligence (AI) and the deployment of Augmented Reality (AR), Virtual Reality (VR), and robotic systems is fundamentally symbiotic. While AI serves as the cognitive layer that enhances device performance, the operational contexts of heritage sites generate the granular data necessary for the iterative refinement of these systems. In this capacity, heritage sites function as "living laboratories," where visitor behavior, environmental telemetry, and conservation metrics create continuous feedback loops that calibrate algorithmic precision. When governed by intentional policy frameworks, the integration of these technologies directly supports sustainability goals (SDGs) through several key mechanisms:

- Physical Preservation: Predictive crowd management systems mitigate physical erosion and structural wear-and-tear caused by over-tourism.
- Environmental Impact: Remote VR access offers a substitute for physical travel, potentially reducing the carbon emissions associated with long-distance tourism for international audiences.
- Inclusivity and Accessibility: AI-driven multimodal descriptions and real-time translation services democratize heritage access for non-native speakers and individuals with disabilities.
- Risk Mitigation: Robotics can execute high-precision inspections in hazardous or fragile chambers, reducing human risk and minimizing physical disturbance to sensitive artifacts.

While the benefits of technological integration are significant, algorithmic mediation introduces critical risks to cultural integrity. AI-driven reconstructions and automated narratives often reduce multifaceted cultural histories into simplified, marketable units. These systems may inadvertently prioritize dominant historical narratives present in their training datasets, thereby marginalizing indigenous voices and the nuanced meanings of intangible heritage.

The deployment of robotics and digital surrogates poses a risk to local custodianship. By potentially substituting human stewards with automated interfaces, these technologies can undermine the role of community interpreters as the primary authors of their own heritage. Furthermore, the trend toward hyper-personalization creates "algorithmic silos," which may restrict visitors to curated experiences, diminishing the potential for serendipitous discovery and shared communal learning. Effective implementation, therefore, necessitates a robust governance framework addressing the following critical domains:

- Epistemic Equity: Ensuring that data ownership and the digitization of cultural expressions involve informed consent and revenue-sharing with source communities.
- Privacy and Protection: Safeguarding sensitive intangible knowledge (e.g., sacred rituals) and managing the privacy implications of visitor behavioral telemetry.
- Co-governance Models: Preventing the disproportionate capture of economic and epistemic value by third-party technology vendors at the expense of local institutions.

Heritage institutions, particularly in developing contexts, often grapple with the "Digital Divide," characterized by budgetary constraints, intermittent connectivity, and significant technical skill gaps. High-fidelity AR/VR and robotics require specialized maintenance and continuous dataset updates. Without proactive investment in capacity-building and sustainable procurement strategies, these deployments risk rapid degradation, leading to "abandoned tech" and the generation of electronic waste.

CONCLUSION

AI, AR, VR, and robotics form a tightly coupled technology ecosystem whose combined effect on heritage tourism is simultaneously enabling and disruptive. Thoughtful stewardship, community co-ownership, and interdisciplinary evaluation are essential to harness benefits, enhanced interpretation, conservation efficiency, accessibility while guarding against threats to authenticity, equity, and sustainability. Future research should prioritize empirical, participatory, and lifecycle perspectives so that technological innovation aligns with the cultural and ecological imperatives of heritage stewardship.

REFERENCES

Ahmad, S. F., Alam, M. M., Rahmat, M. K., Mubarik, M. S., & Hyder, S. I. (2022). Academic and Administrative Role of Artificial Intelligence in Education. In Sustainability (Switzerland) (Vol. 14, Issue 3). MDPI. https://doi.org/10.3390/su14031101

Ahmad, S. F., Rahmat, M. K., Mubarik, M. S., Alam, M. M., & Hyder, S. I. (2021). Artificial intelligence and its role in education. Sustainability (Switzerland), 13(22). https://doi.org/10.3390/su132212902

Akdim, K., Belanche, D., & Flavián, M. (2021). Attitudes toward service robots: analyses of explicit and implicit attitudes based on anthropomorphism and construal level theory. International Journal of Contemporary Hospitality Management, 35(8), 2816–2837. https://doi.org/10.1108/IJCHM-12-2020-1406

Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. In Social Sciences and Humanities Open (Vol. 8, Issue 1). Elsevier Ltd. https://doi.org/10.1016/j.ssaho.2023.100532

Almasi, S., Cosmas, A., Cowan, S., Ellencweig. Ben, Krishnan, V., Nirva, V., Geerts, W., Borko, S., & Agarwal, P. (2023). The Promise of Travel in the Age of AI.

Aristidou, M., & Stylianou-Lambert, T. (2024). VR/AR artworks in the museum: Redefining preservation through collaboration. Convergence, 30(5), 1575–1595. https://doi.org/10.1177/13548565241261995

Belanche, D., Casaló, L. V, & Flavián, C. (2021). Frontline robots in tourism and hospitality: service enhancement or cost reduction? Electronic Markets, 31, 477–492. https://doi.org/10.1007/s12525-020-00432-5/Published

Berthelot, A., Caron, E., Jay, M., & Lefèvre, L. (2024). Estimating the environmental impact of Generative-AI services using an LCA-based methodology. Procedia CIRP, 122, 707–712. https://doi.org/10.1016/J.PROCIR.2024.01.098

Blake, J. (2002). Developing a new standard-setting instrument for the safeguarding of intangible cultural heritage: elements for consideration; 2001.

Buhalis, D., & Law, R. (2008). Progress in information technology and tourism management: 20 years on and 10 years after the Internet—The state of eTourism research. Tourism Management, 29(4), 609–623. https://doi.org/10.1016/J.TOURMAN.2008.01.005

Castellanos-Nieves, D., & García-Forte, L. (2024). Strategies of Automated Machine Learning for Energy Sustainability in Green Artificial Intelligence. Applied Sciences (Switzerland), 14(14). https://doi.org/10.3390/app14146196

Cellini, R. (2011). Is UNESCO recognition effective in fostering tourism? A comment on Yang, Lin and Han. Tourism Management, 32(2), 452–454. https://doi.org/10.1016/J.TOURMAN.2010.01.018

Chhabra, D. (2010). Sustainable Marketing of Cultural and Heritage Tourism (1st ed.). Routledge.

Chhabra, D., Healy, R., & Sills, E. (2003). Staged authenticity and heritage tourism. Annals of Tourism Research, 30(3), 702–719. https://doi.org/10.1016/S0160-7383(03)00044-6

Chi, O. H., Denton, G., & Gursoy, D. (2020). Artificially intelligent device use in service delivery: a systematic review, synthesis, and research agenda. Journal of Hospitality Marketing & Management, 29(7), 757–786. https://doi.org/10.1080/19368623.2020.1721394

Chi, Oscar Hengxuan, Gursoy, Dogan, & Chi, Christina G. (2020). Tourists' Attitudes toward the Use of Artificially Intelligent (AI) Devices in Tourism Service Delivery: Moderating Role of Service Value Seeking. Journal of Travel Research, 61(1), 170–185. https://doi.org/10.1177/0047287520971054

Choi, H. S. C., & Sirakaya, E. (2006). Sustainability indicators for managing community tourism. Tourism Management, 27(6), 1274–1289. https://doi.org/10.1016/J.TOURMAN.2005.05.018

Collins, G. R. (2020). Improving human–robot interactions in hospitality settings. International Hospitality Review, 34(1), 61–79. https://doi.org/10.1108/IHR-09-2019-0019

Dash, S. (2025). Green AI: Enhancing Sustainability and Energy Efficiency in AI-Integrated Enterprise Systems. IEEE Access, 13, 21216–21228. https://doi.org/10.1109/ACCESS.2025.3532838

Doborjeh, Z., Hemmington, N., Doborjeh, M., & Kasabov, N. (2021). Artificial intelligence: a systematic review of methods and applications in hospitality and tourism. International Journal of Contemporary Hospitality Management, 34(3), 1154–1176. https://doi.org/10.1108/IJCHM-06-2021-0767

Elisa Sousa, A., Pais, S., & Sofia Viana, A. (2024). Applications of Artificial Intelligence in Tourism and Hospitality: A Systematic Literature Review. In C. Montenegro, Á. Rocha, & J. M. Cueva Lovelle (Eds.), Management, Tourism and Smart Technologies (pp. 291–302). Springer Nature Switzerland.

Esfehani, M. H., & Albrecht, J. N. (2018). Roles of intangible cultural heritage in tourism in natural protected areas. Journal of Heritage Tourism, 13(1), 15–29.

https://doi.org/10.1080/1743873X.2016.1245735
Filieri, Raffaele, Lin, Zhibin, Li, Yulei, Lu, Xiaoqian, & Yang, Xingwei. (2022). Customer Emotions in Service Robot Encounters: A Hybrid Machine-Human Intelligence Approach. Journal of Service Research, 25(4), 614–629. https://doi.org/10.1177/10946705221103937
García-Madurga, M. Á., & Grilló-Méndez, A. J. (2023). Artificial Intelligence in the Tourism Industry: An Overview of Reviews. In Administrative Sciences (Vol. 13, Issue 8). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/admsci13080172
Gaur, L., Afaq, A., Singh, G., & Dwivedi, Y. K. (2021). Role of artificial intelligence and robotics to foster the touchless travel during a pandemic: a review and research agenda. International Journal of Contemporary Hospitality Management, 33(11), 4079–4098. https://doi.org/10.1108/IJCHM-11-2020-1246
Gössling, S. (2023). Extending the theoretical grounding of mobilities research: transport psychology perspectives. Mobilities, 18(2), 167–183. https://doi.org/10.1080/17450101.2022.2092886
Gretzel, U., Mitsche, N., Hwang, Y.-H., & Fesenmaier, D. R. (2004). Tell Me Who You Are and I Will Tell You Where to Go: Use of Travel Personalities in Destination Recommendation Systems. J. of IT & Tourism, 7, 3–12. https://doi.org/10.3727/1098305042781129
Grewal, D., Guha, A., Satornino, C. B., & Schweiger, E. B. (2021). Artificial intelligence: The light and the darkness. Journal of Business Research, 136, 229–236. https://doi.org/10.1016/J.JBUSRES.2021.07.043
Gursoy, D., Chi, O. H., Lu, L., & Nunkoo, R. (2019). Consumers acceptance of artificially intelligent (AI) device use in service delivery. International Journal of Information Management, 49, 157–169. https://doi.org/10.1016/J.IJINFOMGT.2019.03.008
Hall, C. M., & Cooper, C. (2025). Making tourism smart in the age of artificial intelligence. In Current Issues in Tourism (Vol. 28, Issue 1, pp. 1–5). Routledge. https://doi.org/10.1080/13683500.2025.2460922
Holat, O. (2021). Yeni İletişim Teknolojilerinin Olanaklarıyla Yeni Medya Eğitimi (Tam Metin). Uluslararası Covid-19 Kongresi Eğitimde Yeni Normlar 2 Bildiri Kitabı.
Huang, A., Chao, Y., de la Mora Velasco, E., Bilgihan, A., & Wei, W. (2021). When artificial intelligence meets the hospitality and tourism industry: an assessment framework to inform theory and management. Journal of Hospitality and Tourism Insights, 5(5), 1080–1100. https://doi.org/10.1108/JHTI-01-2021-0021
Kolotylo-Kulkarni, M., Xia, W., & Dhillon, G. (2021). Information disclosure in e-commerce: A systematic review and agenda for future research. Journal of Business Research, 126, 221–238. https://doi.org/https://doi.org/10.1016/j.jbusres.2020.12.006
Kong, H., Yuan, Y., Baruch, Y., Bu, N., Jiang, X., & Wang, K. (2021). Influences of artificial intelligence (AI) awareness on career competency and job burnout. International Journal of Contemporary Hospitality Management, 33(2), 717–734. https://doi.org/10.1108/IJCHM-07-2020-0789
Koo, C., Xiang, Z., Gretzel, U., & Sigala, M. (2021). Artificial intelligence (AI) and robotics in travel, hospitality and leisure. In Electronic Markets (Vol. 31, Issue 3, pp. 473–476). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/s12525-021-00494-z
Ku, E. C. S., & Chen, C. Der. (2024). Artificial intelligence innovation of tourism businesses: From satisfied tourists to continued service usage intention. International Journal of Information Management, 76, 102757. https://doi.org/10.1016/J.IJINFOMGT.2024.102757
Lampropoulos, G. (2025). Combining Artificial Intelligence with Augmented Reality and Virtual Reality in Education: Current Trends and Future Perspectives. In Multimodal Technologies and Interaction (Vol. 9, Issue 2). Multidisciplinary Digital Publishing

Institute (MDPI). https://doi.org/10.3390/mti9020011

Li, Cai, Ashraf, Sheikh Farhan, Amin, Saba, & Safdar, Muhammad Nabeel. (2023). Consequence of Resistance to Change on AI Readiness: Mediating–Moderating Role of Task-oriented Leadership and High-Performance Work System in the Hospitality Sector. Sage Open, 13(4), 21582440231217732. https://doi.org/10.1177/21582440231217731

Li, J. (Justin), Bonn, M. A., & Ye, B. H. (2019). Hotel employee's artificial intelligence and robotics awareness and its impact on turnover intention: The moderating roles of perceived organizational support and competitive psychological climate. Tourism Management, 73, 172–181. https://doi.org/10.1016/J.TOURMAN.2019.02.006

Liu, Y., Wang, X., Du, Y., & Wang, S. (2023). Service robots vs. human staff: The effect of service agents and service exclusion on unethical consumer behavior. Journal of Hospitality and Tourism Management, 55, 401–415. https://doi.org/10.1016/J.JHTM.2023.05.015

Liu, Z. (2003). Sustainable Tourism Development: A Critique. Journal of Sustainable Tourism, 11(6), 459–475. https://doi.org/10.1080/09669580308667216

Lv, L., Chen, S., Liu, G. G., & Benckendorff, P. (2024). Enhancing customers' life satisfaction through AI-powered personalized luxury recommendations in luxury tourism marketing. International Journal of Hospitality Management, 123, 103914. https://doi.org/10.1016/J.IJHM.2024.103914

Majid, G. M., Tussyadiah, I., Kim, Y. R., & Pal, A. (2023). Intelligent automation for sustainable tourism: a systematic review. Journal of Sustainable Tourism, 31(11), 2421–2440. https://doi.org/10.1080/09669582.2023.2246681

Mariani, M., & Borghi, M. (2021). Customers' evaluation of mechanical artificial intelligence in hospitality services: a study using online reviews analytics. International Journal of Contemporary Hospitality Management, 33(11), 3956–3976. https://doi.org/10.1108/IJCHM-06-2020-0622

Morosan, C., & Bowen, J. (2022). Labor shortage solution: redefining hospitality through digitization. International Journal of Contemporary Hospitality Management, 34. https://doi.org/10.1108/IJCHM-03-2022-0304

Nam, K., Dutt, C. S., Chathoth, P., Daghfous, A., & Khan, M. S. (2021). The adoption of artificial intelligence and robotics in the hotel industry: prospects and challenges. Electronic Markets, 31(3), 553–574. https://doi.org/10.1007/s12525-020-00442-3

Nannelli, M., Capone, F., & Lazzeretti, L. (2023). Artificial intelligence in hospitality and tourism. State of the art and future research avenues. European Planning Studies, 31(7), 1325–1344. https://doi.org/10.1080/09654313.2023.2180321

Negm, E. (2024). The impact of augmented reality on consumer behavior: a focus on value development, leading to brand engagement and purchase intention. Management & Sustainability: An Arab Review, 4(2), 320–341. https://doi.org/10.1108/MSAR-08-2023-0044

Pei, Y., & Zhang, Y. (2021). A Study on the Integrated Development of Artificial Intelligence and Tourism from the Perspective of Smart Tourism. Journal of Physics: Conference Series, 1852(3). https://doi.org/10.1088/1742-6596/1852/3/032016

PEPawar, P., Yadav, S., Jagtap, A., Deshmukh, M., Jankar, N., Nikam, A., Ghadge, S., & Mahadik, S. (2025). Green AI: Advancing Environmentally Sustainable Artificial Intelligence. International Journal of Science, Engineering and Technology, 13(3).

Pillai, R., & Sivathanu, B. (2020). Adoption of AI-based chatbots for hospitality and tourism. International Journal of Contemporary Hospitality Management, 32(10), 3199–3226. https://doi.org/10.1108/IJCHM-04-2020-0259

Plociennik, C., Watjanatepin, P., Acker, K. Van, & Ruskowski, M. (2025). Life Cycle Assessment of Artificial Intelligence Applications: Research Gaps and Opportunities. Procedia CIRP, 135, 924–929. https://doi.org/10.1016/j.procir.2025.01.079

Popowicz, M., Katzer, N. J., Kettele, M., Schöggl, J.-P., & Baumgartner, R. J. (2025).

Digital technologies for life cycle assessment: a review and integrated combination framework. The International Journal of Life Cycle Assessment, 30(3), 405–428. https://doi.org/10.1007/s11367-024-02409-4

Prentice, C., Lopes, S. D., & Wang, X. (2020). The impact of artificial intelligence and employee service quality on customer satisfaction and loyalty. Journal of Hospitality Marketing & Management, 29, 739–756. https://api.semanticscholar.org/CorpusID:213039532

Qiu, H., Li, M., Shu, B., & Bai, B. (2020). Enhancing hospitality experience with service robots: the mediating role of rapport building. Journal of Hospitality Marketing & Management, 29(3), 247–268. https://doi.org/10.1080/19368623.2019.1645073

Rai, P., & Rai, S. (2021). Text Refinement Powered by Artificial Intelligence for Tourism. Wireless Personal Communications, 120(2), 1193–1205. https://doi.org/10.1007/s11277-021-08510-3

Rajput, S., Saad, M., & Sharma, T. (2025). Tu(r)ning AI Green: Exploring Energy Efficiency Cascading with Orthogonal Optimizations. http://arxiv.org/abs/2506.18289

Ran, D., Yingli, W., & Haoxin, Q. (2020). Artificial intelligence speech recognition model for correcting spoken English teaching. Journal of Intelligent & Fuzzy Systems, 40, 1–12. https://doi.org/10.3233/JIFS-189388

Rojahn, M., & Grum, M. (2025). Green AI: A systematic review and meta-analysis of its definitions, lifecycle models, hardware and measurement attempts. http://arxiv.org/abs/2511.07090

Romeiko, X. X., Zhang, X., Pang, Y., Gao, F., Xu, M., Lin, S., & Babbitt, C. (2024). A review of machine learning applications in life cycle assessment studies. Science of The Total Environment, 912, 168969. https://doi.org/10.1016/J.SCITOTENV.2023.168969

Różycki, R., Solarska, D. A., & Waligóra, G. (2025). Energy-Aware Machine Learning Models—A Review of Recent Techniques and Perspectives. In Energies (Vol. 18, Issue 11). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/en18112810

Šakytė-Statnickė, G., & Budrytė-Ausiejienė, L. (2025). Application of Artificial Intelligence in the Tourism Sector: Benefits and Challenges of AI-Based Digital Tools in Tourism Organizations of Lithuania, Latvia, and Sweden. Tourism and Hospitality, 6(2). https://doi.org/10.3390/tourhosp6020067

Salla, J. V. E., de Almeida, T. A., & Silva, D. A. L. (2025). Integrating machine learning with life cycle assessment: a comprehensive review and guide for predicting environmental impacts. The International Journal of Life Cycle Assessment. https://doi.org/10.1007/s11367-025-02437-8

Samala, N., Katkam, B. S., Bellamkonda, R. S., & Rodriguez, R. V. (2020). Impact of AI and robotics in the tourism sector: a critical insight. Journal of Tourism Futures, 8(1), 73–87. https://doi.org/10.1108/JTF-07-2019-0065

Schwartz, R., Dodge, J., Smith, N., & Etzioni, O. (2020). Green AI. Communications of the ACM, 63, 54–63. https://doi.org/10.1145/3381831

Selmanović, E., Rizvic, S., Harvey, C., Boskovic, D., Hulusic, V., Chahin, M., & Sljivo, S. (2020). Improving Accessibility to Intangible Cultural Heritage Preservation Using Virtual Reality. J. Comput. Cult. Herit., 13(2). https://doi.org/10.1145/3377143

Sharma, K., Jain, M., & Dhir, S. (2021). Analysing the impact of artificial intelligence on the competitiveness of tourism firms: a modified total interpretive structural modeling (m-TISM) approach. International Journal of Emerging Markets, 17(4), 1067–1084. https://doi.org/10.1108/IJOEM-05-2021-0810

Siliutina, I., Tytar, O., Barbash, M., Petrenko, N., & Yepyk, L. (2024). Cultural preservation and digital heritage: challenges and opportunities. Revista Amazonia Investiga, 14, 262–273. https://doi.org/10.34069/AI/2024.75.03.22

Singh, P., Pahuja, N., Kansal, M., Gurung, S., Shukla, U., & Gupta, S. (2024). Enhancing Tourism Experiences and Preserving Cultural Heritage with AR and VR. 2024 2nd International Conference on Disruptive Technologies (ICDT), 225–231. https://doi.org/10.1109/ICDT61202.2024.10489490

Skrzek-Lubasińska, M., & Szaban, J. M. (2019). Nomenclature and harmonised criteria for the self-employment categorisation. An approach pursuant to a systematic review of the literature. European Management Journal, 37(3), 376–386. https://doi.org/10.1016/J.EMJ.2018.11.001

Solakis, K., Katsoni, V., Mahmoud, A. B., & Grigoriou, N. (2022). Factors affecting value co-creation through artificial intelligence in tourism: a general literature review. Journal of Tourism Futures, 10(1), 116–130. https://doi.org/10.1108/JTF-06-2021-0157

Tang, G. X., Park, K., Agarwal, A., & Liu, F. (2020). Impact of innovation culture, organization size and technological capability on the performance of SMEs: The case of China. Sustainability (Switzerland), 12(4). https://doi.org/10.3390/su12041355

Trunfio, M., Lucia, M. Della, Campana, S., & Magnelli, A. (2022). Innovating the cultural heritage museum service model through virtual reality and augmented reality: the effects on the overall visitor experience and satisfaction. Journal of Heritage Tourism, 17(1), 1–19. https://doi.org/10.1080/1743873X.2020.1850742

Tuomi, Aarni, Tussyadiah, Iis P, & Stienmetz, Jason. (2020). Applications and Implications of Service Robots in Hospitality. Cornell Hospitality Quarterly, 62(2), 232–247. https://doi.org/10.1177/1938965520923961

Tussyadiah, I. P., Zach, F. J., & Wang, J. (2020). Do travelers trust intelligent service robots? Annals of Tourism Research, 81, 102886. https://doi.org/10.1016/J.ANNALS.2020.102886

Vasiljeva, T., Shaikhulina, S., & Kreslins, K. (2017). Cloud Computing: Business Perspectives, Benefits and Challenges for Small and Medium Enterprises (Case of Latvia). Procedia Engineering, 178, 443–451. https://doi.org/https://doi.org/10.1016/j.proeng.2017.01.087

Vecco, M. (2010). A definition of cultural heritage: From the tangible to the intangible. Journal of Cultural Heritage, 11(3), 321–324. https://doi.org/10.1016/J.CULHER.2010.01.006

Vidal González, M. (2008). Intangible heritage tourism and identity. Tourism Management, 29(4), 807–810. https://doi.org/10.1016/J.TOURMAN.2007.07.003

Wong, I. K. A., Zhang, T., Lin, Z. (CJ), & Peng, Q. (2023). Hotel AI service: Are employees still needed? Journal of Hospitality and Tourism Management, 55, 416–424. https://doi.org/10.1016/J.JHTM.2023.05.005

World Economic Forum. (2024). The Global Risks Report 2024. www.weforum.org

Xu, S. T., Cao, Z. C., & Huo, Y. (2020). Antecedents and outcomes of emotional labour in hospitality and tourism: A meta-analysis. Tourism Management, 79, 104099. https://doi.org/10.1016/J.TOURMAN.2020.104099

Yang, L., Henthorne, T. L., & George, B. (2020). Artificial Intelligence and Robotics Technology in the Hospitality Industry: Current Applications and Future Trends. In B. George & J. Paul (Eds.), Digital Transformation in Business and Society: Theory and Cases (pp. 211–228). Springer International Publishing. https://doi.org/10.1007/978-3-030-08277-2_13

Zhang, S., Lin, X., Li, X., & Ren, A. (2022). Service robots' anthropomorphism: dimensions, factors and internal relationships. Electronic Markets, 32(1), 277–295. https://doi.org/10.1007/s12525-022-00527-1

Zhao, Xiaoli, Ren, Yu, & Cheah, Kenny S L. (2023). Leading Virtual Reality (VR) and Augmented Reality (AR) in Education: Bibliometric and Content Analysis From the Web of Science (2018–2022). Sage Open, 13(3), 21582440231190820. https://doi.org/10.1177/21582440231190821

Zheng, S., & Zhang, Z. (2023). Adaptive tourism forecasting using hybrid artificial intelligence model: a case study of Xi'an international tourist arrivals. PeerJ Computer Science, 9. https://doi.org/10.7717/peerj-cs.1573

Zhu, J. J., Liu, Z., Huang, T., & Guo, X. S. (2023). Roboethics of tourism and hospitality industry: A systematic review. PLoS ONE, 18(6 June). https://doi.org/10.1371/journal.pone.0287439