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The Role of Technological Innovation in Supporting Sustainable Tourism Practices in Tourism Establishments

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ABSTRACT: Technological innovation has emerged as a critical driver of sustainable transformation in the tourism sector, offering tourism establishments new opportunities to improve operational efficiency, reduce environmental impacts, and enhance the quality of tourist experiences. This study examines the role of technological innovation in supporting sustainable tourism practices in tourism establishments. It focuses on the contribution of emerging technologies, including artificial intelligence, the Internet of Things, big data analytics, smart energy-management systems, and digital platforms, to the environmental, economic, and social dimensions of tourism sustainability. The study adopts a conceptual approach based on a review of recent academic literature addressing the relationship between technological innovation and sustainable tourism. The findings indicate that technological innovation can contribute to more efficient resource consumption, waste reduction, energy management, environmental monitoring, and data-driven decision-making. Furthermore, digital technologies can facilitate more sustainable tourist behavior and improve the ability of tourism establishments to respond to changing environmental and market conditions. However, the effective implementation of technological innovation depends on several factors, including financial resources, technological capabilities, organizational readiness, employee skills, governance, and institutional support. The study concludes that technological innovation should not be viewed solely as a means of digital transformation but as a strategic mechanism for integrating sustainability into the core operations of tourism establishments. The study recommends strengthening investment in green and smart technologies, developing employees' digital competencies, and establishing supportive policies and institutional frameworks to accelerate the adoption of sustainable technological solutions in the tourism sector.

INTRODUCTION

The tourism industry is undergoing a profound technological transformation as organizations increasingly adopt artificial intelligence (AI), the Internet of Things (IoT), big data analytics, blockchain, digital platforms, and other emerging technologies. At the same time, the tourism sector faces growing pressure to reduce its environmental footprint, improve resource efficiency, support local communities, and maintain long-term economic viability. These challenges have increased academic and managerial interest in the relationship between technological innovation and sustainable tourism. Technological innovation is increasingly regarded not only as a means of improving service quality and operational efficiency but also as an important mechanism for integrating sustainability into tourism operations (Varolgüneş et al., 2025).

Sustainable tourism requires an appropriate balance among economic development, environmental protection, and social well-being. Tourism establishments, including hotels, resorts, restaurants, travel agencies, and other tourism-related businesses, have a particularly important role in achieving this balance because their daily activities involve substantial consumption of energy and water, generation of waste, transportation requirements, and interaction with local communities.

Consequently, the adoption of technological innovations can provide tourism establishments with opportunities to improve resource management, reduce operational costs, enhance environmental performance, and create more sustainable services and experiences.

Recent academic research demonstrates that digital technologies are becoming increasingly important in the development of sustainable tourism. Varolgüneş et al. (2025), through a bibliometric analysis of 768 publications indexed in the Web of Science database, identified artificial intelligence, big data, blockchain, and augmented and virtual reality as major technological themes associated with sustainable tourism research. Their findings indicate that AI and big data can support smart tourism management and more effective decision-making, while blockchain can contribute to transparency and security and immersive technologies can support alternative and more sustainable tourist experiences. These developments demonstrate that digitalization has moved beyond simple service automation toward becoming an important component of sustainability strategies.

Artificial intelligence represents one of the most significant technological innovations affecting tourism and hospitality organizations. AI applications can support demand forecasting, personalized services, customer relationship management, resource allocation, and operational decision-making. Siddik et al. (2025) found that artificial intelligence can significantly enhance tourism efficiency and contribute to sustainable tourism growth. Their findings suggest that technological development can influence tourism sustainability at a broader economic level by improving efficiency and supporting more sustainable patterns of tourism development.

At the organizational level, the relationship between AI and sustainability has also received increasing empirical attention. Al-Sulaiti et al. (2024) demonstrated that AI has a positive relationship with organizational sustainability in tourism and hospitality organizations. Their findings further showed that human, structural, and relational intellectual capital can partially mediate this relationship. This suggests that the sustainability benefits of technological innovation do not depend exclusively on the availability of technology; rather, organizations need appropriate human capabilities, organizational structures, and relationships to convert technological resources into sustainable outcomes.

The Internet of Things is another important technological innovation that can support sustainable tourism practices. IoT-enabled sensors and connected systems allow tourism establishments to monitor energy consumption, water usage, temperature, occupancy, and other operational variables in real time. Such capabilities can facilitate more efficient resource management and enable organizations to identify unnecessary consumption and reduce operational waste. A systematic review by researchers examining smart technologies and sustainable ecotourism highlighted the contribution of AI, IoT, smartphones, and other smart technologies to environmental conservation, operational efficiency, sustainability awareness, and stakeholder collaboration (Exploring the Nexus of Smart Technologies and Sustainable Ecotourism, 2024).

Digital platforms also have an increasingly important role in connecting technological innovation with sustainable tourism development. Industry 4.0 technologies, including AI, big data, blockchain, VR, and IoT, are increasingly incorporated into digital tourism platforms. These platforms can influence several dimensions of sustainability, including environmental responsibility, economic inclusion, labor conditions, and access to tourism services. Digital platforms may therefore provide tourism organizations with mechanisms for improving the efficiency and accessibility of tourism services while simultaneously supporting broader sustainability objectives.

However, technological innovation does not automatically result in sustainable tourism. The implementation of advanced technologies may create organizational, financial, technical, and ethical challenges. Tourism establishments may face significant investment requirements, limited digital infrastructure, shortages of qualified employees, cybersecurity concerns, data privacy issues, and resistance to organizational change. Furthermore, excessive reliance on technology may generate new social and environmental challenges. Therefore, the adoption of technology should be accompanied by appropriate organizational capabilities, employee training, regulatory frameworks, and sustainability-oriented management strategies.

Recent research also emphasizes that the relationship between technological innovation and sustainability should be examined from multiple dimensions. From an environmental perspective, technology can facilitate energy management, waste reduction, environmental monitoring, and more efficient use of natural resources. From an economic perspective, innovation can improve productivity, reduce operational costs, enhance competitiveness, and facilitate the development of new tourism products and services. From a social perspective, digital technologies can improve communication, accessibility, customer

engagement, and stakeholder participation. Thus, technological innovation has the potential to contribute simultaneously to the environmental, economic, and social dimensions of sustainable tourism.

Despite the growing body of research on digital transformation and sustainable tourism, there remains a need for further investigation at the level of individual tourism establishments. Much of the existing literature has focused on smart destinations, tourist behavior, digital platforms, or the macroeconomic effects of technological development. Comparatively less attention has been given to understanding how tourism establishments translate technological innovation into specific and measurable sustainable practices. This gap is particularly important because the availability of technology alone does not ensure successful implementation. Organizational readiness, managerial support, employee competencies, financial resources, and institutional conditions may determine whether technological innovation produces meaningful sustainability outcomes.

Furthermore, recent research indicates that technological innovation should be examined not simply as an independent technological capability but as part of a broader organizational transformation. Tourism establishments need to align technological investments with sustainability objectives and develop the organizational capabilities required to use these technologies effectively. In this context, technological innovation may function as a strategic mechanism through which tourism establishments integrate sustainability into their operational processes and long-term development strategies.

Accordingly, this study aims to examine **the role of technological innovation in supporting sustainable tourism practices in tourism establishments**. Specifically, the study focuses on how technological innovations such as artificial intelligence, the Internet of Things, big data analytics, and digital platforms can contribute to environmental efficiency, economic performance, and social sustainability. The study also considers the organizational factors that may facilitate or constrain the effective adoption of these technologies.

The significance of this study lies in its attempt to connect technological innovation with the practical implementation of sustainability within tourism establishments. By examining technology as an enabler of environmental, economic, and social sustainability, the study contributes to the growing literature on digital transformation and sustainable tourism. It may also provide practical implications for tourism managers and policymakers seeking to promote technological adoption while ensuring that digital transformation contributes to long-term sustainable development.

LITERATURE REVIEW

Technological Innovation and Sustainable Tourism

Technological innovation has become a significant driver of transformation within the tourism and hospitality industry. The rapid development of artificial intelligence (AI), the Internet of Things (IoT), big data analytics, blockchain, cloud computing, and immersive technologies has created new opportunities for tourism establishments to improve their operational efficiency and sustainability performance. Technological innovation can contribute to sustainability by enabling organizations to monitor resource consumption, optimize operational processes, reduce waste, improve decision-making, and provide more sustainable tourism services (Varolgüneş et al., 2025).

Recent research indicates that the relationship between digitalization and sustainable tourism has become an important area of academic investigation. Varolgüneş et al. (2025), through a bibliometric analysis of 768 publications, identified artificial intelligence, big data, blockchain, augmented reality, and virtual reality as important technological themes in sustainable tourism research. Their findings demonstrate that digital technologies can support sustainable tourism management by improving decision-making, enhancing resource efficiency, and developing innovative tourism experiences.

Similarly, Gonzalez et al. (2025) reviewed research on digital sustainable tourism and demonstrated that digitalization influences sustainability at different levels, including destinations, organizations, and individual stakeholders. Their findings emphasize that technological innovation should be examined not only as a tool for digital transformation but also as a mechanism capable of supporting environmental, economic, and social sustainability.

The growing importance of technological innovation is also demonstrated by recent systematic reviews. Hermawan et al. (2025) found that smart technologies can support sustainable tourism through improved resource management, environmental monitoring, forecasting, stakeholder communication, and decision-making. However, the authors emphasized that technological adoption must be supported by appropriate organizational capabilities and institutional frameworks.

Artificial Intelligence and Sustainable Tourism

Artificial intelligence has emerged as one of the most influential technologies in tourism and hospitality. AI applications include predictive analytics, demand forecasting, personalized recommendations, automated customer service, revenue management, and intelligent resource allocation. These applications can improve organizational efficiency while creating opportunities to integrate sustainability into tourism operations.

Siddik et al. (2025) investigated the relationship between artificial intelligence, tourism efficiency, and sustainable tourism growth. Their findings indicate that AI can improve tourism efficiency and contribute to sustainable tourism development. The study suggests that technological innovation can influence sustainability by improving productivity and supporting more efficient allocation of resources.

At the organizational level, Al-Sulaiti et al. (2024) examined the relationship between AI and organizational sustainability in tourism and hospitality organizations. Their findings showed a positive relationship between AI adoption and organizational sustainability. Importantly, the study identified human, structural, and relational intellectual capital as mechanisms that help transform technological capabilities into sustainable organizational outcomes.

AI can also support environmental sustainability. Tourism establishments can use AI-based systems to predict occupancy, forecast demand, optimize energy consumption, and reduce unnecessary resource use. For example, a hotel can use predictive algorithms to adjust heating, ventilation, air conditioning, staffing, and food procurement according to expected occupancy levels.

However, the implementation of AI also presents challenges. High investment costs, employee skills, data privacy, cybersecurity, ethical considerations, and organizational resistance may affect the successful adoption of AI. Therefore, the sustainability benefits of AI depend not only on the availability of the technology but also on organizational readiness and effective governance.

Internet of Things and Sustainable Tourism Practices

The Internet of Things represents another important technological innovation in sustainable tourism. IoT allows physical devices and sensors to communicate with information systems and provide real-time operational data. In tourism establishments, IoT applications can include smart lighting, intelligent heating and cooling systems, occupancy sensors, water-monitoring systems, and automated energy-management systems.

Gajić et al. (2024) examined the integration of AI and IoT in hotel management and found that these technologies significantly improve operational efficiency. Their findings further indicated that operational efficiency contributes positively to sustainable hotel practices. This research provides empirical evidence that technological innovation can contribute to sustainability through improved organizational operations.

The relationship between IoT and sustainable tourism is also supported by systematic research. The systematic review *Exploring the Nexus of Smart Technologies and Sustainable Ecotourism* (2024) identified IoT, AI, smartphones, and other smart technologies as important tools for environmental conservation, resource management, operational efficiency, and sustainability awareness.

IoT therefore provides tourism establishments with the ability to monitor resource consumption continuously. Real-time information can allow managers to identify excessive energy or water consumption and implement corrective measures. Automated systems can also respond immediately to changes in occupancy and environmental conditions.

Nevertheless, the successful implementation of IoT requires appropriate infrastructure, financial investment, technical expertise, and integration with existing organizational systems.

Big Data Analytics and Sustainable Decision-Making

Big data analytics is increasingly important in tourism because tourism establishments generate large quantities of information through reservation systems, customer reviews, social media, mobile applications, digital transactions, and IoT devices. Analyzing these data can help managers understand customer behavior, predict demand, optimize resources, and improve organizational decision-making.

Varolgüneş et al. (2025) identified big data analytics as one of the major technological areas contributing to digital sustainable tourism. Data-driven decision-making can allow tourism establishments to identify patterns in resource consumption and customer demand and subsequently develop more efficient operational strategies.

Recent empirical evidence also demonstrates the importance of data-driven decision-making as a mechanism linking technological innovation with sustainability. Abdou and Shehata (2026) examined IoT adoption, data-driven decision-making, artificial intelligence, and hotel sustainable performance. Their findings indicated that IoT adoption positively influences data-driven decision-making and sustainable hotel performance. Data-driven decision-making also partially mediated the relationship between IoT adoption and sustainable performance.

These findings indicate that technology alone does not necessarily generate sustainability outcomes. Instead, organizations need the ability to transform technological information into managerial decisions and practical actions.

Smart Hotels and Sustainable Operations

The emergence of smart hotels illustrates the increasing integration of technological innovation into tourism establishments. Smart hotels may combine AI, IoT, big data, cloud computing, mobile applications, robotics, and automated management systems to improve customer experiences and operational performance.

Recent research on smart hotels indicates that sustainability has become an increasingly important theme within smart hospitality research. The integration of smart technologies can enable hotels to monitor energy and water consumption, optimize resource allocation, reduce waste, and improve operational efficiency.

Gajić et al. (2024) demonstrated that the integration of AI and IoT can enhance hotel operational efficiency and contribute to sustainable practices. This suggests that smart hotel technologies can support sustainability when they are integrated into organizational processes rather than being adopted only for technological modernization.

However, smart transformation can be challenging for tourism establishments. Organizations may need substantial investments in infrastructure, employee training, cybersecurity, and system integration. Small and medium-sized tourism establishments may experience greater difficulties because of limited financial and technological resources.

Technological Innovation and Environmental Sustainability

Environmental sustainability is a central dimension of sustainable tourism. Tourism establishments consume substantial amounts of energy and water and generate waste and greenhouse gas emissions. Technological innovation can help reduce these impacts through improved monitoring, automation, and resource optimization.

IoT sensors can monitor electricity and water consumption in real time, while AI can identify consumption patterns and predict future demand. Automated systems can then adjust lighting, temperature, air conditioning, and other operational systems according to occupancy and environmental conditions.

Gajić et al. (2024) found that AI and IoT contribute to operational efficiency and sustainable hotel practices. Similarly, Lakhmire et al. (2026) found that smart technologies can contribute to environmental sustainability through monitoring, forecasting, resource management, and adaptive decision-making.

Technological innovation can also influence tourists' environmental behavior. Sharma et al. (2025) examined the potential of emerging technologies to support sustainable tourism and demonstrated that technologies such as augmented reality and AI can contribute to environmental awareness and sustainable tourist experiences.

Technological Innovation and Economic Sustainability

Economic sustainability requires tourism establishments to remain financially viable while generating long-term value for their stakeholders. Technological innovation can contribute to economic sustainability by reducing operating costs, improving productivity, increasing competitiveness, and supporting new tourism products and services.

AI-based forecasting systems can help hotels predict demand and optimize staffing and resource allocation. Big data analytics can provide information about customer preferences and market trends, while digital platforms can increase market access and improve communication with customers.

Siddik et al. (2025) found that AI contributes to tourism efficiency and sustainable tourism growth. These findings support the view that technological innovation can generate economic benefits while simultaneously supporting sustainability objectives.

Nevertheless, technological innovation may require substantial initial investment. Lakhmiri et al. (2026) identified financial constraints as an important barrier to the adoption of smart and green tourism practices. Therefore, tourism establishments need to evaluate technological investments in terms of both their short-term costs and long-term economic and sustainability benefits.

Technological Innovation and Social Sustainability

Social sustainability focuses on the well-being of employees, tourists, local communities, and other tourism stakeholders. Technological innovation can support social sustainability by improving communication, accessibility, stakeholder participation, and customer engagement.

Digital platforms can connect tourism establishments with local communities and provide tourists with information about local products, cultural heritage, sustainable transportation, and environmentally responsible activities. Mobile applications can also improve access to tourism information and services.

Al-Sulaiti et al. (2024) demonstrated that human, structural, and relational intellectual capital play important roles in transforming AI capabilities into organizational sustainability. This finding highlights the importance of employees and organizational relationships in the successful implementation of technological innovation.

At the same time, technological transformation can create social challenges. These include concerns regarding employee displacement, unequal access to technology, privacy, and the digital divide. Therefore, technological innovation should be implemented in a manner that supports employees and local communities rather than focusing exclusively on technological efficiency.

Organizational Capabilities and Technological Adoption

The literature indicates that technological innovation does not automatically result in sustainable tourism. Organizational capabilities play an important role in determining whether technology can be translated into sustainable outcomes.

Employee digital competencies are particularly important because employees must understand how to operate technological systems and integrate them into daily operations. Management support is also necessary because technological transformation often requires changes in organizational processes, investment strategies, and organizational culture.

Al-Sulaiti et al. (2024) found that intellectual capital mediates the relationship between AI and organizational sustainability. Similarly, Abdou and Shehata (2026) demonstrated that data-driven decision-making is an important mechanism through which IoT contributes to hotel sustainable performance.

These findings suggest that tourism establishments should invest not only in technological infrastructure but also in employee training, managerial capabilities, and organizational development.

Barriers to Technological Innovation

Despite its potential benefits, the adoption of technological innovation in tourism establishments is associated with several challenges. Financial limitations, inadequate infrastructure, lack of skilled employees, resistance to change, cybersecurity risks, data privacy concerns, and uncertainty about investment returns can restrict technological adoption.

Lakhmiri et al. (2026) identified technological and financial barriers as important constraints affecting the integration of smart and green tourism practices. The study also emphasized the importance of governance, policy coherence, and institutional support.

Varolgüneş et al. (2025) similarly highlighted ethical, regulatory, and accessibility challenges associated with digitalization. These findings indicate that technological innovation requires a supportive institutional environment to produce sustainable outcomes.

Small and medium-sized tourism establishments may be particularly vulnerable to these challenges because they often have fewer financial and human resources. Government incentives, training programs, technological partnerships, and financial support may therefore be necessary to facilitate inclusive technological transformation.

Research Gap

The reviewed literature demonstrates that technological innovation has considerable potential to support sustainable tourism. However, several research gaps remain.

First, many studies focus on smart destinations, tourist behavior, or digital platforms, while relatively fewer studies investigate technological innovation specifically within tourism establishments. Second, existing research frequently examines individual technologies, such as AI or IoT, separately, despite the increasing integration of multiple technologies within tourism operations.

Third, there is a need for further empirical research examining the mechanisms through which technological innovation affects sustainability. Recent studies suggest that operational efficiency and data-driven decision-making may represent important mechanisms connecting technological adoption with sustainable performance (Abdou & Shehata, 2026; Gajić et al., 2024).

Fourth, relatively limited research simultaneously examines the environmental, economic, and social dimensions of sustainability at the organizational level. Examining these dimensions together can provide a more comprehensive understanding of the contribution of technological innovation to sustainable tourism.

Therefore, the present study addresses these gaps by examining **the role of technological innovation in supporting sustainable tourism practices in tourism establishments**. The study conceptualizes technological innovation as a multidimensional organizational capability and investigates its contribution to environmental, economic, and social sustainability. It also considers the importance of operational efficiency, data-driven decision-making, employee competencies, and organizational readiness in translating technological innovation into sustainable tourism outcomes.

RESEARCH METHODOLOGY

Research Approach and Design

This study adopts a quantitative research approach to examine the role of technological innovation in supporting sustainable tourism practices in tourism establishments. A quantitative approach is appropriate because it enables the researcher to measure the relationships between technological innovation and the environmental, economic, and social dimensions of sustainable tourism using numerical data and statistical techniques.

The study employs a cross-sectional research design, in which data are collected from respondents at a specific point in time. A cross-sectional design is suitable for examining the current level of technological innovation adoption and its relationship with sustainable tourism practices within tourism establishments. The study is also explanatory in nature because it seeks to determine whether and to what extent technological innovation contributes to sustainable tourism outcomes.

Research Population and Sampling

The target population consists of managers, supervisors, and employees working in tourism establishments, including hotels, resorts, travel agencies, tour operators, and other tourism-related organizations. These respondents are considered appropriate because they are directly involved in organizational operations and are likely to have knowledge of technological adoption and sustainability practices.

A purposive sampling technique can be employed to ensure that respondents have sufficient knowledge of the technological and sustainability practices of their organizations. The inclusion criteria may require respondents to have worked in their current tourism establishment for at least one year.

The required sample size can be determined using an appropriate statistical formula based on the estimated population size. Where the population is large or difficult to determine, a minimum sample size of approximately 300 respondents is recommended to provide adequate statistical power for regression or structural equation modeling. The final sample size should be determined according to the characteristics of the research context and the statistical technique employed.

Data Collection

Primary data will be collected through a structured questionnaire developed based on the existing literature on technological innovation and sustainable tourism. The questionnaire will be distributed electronically and/or in printed form to employees and managers of selected tourism establishments.

Before the main data collection, a pilot test will be conducted with approximately 30 respondents who are similar to the target population but are not included in the final sample. The purpose of the pilot study is to assess the clarity, reliability, and appropriateness of the questionnaire items. Feedback obtained during the pilot test will be used to revise ambiguous or difficult items.

Participation in the study will be voluntary. Respondents will be informed about the purpose of the research, the confidentiality of their responses, and their right to withdraw from participation. No personally identifiable information will be required unless necessary for the research.

Research Instrument

The questionnaire will consist of three main sections.

Section A: Demographic and Organizational Information

This section will collect information about respondents' demographic and professional characteristics, such as gender, age, educational level, years of work experience, organizational position, and type of tourism establishment.

Section B: Technological Innovation

This section will measure the extent to which tourism establishments adopt and use technological innovations. The construct will include several dimensions:

- Artificial intelligence (AI)
- Internet of Things (IoT)
- Big data analytics
- Digital platforms and applications
- Smart operational systems

Items will assess the extent to which these technologies are used to support organizational operations, decision-making, customer services, and resource management.

Section C: Sustainable Tourism Practices

Sustainable tourism practices will be measured through three dimensions:

- **Environmental sustainability:** energy efficiency, water conservation, waste reduction, pollution reduction, and efficient use of natural resources.
- **Economic sustainability:** operational efficiency, cost reduction, productivity, competitiveness, and long-term economic performance.
- **Social sustainability:** employee well-being, local community engagement, stakeholder participation, accessibility, and contribution to local development.

A five-point Likert scale will be used, ranging from **1 = Strongly Disagree** to **5 = Strongly Agree**.

Variables of the Study

The independent variable in this study is **Technological Innovation**, while the dependent variable is **Sustainable Tourism Practices**.

Technological innovation is conceptualized as a multidimensional construct consisting of the adoption and effective use of emerging digital technologies within tourism establishments.

Sustainable tourism practices are conceptualized as organizational practices that contribute to environmental protection, economic viability, and social well-being.

The proposed conceptual relationship can be represented as follows:

Technological Innovation → Sustainable Tourism Practices

The study further examines the three dimensions of sustainable tourism:

Technological Innovation → Environmental Sustainability

Technological Innovation → Economic Sustainability

Technological Innovation → Social Sustainability

Measurement of Variables

The study will use multiple items to measure each construct. All items will be measured using a five-point Likert scale.

Validity

Several procedures will be used to establish the validity of the research instrument.

First, **content validity** will be assessed by presenting the questionnaire to a panel of academic experts specializing in tourism, hospitality, sustainability, and information technology. The experts will evaluate the relevance, clarity, and comprehensiveness of the questionnaire items.

Second, **construct validity** will be assessed statistically. Exploratory Factor Analysis (EFA) may be conducted to determine whether questionnaire items load appropriately on their expected constructs. If the measurement model is theoretically established, Confirmatory Factor Analysis (CFA) can subsequently be employed to assess the factor structure.

Convergent validity will be assessed using factor loadings and Average Variance Extracted (AVE), while discriminant validity will be evaluated using appropriate criteria such as the Fornell–Larcker criterion and the Heterotrait–Monotrait ratio.

Reliability

The internal consistency of the measurement scales will be assessed using **Cronbach's alpha** and, where appropriate, **Composite Reliability (CR)**.

A Cronbach's alpha coefficient of 0.70 or higher will generally be considered acceptable for established scales. Composite reliability values above 0.70 will also indicate satisfactory internal consistency.

The reliability analysis will be conducted for each major construct and its dimensions separately.

Data Analysis

The collected data will be analyzed using appropriate statistical software such as SPSS and, if required, SmartPLS or AMOS.

The analysis will be conducted in several stages.

First, **descriptive statistics** will be used to summarize the characteristics of the respondents and the main study variables. Frequencies, percentages, means, and standard deviations will be calculated.

Second, **reliability analysis** will be performed using Cronbach's alpha and Composite Reliability.

Third, **correlation analysis** will be conducted to examine the direction and strength of the relationships between technological innovation and sustainable tourism practices.

Fourth, **regression analysis** will be employed to determine the predictive effect of technological innovation on sustainable tourism practices. Multiple regression may also be used to examine the effects of different technological innovation dimensions, such as AI, IoT, and big data analytics.

If the study uses Structural Equation Modeling (SEM), the measurement model will first be evaluated through reliability and validity tests, followed by assessment of the structural model. Path coefficients, t-values, p-values, effect sizes, and coefficients of determination (R^2) will be examined.

A statistical significance level of $p < 0.05$ will be adopted for hypothesis testing.

Research Hypotheses

Based on the theoretical framework and previous literature, the study proposes the following hypotheses:

H1: Technological innovation has a significant positive effect on sustainable tourism practices in tourism establishments.

H1a: Artificial intelligence has a significant positive effect on environmental sustainability.

H1b: Internet of Things adoption has a significant positive effect on environmental sustainability.

H1c: Big data analytics has a significant positive effect on environmental sustainability.

H2: Technological innovation has a significant positive effect on economic sustainability in tourism establishments.

H3: Technological innovation has a significant positive effect on social sustainability in tourism establishments.

H4: Operational efficiency mediates the relationship between technological innovation and sustainable tourism practices.

H5: Data-driven decision-making mediates the relationship between technological innovation and sustainable tourism practices.

Ethical Considerations

Ethical principles will be followed throughout the research process. Participation will be voluntary, and respondents will receive information about the purpose and nature of the study before completing the questionnaire. Respondents will not be required to provide unnecessary personal information, and all collected data will be treated confidentially.

The data will be used exclusively for academic research purposes. The researcher will also ensure that the findings are reported objectively and that no information is manipulated or fabricated.

Methodological Summary

Overall, the study employs a quantitative, cross-sectional methodology to investigate the relationship between technological innovation and sustainable tourism practices in tourism establishments. Data will be collected using a structured questionnaire and analyzed using descriptive statistics, reliability and validity tests, correlation analysis, and regression or structural equation modeling.

The methodology is designed to provide empirical evidence regarding whether technological innovation contributes to environmental, economic, and social sustainability and to identify the mechanisms through which technological innovation may influence sustainable tourism practices.

RESULTS AND DISCUSSION

1. The Role of Technological Innovation in Supporting Sustainable Tourism

The findings of the reviewed literature indicate that technological innovation plays an important role in supporting sustainable tourism practices within tourism establishments. The integration of artificial intelligence (AI), the Internet of Things (IoT), big data analytics, digital platforms, and smart operational systems provides tourism organizations with opportunities to improve operational efficiency while addressing environmental, economic, and social sustainability challenges.

The literature suggests that the contribution of technological innovation to sustainability does not result simply from adopting advanced technologies. Rather, its value depends on how effectively tourism establishments integrate these technologies into their organizational processes and sustainability strategies. Varolgüneş et al. (2025) identified artificial intelligence, big data, blockchain, augmented reality, and virtual reality as important technological themes within sustainable tourism research. Their findings demonstrate the increasing connection between technological development and sustainable tourism management.

Similarly, Gonzalez et al. (2025) emphasized that digitalization influences sustainability at different levels, including tourism destinations, organizations, and stakeholders. This indicates that technological innovation should not be viewed only as a tool for improving service delivery, but also as a mechanism for supporting environmental protection, economic performance, and social well-being.

From an organizational perspective, technological innovation can therefore be understood as a strategic capability that enables tourism establishments to monitor their operations, identify inefficiencies, make informed decisions, and respond more effectively to environmental and market changes. These findings support the central argument of the present study that technological innovation can contribute positively to sustainable tourism practices.

2. Technological Innovation and Environmental Sustainability

One of the most important findings of the reviewed literature concerns the contribution of technological innovation to environmental sustainability. Tourism establishments consume substantial amounts of energy and water and generate different forms of waste. Consequently, technologies that enable continuous monitoring and optimization can play an important role in reducing the environmental impacts of tourism operations.

The Internet of Things is particularly relevant because connected sensors can provide real-time information about electricity consumption, water usage, temperature, occupancy, and other operational conditions. Such information enables tourism establishments to identify excessive consumption and take corrective action. Smart lighting, automated heating and cooling systems, occupancy sensors, and intelligent energy-management systems can reduce unnecessary resource consumption and improve operational efficiency (Gajić et al., 2024).

Artificial intelligence can complement these capabilities by analyzing operational information and identifying consumption patterns. Tourism establishments can use AI-based systems to forecast occupancy and demand and subsequently adjust energy use, staffing, food procurement, and other resources according to expected operational requirements. Siddik et al. (2025) emphasized that AI can improve tourism efficiency and contribute to sustainable tourism growth, suggesting that intelligent technologies can support sustainability through more efficient allocation of organizational resources.

Big data analytics also strengthens environmental sustainability by enabling tourism establishments to analyze patterns in resource consumption and operational performance. Instead of relying exclusively on traditional managerial judgment, organizations can use data to identify areas of excessive consumption and develop more efficient operational strategies. Varolgüneş et al. (2025) identified big data as one of the major technological areas associated with sustainable tourism research.

The literature therefore supports the view that AI, IoT, and big data can contribute to environmental sustainability by improving monitoring, forecasting, automation, and resource management. These findings are consistent with the environmental dimension of the conceptual framework proposed in this study.

3. Technological Innovation and Economic Sustainability

The reviewed literature further indicates that technological innovation can support the economic sustainability of tourism establishments. Economic sustainability requires tourism organizations to remain financially viable while generating long-term value for their stakeholders. Technology can contribute to this objective through improved productivity, reduced operating costs, better resource allocation, increased competitiveness, and the development of new tourism products and services.

Artificial intelligence can assist tourism establishments in forecasting demand and optimizing the allocation of employees and other resources. Big data analytics can provide managers with information concerning customer preferences, booking patterns, market trends, and organizational performance. Such information can improve managerial decision-making and reduce operational inefficiencies (Siddik et al., 2025).

Digital platforms can also contribute to economic sustainability by expanding market access and improving communication between tourism establishments and customers. Through digital channels, tourism businesses can reach wider markets, promote their services more efficiently, and develop products that respond to changing tourist preferences.

However, the economic benefits of technological innovation need to be considered alongside implementation costs. Advanced technological systems may require considerable investment in infrastructure, software, employee training,

maintenance, and cybersecurity. Lakhmiri et al. (2026) highlighted financial constraints as an important barrier to the adoption of smart and green tourism practices. Therefore, technology is more likely to contribute to economic sustainability when investments are strategically aligned with organizational needs and long-term sustainability objectives.

4. Technological Innovation and Social Sustainability

The findings also indicate that technological innovation can contribute to the social dimension of sustainable tourism. Although technological transformation is frequently associated with efficiency and environmental performance, its effects extend to employees, tourists, local communities, and other tourism stakeholders.

Digital platforms and mobile applications can improve access to tourism information and services, facilitate communication with customers, and strengthen interaction between tourism establishments and local communities. Digital technologies can also provide tourists with information about local products, cultural heritage, sustainable transportation, and environmentally responsible activities.

The role of employees is particularly important in this relationship. Al-Sulaiti et al. (2024) found that human, structural, and relational intellectual capital contribute to transforming AI capabilities into organizational sustainability. This finding demonstrates that technology cannot independently produce sustainable outcomes; rather, human capabilities and organizational resources are necessary to translate technological innovation into meaningful sustainability practices.

At the same time, technological transformation may create social challenges, including concerns about employee displacement, unequal access to technology, privacy, and the digital divide. Therefore, tourism establishments should adopt a human-centered approach to technological transformation. Employee training, digital competency development, stakeholder participation, and responsible data management should accompany technological investment to ensure that technological innovation contributes positively to social sustainability.

5. The Role of Operational Efficiency

Another important finding emerging from the reviewed literature is that operational efficiency represents an important mechanism connecting technological innovation with sustainable tourism practices.

AI, IoT, and smart management systems can improve the efficiency of daily tourism operations by allowing establishments to monitor processes, identify inefficiencies, and allocate resources more effectively. Improved operational efficiency can simultaneously generate economic and environmental benefits because reducing unnecessary resource consumption can lower operating costs while also reducing environmental impacts.

Gajić et al. (2024) demonstrated that the integration of AI and IoT can improve hotel operational efficiency and contribute to sustainable hotel practices. This finding suggests that the sustainability value of technological innovation is partly realized through improvements in organizational operations.

Therefore, operational efficiency can be considered an important pathway through which technological innovation supports sustainable tourism. Technology becomes particularly valuable when it produces practical improvements in resource use, service delivery, and organizational processes.

6. The Role of Data-Driven Decision-Making

The literature further indicates that data-driven decision-making is an important mechanism through which technological innovation can influence sustainable performance.

Modern tourism establishments generate large volumes of data through reservation systems, customer interactions, digital transactions, social media, mobile applications, and IoT devices. However, the availability of data alone does not guarantee sustainability. Organizations must possess the ability to transform data into useful managerial knowledge and appropriate operational decisions.

Abdou and Shehata (2026) examined the relationship between IoT adoption, data-driven decision-making, artificial intelligence, and hotel sustainable performance. Their findings indicate that IoT adoption can strengthen data-driven decision-making and sustainable hotel performance. This suggests that the value of technological innovation depends partly on the organizational ability to interpret technological information and convert it into practical decisions.

Accordingly, tourism establishments should develop analytical and managerial capabilities alongside technological infrastructure. This finding provides theoretical support for the proposed role of data-driven decision-making as a mechanism linking technological innovation with sustainable tourism practices.

7. Organizational Readiness and Technological Adoption

The reviewed literature consistently indicates that organizational readiness is a critical condition for achieving sustainability benefits from technological innovation. The availability of advanced technology does not automatically guarantee successful implementation.

Tourism establishments require qualified employees, management support, appropriate organizational structures, sufficient financial resources, adequate technological infrastructure, and an organizational culture that supports innovation. Al-Sulaiti et al. (2024) emphasized the importance of intellectual capital in converting AI capabilities into organizational sustainability.

Employee digital competencies are particularly important because employees need to understand how technological systems operate and how they can be integrated into everyday organizational activities. Management support is equally important because technological transformation frequently requires changes in organizational processes, investment priorities, and organizational culture.

Therefore, tourism establishments should invest not only in technological infrastructure but also in human resources, employee training, managerial capabilities, and organizational development. Technological innovation is more likely to produce sustainable outcomes when it is supported by organizational capabilities.

8. Barriers to Technological Innovation

Despite its potential benefits, the adoption of technological innovation in tourism establishments is associated with several barriers. Financial limitations, inadequate technological infrastructure, shortage of qualified employees, resistance to organizational change, cybersecurity risks, data privacy concerns, and uncertainty regarding investment returns may restrict technological adoption.

Lakhmiri et al. (2026) identified financial and technological barriers as important constraints affecting the integration of smart and green tourism practices. These barriers may be particularly significant for small and medium-sized tourism establishments because such organizations often have fewer financial and human resources.

Varolgüneş et al. (2025) also highlighted ethical, regulatory, and accessibility challenges associated with digitalization in sustainable tourism. These findings indicate that technological innovation requires not only organizational readiness but also an appropriate institutional environment.

Government incentives, training programs, technological partnerships, financial support, and clear regulatory frameworks can therefore facilitate more inclusive technological transformation. Such support can help tourism establishments overcome financial and technical limitations while ensuring that the benefits of digital innovation are distributed more broadly.

9. Integrated Contribution to Sustainable Tourism

An important overall finding of the literature is that the environmental, economic, and social dimensions of sustainable tourism are interconnected. Technological innovation has the potential to influence these dimensions simultaneously rather than separately.

For example, an intelligent energy-management system can reduce electricity consumption, contributing to environmental sustainability while simultaneously reducing operating costs and supporting economic sustainability. Similarly, digital platforms can improve access to tourism services while creating opportunities for local businesses and communities, thereby contributing to both social and economic sustainability.

This interconnectedness suggests that tourism establishments should avoid treating technological innovation and sustainability as separate organizational initiatives. Instead, technological investments should be incorporated into an integrated sustainability strategy that considers environmental performance, economic viability, employee well-being, customer needs, and community interests.

10. Overall Discussion

Overall, the findings of the reviewed literature support the central argument of this study that technological innovation can serve as an important strategic mechanism for supporting sustainable tourism practices in tourism establishments.

Artificial intelligence can contribute to forecasting, optimization, personalization, and intelligent resource allocation. The Internet of Things can provide real-time monitoring and automation of operational processes. Big data analytics can strengthen evidence-based decision-making, while digital platforms can improve communication, accessibility, market reach, and stakeholder engagement (Varolgüneş et al., 2025; Gonzalez et al., 2025).

Nevertheless, the relationship between technological innovation and sustainability is not automatic. The sustainability outcomes of technological innovation depend on organizational readiness, employee competencies, managerial support, financial capacity, infrastructure, governance, and responsible implementation (Al-Sulaiti et al., 2024; Lakhmiri et al., 2026).

The literature also suggests that operational efficiency and data-driven decision-making represent important mechanisms through which technology can be translated into sustainability outcomes (Gajić et al., 2024; Abdou & Shehata, 2026). Consequently, tourism establishments should not focus exclusively on acquiring advanced technologies. They should also develop the organizational capabilities required to use these technologies effectively.

In conclusion, technological innovation should not be understood merely as a process of digital transformation. Rather, it should be considered a strategic component of sustainable tourism management through which tourism establishments can integrate environmental responsibility, economic efficiency, and social well-being into their daily operations and long-term development strategies.

CONCLUSION

This study examined the role of technological innovation in supporting sustainable tourism practices in tourism establishments, with particular attention to artificial intelligence, the Internet of Things, big data analytics, digital platforms, and smart operational systems. Based on the reviewed literature, the study concludes that technological innovation represents an important strategic mechanism for integrating sustainability into tourism operations.

The findings indicate that technological innovation can contribute to the three major dimensions of sustainable tourism: environmental, economic, and social sustainability. From an environmental perspective, technologies such as IoT sensors, AI-based systems, and smart energy-management solutions can support more efficient consumption of energy and water, reduce waste, and improve environmental monitoring. From an economic perspective, technological innovation can enhance operational efficiency, reduce unnecessary costs, improve productivity, strengthen competitiveness, and support the development of innovative tourism products and services. From a social perspective, digital technologies can improve communication, accessibility, stakeholder engagement, and interaction with local communities, while also creating opportunities for more sustainable tourist experiences.

The study further concludes that the sustainability benefits of technological innovation do not depend solely on the availability of advanced technologies. Organizational capabilities play a critical role in transforming technological resources into sustainable outcomes. Employee digital competencies, managerial support, organizational readiness, data-driven decision-making, and operational efficiency are important factors that determine the effectiveness of technological adoption. In this regard, tourism establishments should view technological innovation as part of a broader organizational transformation rather than simply as an investment in digital tools.

The reviewed literature also demonstrates that operational efficiency and data-driven decision-making can serve as important mechanisms through which technological innovation contributes to sustainable tourism practices. Technologies can generate valuable information and improve organizational processes, but sustainable

RECOMMENDATIONS FOR FUTURE STUDIES

Based on the findings and limitations of the present study, several recommendations are proposed for future research.

First, future studies should conduct empirical investigations to examine the relationship between technological innovation and sustainable tourism practices in different types of tourism establishments, including hotels, resorts, restaurants, travel

agencies, and tour operators. Empirical research can provide further evidence regarding how technological innovation is translated into practical sustainability outcomes.

Second, future research should examine the individual and combined effects of different technologies, such as artificial intelligence, the Internet of Things, big data analytics, blockchain, cloud computing, and digital platforms. Investigating the interaction between multiple technologies may provide a more comprehensive understanding of how integrated technological systems contribute to sustainable tourism.

Third, future studies should examine the mediating and moderating factors that influence the relationship between technological innovation and sustainability. Particular attention should be given to operational efficiency, data-driven decision-making, employee digital competencies, organizational readiness, managerial support, and organizational culture.

Fourth, future research should give greater attention to small and medium-sized tourism establishments. These organizations may face greater financial, technological, and human-resource constraints than larger tourism establishments. Investigating these barriers could help identify appropriate strategies and policies for supporting inclusive technological transformation.

Fifth, future studies should examine the long-term environmental, economic, and social effects of technological innovation. Longitudinal research could provide deeper insights into whether the sustainability benefits of technological adoption are maintained over time and how technological investments influence organizational sustainability in the long term.

Sixth, future research should investigate the social and ethical implications of technological transformation in tourism. Issues related to employee displacement, data privacy, cybersecurity, digital inequality, accessibility, and the responsible use of artificial intelligence require greater academic attention to ensure that technological development does not undermine social sustainability.

Seventh, comparative studies across different countries and tourism contexts are recommended. Differences in technological infrastructure, government policies, economic conditions, organizational capabilities, and cultural factors may influence the adoption and effectiveness of sustainable tourism technologies.

Finally, future researchers should develop and test comprehensive conceptual and empirical models that integrate technological innovation with organizational capabilities and the three dimensions of sustainable tourism. Such research could contribute to a deeper understanding of the conditions under which technological innovation can become an effective and sustainable component of tourism management.

CONFLICT OF INTEREST

The author declare no conflict of interest

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