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SMART & GREEN TOURISM IN BALI: INTEGRATING DIGITAL TECHNOLOGIES AND CIRCULAR ECONOMY PRINCIPLES FOR A LOW-CARBON DESTINATION DEVELOPMENT

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Abstract

This study examines the integration of digital technologies and circular economy principles to support Bali's transition toward a low-carbon tourism destination. Employing a qualitative descriptive approach with secondary data analysis, the research synthesizes evidence from academic literature, government policies, and industry reports to explore how smart and green tourism can be effectively operationalized. The findings demonstrate that digital technologies including IoT, big data, artificial intelligence, and VR/AR play a pivotal role in improving energy efficiency, optimizing transportation flows, enabling smart waste management, and preserving cultural heritage, while simultaneously enhancing visitor experiences and destination competitiveness. In parallel, circular economy practices such as waste reduction, recycling, eco-design, and resource efficiency address pressing environmental challenges while also strengthening local economies, cultural industries, and community resilience. Despite progress, Bali's implementation remains partial and fragmented, constrained by weak market demand for eco-friendly products, limited infrastructure, and low community literacy regarding sustainability practices. Theoretically, this study enriches sustainable tourism literature by advancing an integrative framework that connects smart and green paradigms. Practically, it offers strategic insights for policymakers, industry stakeholders, and local communities to enhance competitiveness while safeguarding cultural identity and ecological sustainability. The study concludes that Bali's pathway to sustainable tourism requires stronger regulations, fiscal incentives, digital literacy programs, and collaborative governance to build a holistic low-carbon ecosystem.

Keywords: Circular Economy Practices, Community-Based Tourism Innovation, Digital Transformation in Tourism, Low-Carbon Strategies, Sustainable Destination Development

1. INTRODUCTION

Climate change is manifested through gradual shifts in temperature, precipitation, atmospheric moisture, wind intensity, sea-level rise, and the increasing frequency of extreme events. Nevertheless, its potential future consequences remain insufficiently

understood. A critical question arises: could anthropogenic climate change lead to global societal collapse or even the eventual extinction of humankind? At present, this issue remains dangerously underexplored, despite substantial reasons to suspect that climate change may indeed pose the risk of a global catastrophe (Sesana et al., 2021; Jehn et al., 2022).

The tourism industry is one of the fastest-growing sectors of the global economy; however, this expansion generates significant social and environmental impacts. The increasing number of tourists and uncontrolled tourism activities have triggered various issues, including rising carbon emissions, degradation of fragile ecosystems (such as forests, coastal areas, and national parks), and disruptions to local communities. The development of tourism infrastructure such as hotels, airports, and highways often exacerbates environmental damage, while global warming and pollution emerge as serious consequences of industry's rapid expansion (Susanti et al., 2023).

Conventional tourism, with its rapid growth, has exerted significant pressure on the environment, including rising carbon emissions, ecosystem degradation, and the overcapacity of destination carrying capacity. A study in China emphasizes that without the integration of sustainability principles and the support of green financing mechanisms, tourism expansion will exacerbate ecological footprints while threatening cultural heritage and community well-being. Similarly, research in Taiwan reveals that tourism growth exceeding ecological limits leads to ecological deficits, environmental stress, and increased vulnerability to natural disasters and global crises.

These findings highlight that the transition toward sustainable tourism is an urgent necessity to balance economic benefits with environmental conservation and social sustainability (Chen, 2025; Fu et al., 2024). This urgency aligns with global agendas such as the SDGs particularly Goal 12 (Responsible Consumption and Production), Goal 13 (Climate Action), and Goal 15 (Life on Land) which emphasize reducing ecological pressures while fostering inclusive development. Similarly, the Paris Agreement highlights the imperative to cut carbon emissions across all sectors, including tourism. Within this context, the green transition becomes pivotal, requiring low-carbon technologies, circular economy practices, and stronger community resilience. Thus, advancing sustainable tourism is not only a local policy need but also a critical contribution to global commitments for a more equitable, climate-resilient, and environmentally responsible future.

Bali, as Indonesia's leading tourist destination that accounts for nearly 40% of international arrivals, faces significant challenges stemming from the rapid expansion of mass tourism. Rising emissions from transportation, intensive energy use, and increasing waste volumes have exacerbated pollution, while land conversion and the degradation of coastal, agricultural, and forest ecosystems threaten environmental sustainability. On the social front, cultural commodification, gentrification, soaring land prices, and unequal distribution of economic benefits have intensified pressures on local communities. The region's heavy economic dependence on tourism, contributing approximately 80% of its GDP, further heightens its vulnerability to external crises. Consequently, the implementation of sustainable tourism through the integration of *Tri Hita Karana* principles, the development of community-based tourism, and the adoption of a decarbonization roadmap constitutes a strategic agenda to ensure the long-term sustainability of the destination (Astuti et al., 2024; Januar, 2024).

Bali serves as a crucial reference point for sustainable tourism in both Indonesia and Southeast Asia due to its role as a major international destination, accounting for

nearly 40% of Indonesia's foreign tourist arrivals and contributing substantially to the regional economy. The island's multifaceted challenges, including rising carbon emissions, environmental degradation, and cultural pressures make it an ideal case study for implementing sustainable tourism strategies. By combining digital innovation, circular economy approaches, and the indigenous philosophy of Tri Hita Karana, Bali demonstrates a model that can inspire other destinations in the region. Consequently, its shift toward becoming a low-carbon destination represents not only a local imperative but also a regional benchmark for fostering tourism that is competitive, environmentally responsible, and socially equitable.

To build sustainable tourism in Bali, Bali must implement what is called smart and green tourism. The concept of smart tourism refers to the integration of advanced digital technologies such as IoT, big data, AI, and mobile applications to enhance tourist experiences while strengthening destination competitiveness. These technologies enable service personalization, interactivity, accessible information, and efficient transactions, thereby fostering tourist satisfaction and loyalty. Furthermore, the adoption of smart tourism emphasizes trust dynamics, ethical AI practices, and tourists perceived value in shaping behavioral intentions. From a sustainability perspective, the notion of smart green tourism emerges, combining intelligent technologies with eco-friendly principles to encourage sustainable tourist behavior without diminishing the authenticity of the experience (Inmor et al., 2025; Koo et al., 2025; Yap et al., 2025).

The concept of smart tourism plays a crucial role in enhancing energy efficiency, destination management, and the overall visitor experience through the integration of advanced digital technologies. Data-driven transportation management, supported by IoT and big data, can reduce congestion and emissions, while energy monitoring systems help optimize electricity use across accommodations and tourism facilities. Similarly, smart waste management solutions using real-time sensors and analytics improve waste reduction and maintain cleaner destinations. Beyond operational benefits, these technologies not only create more seamless and satisfying travel experiences but also significantly contribute to lowering the carbon footprint, thereby fostering more sustainable and resilient tourism development.

Green Tourism is a sustainable tourism approach that emphasizes energy efficiency, resource conservation, and waste reduction to balance economic, social, and ecological benefits. In parallel, the Circular Economy offers a closed-loop economic model that prioritizes reuse, recycling, and eco-design to minimize waste and extend the lifecycle of resources (Chen, 2025; Modic et al., 2025; Tandon et al., 2023; Xu et al., 2024). Green tourism represents a sustainable approach to tourism that aligns with low-carbon development by promoting energy efficiency, resource conservation, and environmentally responsible practices.

The application of circular economy principles such as waste reduction, recycling, renewable energy adoption, and the reuse of local products strengthens the tourism ecosystem by fostering sustainable production and consumption cycles. In the context of Bali, the relevance of the circular economy is particularly evident in cultural festivals, small and medium enterprises (SMEs), and the creative industries, which draw upon local wisdom, traditional products, and culture-based innovation. Integrating these principles not only reduces the carbon footprint but also enhances destination competitiveness by reinforcing the local economy and preserving cultural identity.

The integration of digital technologies with circular economic principles in tourism represents not merely a contemporary trend but a strategic imperative for long-

term destination development. Smart tourism facilitates efficiency in energy use, mobility, and waste management through data-driven systems, while green tourism emphasizes the reduction of environmental impacts through waste minimization, renewable energy, and the valorization of local products. Their convergence enhances destination competitiveness while simultaneously safeguarding environmental sustainability and preserving local cultural heritage.

Despite growing academic interest in both smart tourism and green tourism, empirical research in Indonesia particularly in Bali remains limited in addressing their integration. Existing studies have predominantly examined either digital technologies to promote smart destinations or environmental practices within green tourism frameworks in isolation. Few studies have comprehensively combined these two perspectives to explore their synergistic role in advancing low-carbon destination development. This gap highlights the necessity of research that situates smart and green tourism within a unified framework.

The primary objective of this study is to examine how the integration of digital technologies and circular economy principles can foster the development of low-carbon destinations in Bali. Theoretically, this research contributes to the sustainable tourism literature by advancing an integrative approach that links smart and green paradigms. Practically, the study offers policy and managerial recommendations for local governments, tourism stakeholders, and community actors to operationalize smart and green strategies, thereby reinforcing Bali's trajectory toward becoming a sustainable, competitive, and climate-resilient destination.

2. LITERATURE REVIEW

2.1 Climate Change and Tourism

Tourism is recognized as both highly susceptible to climate change impacts and a substantial driver of environmental pressures. Evidence shows that tourism activities intensify carbon emissions, degrade fragile ecosystems, and expand ecological footprints when growth surpasses environmental carrying capacities (Sesana et al., 2021; Jehn et al., 2022). Research in China demonstrates that the absence of sustainability principles and green financing mechanisms in tourism development deepens ecological deficits while threatening cultural heritage and local community welfare. Similarly, studies in Taiwan reveal that unchecked tourism growth beyond ecological limits heightens vulnerability to disasters and global crises (Fu et al., 2024; H. S. Chen, 2025). Collectively, these findings emphasize the urgent need to embed sustainability into tourism practices, in line with global frameworks such as the Sustainable Development Goals (SDGs) and the Paris Agreement, which call for emission reduction and climate-resilient pathways across all sectors.

2.2 Green Tourism and Circular Economy

Green tourism is widely recognized as an approach that emphasizes energy efficiency, conservation of natural resources, and waste reduction in order to balance economic, social, and ecological benefits (Tandon et al., 2023; Xu et al., 2024). Within this framework, the concept of the circular economy provides a closed-loop model that prioritizes eco-design, reuse, and recycling to minimize waste and extend the lifecycle of resources (Chen, 2025; Modic et al., 2025). Empirical studies suggest that integrating circular economy principles into tourism enhances sustainability by reducing carbon emissions while fostering local economic empowerment through the valorization of

traditional products, renewable energy use, and creative industries. In the context of Bali, the application of circular economy principles is particularly relevant in cultural festivals, small and medium enterprises (SMEs), and community-driven creative industries, where local culture and traditions are embedded in production and consumption cycles.

2.3 Smart Tourism and Digital Technologies

The notion of smart tourism refers to the adoption of advanced digital technologies such as IoT, big data, AI, and mobile applications to enhance tourist experiences, optimize resource management, and increase destination competitiveness (Yap et al., 2025; Koo et al., 2025). These technologies facilitate service personalization, real-time interaction, and seamless transactions while improving operational efficiency. From a sustainability perspective, digital innovations play a crucial role in energy efficiency, transport optimization, and waste management. For instance, data-driven transportation systems reduce congestion and emissions, while smart waste monitoring helps minimize pollution. Moreover, ethical considerations such as trust, perceived value, and responsible AI use are increasingly recognized as critical factors shaping tourists' behavioral intentions and acceptance of smart solutions (Inmor et al., 2025).

As supported by recent studies, technology plays a pivotal role in shaping low-carbon tourism systems through innovation and informatization (Song et al., 2022; Zimeng et al., 2023; Sgroi & Modica, 2024). These concepts form the theoretical basis for analyzing how digital technologies contribute to sustainable destination development in Bali.

2.4 Integrating Smart Tourism and Green Tourism

While smart tourism and green tourism have been widely studied independently, limited empirical research has explored their integration. Smart tourism contributes efficiency and optimization, while green tourism ensures ecological balance and resource conservation. Their convergence often referred to as *smart green tourism* enables destinations to reduce their carbon footprint while maintaining cultural authenticity and visitor satisfaction (Yap et al., 2025). Studies suggest that digital technologies can act as enablers for circular economic practices by monitoring resource flows, promoting eco-friendly behavior among tourists, and supporting sustainable mobility systems. However, in the Indonesian context, and particularly in Bali, most research has been fragmented, focusing either on digitalization for smart destinations or on environmental practices in green tourism. A holistic framework that unifies these two paradigms remains underexplored.

2.5 Theoretical Framework: Behavioral Theories in Sustainable Tourism

Understanding tourists' adoption of smart and green tourism practices requires a behavioral foundation that links attitudes, values, and intentions toward sustainable actions. The Theory of Planned Behavior (TPB) (Ajzen, 1991) posits that an individual's behavior is determined by three key factors: attitude toward the behavior, subjective norms, and perceived behavioral control. Within tourism, this framework explains how tourists' beliefs about environmental responsibility and perceived control over sustainable actions (e.g., waste reduction, energy saving, eco-friendly choices) shape their intention to engage in responsible behavior.

Complementing TPB, the Value–Belief–Norm (VBN) Theory (Stern, 2000) emphasizes that pro-environmental behavior arises from deeply held values, ecological worldviews, and moral obligations to act sustainably. When tourists internalize

environmental and cultural preservation values, they are more likely to support green innovations, choose low-carbon travel options, and participate in community-based tourism initiatives.

By integrating these two theories, this study provides a comprehensive lens for interpreting how digital technologies and circular economy principles influence not only structural transformations within the tourism system but also the psychological mechanisms that encourage sustainable behavior among tourists and local communities. Thus, behavioral theories complement the smart–green tourism framework by connecting technological innovation and circular practices with the human dimension of sustainability.

2.6 Research GAP and Contribution

Existing literature highlights the potential of smart technologies and green principles to foster sustainable tourism; however, their integration in empirical settings remains limited. In Bali, despite its role as Indonesia's premier tourism hub and Southeast Asian benchmark, research has predominantly focused on single aspects of sustainability without adequately addressing synergies between digital innovation and circular economy practices. This gap presents an opportunity to examine how both approaches can be jointly operationalized to advance Bali's transition toward a low-carbon destination. Theoretically, this study extends sustainable tourism literature by proposing an integrative framework linking smart and green paradigms. Practically, it provides policy recommendations and strategic insights for local governments, industry stakeholders, and community actors to strengthen Bali's competitiveness while ensuring environmental sustainability and cultural preservation.

3. RESEARCH METHODS

This study adopts a qualitative descriptive approach with an exclusive focus on secondary data analysis, as this method is appropriate for exploring complex socio-environmental issues without direct field intervention. The choice of this method is based on the need to synthesize diverse forms of documented evidence ranging from statistical reports to policy frameworks and scholarly works to obtain a comprehensive understanding of how digital technologies and circular economy principles contribute to the development of low-carbon tourism destinations in Bali.

Secondary data were collected through documentary research, which involved systematically accessing, selecting, and reviewing relevant documents. The sources included academic literature published within the last 5 years. The selection process was guided by three criteria: (1) direct relevance to the research focus on smart and green tourism, (2) recency of publication to ensure data validity, and (3) credibility of the issuing institution or author.

The collected data were analyzed using content analysis, which consisted of three systematic stages: (a) identification of key issues related to digitalization, circular economy, and low-carbon tourism strategies; (b) categorization of data according to major themes; and (c) interpretation by connecting findings to theoretical frameworks and the empirical context of Bali. To strengthen validity, source triangulation was applied by cross-examining governmental, industrial, and academic documents. The synthesis of findings was then carried out by comparing thematic patterns across sources, enabling the study to construct a holistic narrative about the opportunities, challenges, and policy implications of implementing *smart and green tourism* in Bali.

4. FINDINGS AND DISCUSSION

4.1 Digital Technologies Principles Contribute to the Development of Low-Carbon Tourism Destinations

Currently, technology plays a pivotal role in shaping human civilization, including within the tourism sector. According to (Song et al., 2022), (Zimeng et al., 2023), (Sgroi & Modica, 2024) The contribution of digital technologies to the development of low-carbon tourism destinations can be explained through several key points:

a. Optimizing energy and transportation through digitalization

Digital technologies such as the Internet of Things (IoT), big data, cloud computing, blockchain, and digital twins facilitate more efficient management of energy and transportation systems. The deployment of sensors, 5G/6G communication networks, and predictive traffic algorithms help alleviate congestion, reduce energy consumption, and enable the integration of electric vehicles (EVs) into energy infrastructures. Consequently, these technologies play a pivotal role in lowering the carbon footprint associated with tourist mobility and destination infrastructure.

b. Promoting innovation and informatization in tourism

Digitalization strengthens the integration between technological innovation and tourism development. Studies indicate that information technology enhances the operational efficiency of destinations, improves service quality, and supports structural transformation toward low-carbon tourism. Technologies such as big data, cloud computing, blockchain, AR/VR, and artificial intelligence (AI) enable destinations to reduce resource consumption, increase productivity, and adapt to market demands that increasingly emphasize sustainability.

c. Digital-based natural resource management and tourism experiences

In the context of sustainable tourism such as mountainous regions, digital tools such as mobile applications, online booking systems, interactive reviews, and cloud-based information platforms enhance tourist accessibility while minimizing environmental impacts. Moreover, digitalization facilitates more effective planning in the utilization of natural resources (forests, water, landscapes), ensuring the preservation of ecosystem functions. At the same time, it contributes to carbon emission reduction through more efficient management of tourism attractions.

4.2 Circular Economy Principles Contribute to the Development of Low-Carbon Tourism Destinations

According to (A. Xu et al., 2022), (Strippoli et al., 2024), (Suhardono et al., 2025) there 5 Circular economy principles contribute to low-carbon tourism destinations:

a. Resource Optimization and Emission Reduction

The principles of the circular economy emphasize the cycles of reducing, reusing, recycling, and recovering, alongside product design for durability, serviceability, and material recovery. Within the tourism sector, these principles foster greater energy efficiency, encourage the reuse of materials, and improve waste management practices. By retaining products and materials within the economic cycle for as long as possible, the demand for virgin resources is diminished, thereby lowering carbon emissions associated with the production and consumption processes in tourism.

b. Sustainable Waste and Water Management

Circular Economy (CE) directly addresses critical challenges in the tourism sector, including single-use plastic waste, food waste, and excessive water consumption. Strategies such as reduction, waste segregation, recycling, and the reuse of wastewater for agriculture or agritourism have proven effective in lowering pollution levels and reducing resource consumption. Consequently, CE enhances the ecological carrying capacity of tourist destinations while mitigating the carbon impacts associated with waste cycles.

c. Tourism Industry Ecologization

The concept of ecologization grounded in Circular Economy (CE) can be framed through the DPSIR model (Driver–Pressure–State–Impact–Response). This principle enables the identification of causal relationships within the tourism system and promotes more rational governance of energy, material, information, and value flows. Accordingly, tourism development is positioned not merely around linear economic growth, but toward achieving a balance between consumption patterns, ecological quality, and policy responses that support low-carbon destinations.

d. Linkages to SDGs and Socio-Economic Impacts

In the tourism sector, Circular Economy (CE) is closely aligned with SDG 12 (responsible consumption and production), which directly supports the achievement of other goals such as SDG 7 (clean energy), SDG 13 (climate action), and SDG 15 (life on land). The implementation of CE in tourist destinations contributes to the creation of green jobs, the strengthening of local value chains, and the improvement of community well-being, thereby fostering destinations that are not only low carbon but also socially inclusive.

e. Tourism Design and Consumer Behavior

Recent studies highlight the importance of design strategies such as longevity, serviceability, reusability, and material recovery that enhance tourists' willingness to pay for sustainable products and services. This willingness serves as a driver for tourists' active participation in CE practices, including the purchase of recycled products or the selection of green accommodations. Such consumer behavior aligns with CE principles and reinforces the transition toward low-carbon tourism.

4.3 The Existing State of Digital Technologies and Circular Economy Principle Implementation in Bali

According to (Darmawiguna et al., 2020), (Faris, 2022), (Oka & Subadra, 2024), (Purnamawati & Adnyani, 2024) Currently, the implementation of digital tourism in Bali encompasses three major aspects: (1) the digitalization of tourist villages through websites and online services, (2) innovation based on VR/AR technologies for cultural preservation and promotion, and (3) digital marketing as the primary strategy to attract tourists, particularly in the post-pandemic era.

The implementation of digital tourism in Bali is currently manifested through several key initiatives. First, the digitalization of tourism villages, such as Blimbingsari, demonstrates the use of websites to promote attractions and provide services aligned with the principles of the green economy, although challenges remain in terms of infrastructure, community digital literacy, and the full adoption of sustainability practices. Second, the development of Virtual Reality (VR) and Augmented Reality (AR) applications, exemplified by the Bali Temple VR project, serves both as a strategy for cultural heritage preservation and as an innovative promotional tool, enabling virtual

access to temples while engaging diverse audiences. Third, digital marketing has emerged as a vital instrument for village tourism promotion, with strategies encompassing websites, social media, search engines, email marketing, and online advertising proven effective in influencing tourist decisions despite constraints related to human resources, funding, and innovation. Finally, in the post-pandemic recovery phase, digital technologies have played a pivotal role in revitalizing Bali's tourism industry by accelerating online promotion through social media platforms, enhancing reservation systems, and facilitating rapid information dissemination, thereby supporting the island's re-emergence as a competitive global tourism destination.

The existing condition of the circular economy in Bali remains in a transitional and experimental phase. Efforts are evident through initiatives such as TPS3R (Reduce, Reuse, Recycle Waste Processing Sites), local government policies promoting source-based waste management, integration with the agricultural sector, and small and medium enterprise (SME) initiatives. However, significant challenges persist, including weak market demand for recycled products (e.g., compost), limited financial capacity, low public literacy regarding circular economy principles, and continued dependence on landfills, all of which hinder the achievement of a sustainable circular economy.

According to (Indriana, 2022), (Utomo et al., 2023), (Muliarta, 2023), (Yuniarta & Purnamawati, 2024) The implementation of the existing conditions of the circular economy (CE) in Bali can be explained in the following points:

a. Waste-to-Compost and Integration with Rice Farming

   In Gianyar, Bali, the implementation of circular economy (CE) practices is evident through the operation of TPS3R facilities (Reduce, Reuse, Recycle Waste Processing Units), which convert organic waste into compost and channel plastic waste for resale. The compost produced has the potential to improve soil quality in rice fields and facilitate the agricultural transition from chemical fertilizers to organic alternatives. Nevertheless, the primary challenge lies in the low demand for compost, driven by its relatively low market value and limited farmer interest. Integration efforts with village-level food security programs, however, highlight opportunities for sustaining CE practices at the community level.

b. Transition from Linear to Circular in Waste Management

   Bali continues to operate predominantly under a linear "take–make–dispose" paradigm, with heavy reliance on landfills such as Suwung, resulting in overcapacity and leaving approximately 34.45% of waste unmanaged. The adoption of circular economy (CE) practices remains limited to pilot-scale initiatives. Indriana's research underscores the necessity of systemic transformation through three key strategies: (1) strengthening integrated upstream–downstream waste management systems, (2) enhancing the capacity and awareness of communities and stakeholders, and (3) establishing equitable financing schemes, including service fees, corporate social responsibility (CSR) contributions, and extended producer responsibility (EPR). At present, the transition is still confined to discourse and fragmented efforts, rather than constituting a robust and institutionalized system.

c. Regulation and Source-Based Waste Management

   The implementation of circular economy (CE) in Bali is also reinforced by Bali Governor Regulation No. 47/2019 on Source-Based Waste Management. This regulation mandates households to engage in waste separation, reduction, and processing into value-added products such as compost, liquid fertilizer, eco-enzymes, and biopesticides. While the policy promotes a zero-waste paradigm, its practical

application continues to encounter challenges, including technical limitations, low public awareness, and insufficient financial support. In this context, the role of banking institutions and supporting agencies is considered essential in providing capital and facilitating the development of waste management enterprises.

d. Implementation of CE Principles in the MSME Sector

Beyond the waste sector, the circular economy (CE) in Bali is also applied within micro, small, and medium enterprises (MSMEs) through practices such as raw material efficiency, material recycling, and the development of eco-friendly product innovations. MSMEs that adopt CE principles have been shown to reduce costs, enhance competitiveness, and contribute to both environmental conservation and social well-being. Nevertheless, adoption remains limited, as many MSMEs lack sufficient understanding of CE mechanisms. To address this gap, it is recommended that government bodies and financial institutions provide targeted incentives and support to broaden the scope of implementation.

4.4 Understanding of How Digital Technologies and Circular Economy Principles Contribute to the Development of Low-Carbon Tourism Destinations in Bali

The findings underscore that the integration of digital technologies and circular economy (CE) principles constitutes a critical pillar in advancing low-carbon tourism destinations in Bali. Theoretically, these results reinforce the frameworks of sustainable tourism, circular economy, and behavioral theories that explain how human intentions shape environmental outcomes. The Theory of Planned Behavior (Ajzen, 1991) elucidates how tourists' attitudes, subjective norms, and perceived behavioral control influence their willingness to adopt smart and green tourism practices such as energy efficiency, waste reduction, and the use of eco-friendly facilities. Meanwhile, the Value–Belief–Norm (VBN) Theory (Stern, 2000) highlights the moral and value-based drivers that encourage pro-environmental behavior and support for community-based circular economy initiatives.

By aligning technological innovation with behavioral motivation, the integration of smart tourism and circular economy practices not only enhances efficiency and sustainability but also fosters behavioral transformation among tourists and local stakeholders. This synergy positions digital technology not merely as a technical enabler but as a behavioral catalyst that strengthens community participation, ethical decision-making, and long-term ecological awareness in Bali's tourism ecosystem. The novelty of this study therefore lies in bridging the technological and psychological dimensions of sustainability, offering a comprehensive model for low-carbon destination development.

Compared to previous studies, these findings align with global research that highlights the environmental risks of mass tourism, yet they contribute added value by showcasing hybrid practices in Bali such as the digitalization of tourism villages, the use of VR/AR for cultural preservation, and source-based waste management policies as a living laboratory for the integration of technology and circular economy principles.

Nevertheless, a significant gap remains between existing conditions and the ideal scenario. In Bali, digitalization is still partial, limited mainly to village websites, VR/AR applications, and digital marketing, with insufficient impact on energy and transportation efficiency. Similarly, the implementation of circular economy practices remains transitional, hindered by weak market demand for recycled products, low community literacy, and continued reliance on landfills. The ideal condition requires the establishment of an integrated smart–green destination ecosystem: deploying IoT and big

data for energy, transportation, and waste management; providing fiscal incentives and fostering green markets for circular economy products; and ensuring active tourist engagement in sustainable consumption.

The practical implications of these findings highlight the need for stronger regulations, incentives, and governmental support for MSMEs and digital tourism villages. For the tourism industry, digitalization powered by renewable energy and green marketing strategies emerges as a critical pathway, while for local communities, enhanced digital and circular economy literacy not only broadens economic opportunities but also safeguards cultural heritage. The theoretical implications extend the sustainable tourism literature by introducing a conceptual model of low-carbon smart destinations, positioning digital technologies as the primary enabler of circular economic practices.

The limitations of this study lie in its reliance on secondary data and its focus on Bali as a single case study. Consequently, future research should adopt mixed-method approaches, incorporate direct measurements of carbon impacts, and undertake cross-destination comparisons across Southeast Asia to test the replicability of the Bali model.

5. CONCLUSION

This study concludes that the development of low-carbon destinations in Bali can be achieved through the integration of digital technologies with circular economy principles, operationalized through initiatives such as digitalized tourism villages, VR/AR-based cultural heritage preservation, digital marketing, and source-based waste management (TPS3R). Digital technologies enhance energy efficiency, transportation optimization, and attraction management, while circular economy practices reduce waste, optimize resources, and strengthen local value chains. Theoretically, this study advances the conceptual model of low-carbon smart destinations by positioning digital technology as both a structural enabler and a behavioral catalyst that fosters pro-environmental intentions among tourists and local communities, consistent with the Theory of Planned Behavior (Ajzen, 1991) and the Value–Belief–Norm Theory (Stern, 2000). Practically, stronger regulations, fiscal incentives, and institutional support are needed to expand renewable-energy-based digital adoption and green marketing among SMEs and tourism villages, while enhancing digital and circular economy literacy to preserve Bali's cultural sustainability. Future research should adopt mixed methods, measure direct carbon impacts, and conduct cross-destination comparisons to validate the integrative smart–green tourism framework within broader Southeast Asian contexts.

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