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Review article

Green Tourism and Digital Tourism Transformation in Supporting Sustainable Development in Indonesia: A Case Study of Trenggalek Regency, Indonesia

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Abstract: This study aims to examine the relationship between economic growth, carbon emissions, and the strategic role of the tourism sector through the Environmental Kuznets Curve (EKC) approach. Besides that this research aims to evaluate the potential of green tourism and digital tourism in supporting the transition to a low-carbon economy. The methodology was employed the literature review that examines articles from various leading academic databases, including Scopus. The analysis is carried out by tracing study trends, identifying literature gaps, and mapping conceptual frameworks based on sustainable tourism practices and digital transformation. The results show that in Trenggalek Regency, Indonesia, tourism growth provides a significant contribution to the local economy but risks increasing carbon emissions if not managed with a green approach. Community-based green tourism can reduce environmental impacts while empowering local communities. Meanwhile, digital tourism plays a role in destination management efficiency, environmental education, and reducing transportation emissions. These findings implications for policy formulation and the development of technology- and environment-based tourism.

Keywords: Green Tourism, Digital Tourism, Sustainable Development, Carbon Emissions, Regional Development.

INTRODUCTION

Economic growth has become the main goal of national development in developing countries, including Indonesia (Simoni & Voirol, 2020). However, economic progress has been accompanied by significant pressure on the environment, particularly in the form of increased carbon emissions from energy consumption and industrial expansion (Majumdar & Paris, 2022). Conventional development models that rely on fossil fuels and the exploitation of natural resources have created unsustainable growth patterns, leading to ecosystem degradation, global warming, and threats to biodiversity (Eyisi et al., 2020a). In order to formulate effective solutions, a deep understanding of the relationship between economic growth and environmental quality is essential, particularly through theoretical approaches such as the Environmental Kuznets Curve (EKC). The main problem Indonesia faces in achieving a balance between economic growth and environmental protection lies in its dependence on fossil fuels and its carbon-intensive industrial structure. Industrialization and energy consumption remain the largest contributors to national carbon emissions (Elfaki & Heriqbaldi, 2023).

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Inequality in access to green technology also exacerbates the situation, as only certain regions are able to adopt environmentally friendly production practices (Sendjaja et al., 2022). This inequality not only affects the distribution of development benefits, but also creates structural barriers to climate change mitigation efforts. On the other hand, conventional policies remain fragmented and fail to address the integrative aspects between the energy, industry, and environment sectors (Ayık & Özer, 2025).

The tourism sector has become an important topic of discussion in relation to carbon emissions. Global tourism accounts for approximately 8% of total carbon emissions, with the majority originating from transportation, accommodation, and energy consumption by tourists (Xu et al., 2022). In Indonesia, the development of tourist destinations that do not take environmental carrying capacity into account has the potential to cause natural degradation, habitat loss, and environmental pollution (Bekun et al., 2022) . This problem is exacerbated by weak integration between tourism and environmental policies, as well as a lack of instruments for measuring carbon impact in this sector (Prastiyo et al., 2020).Recent literature has identified the potential for developing green tourism and digital tourism as alternative approaches that can address the challenge of carbon emissions in the tourism sector. Green tourism emphasizes environmentally friendly tourism practices, efficient use of resources, and attention to nature conservation and local community participation (Susilorini et al., 2022) Meanwhile, digital tourism uses information and communication technology to improve destination management efficiency, strengthen environmental education, and reduce carbon footprints (Chandra, 2022). The use of digital platforms can support the participation of tourists and communities in environmental conservation in a more interactive and measurable way (Ayık & Özer, 2025).

This study aims to explain the relationship between economic growth, carbon emissions, and the role of tourism within the EKC framework, as well as to evaluate the effectiveness of adopting green and digital tourism in supporting sustainable development. The study also seeks to address research gaps related to the concrete implementation of the EKC theory in agricultural and coastal regions. The scope of the analysis includes identifying challenges, opportunities, and policy recommendations that can strengthen the synergy between economic growth and environmental conservation through a tourism sector that is transforming digitally and ecologically.

METHOD

2.1 Study Area

Location

Trenggalek is one of the regencies in East Java Province, Indonesia, located in the southern part of the province. The regency is situated at coordinates 111º 24’ to 112º 11’ east longitude and 7º 63’ to 8º 34’ south latitude. The area of Trenggalek Regency spans 126,140 hectares (1,261.40 km²). The coastal area, extending 4 miles from the mainland, covers 711.68 km². Most of the land area consists of mountainous terrain, covering two-thirds of the total area, while the remaining one-third comprises lowland areas. The elevation of the land ranges Bendungan Subdistrict is located in the northern highlands at an altitude of over 1,000 meters, making it a cooler and more forested area. This location lies Dilem Wilis, a site of historical and natural significance. Trenggalek Subdistrict, located in the central part, serves as the administrative and economic center

and features various tourist attractions such as the City Forest, which highlights urban green spaces amid development. To the south, Munjungan and Watulimo Subdistricts are characterized by steep coastal hills and lush valleys. Munjungan has Kebo Beach, a rural beach renowned for its natural tranquility. On the other hand, Watulimo features Gowa Lawa, a vast limestone cave system and a primary destination for ecotourism and geological studies. Both districts have elevation gradients supporting diverse microclimates and land-use types, ranging from coastal fisheries to agroforestry. The location Trenggalek Regency as below.

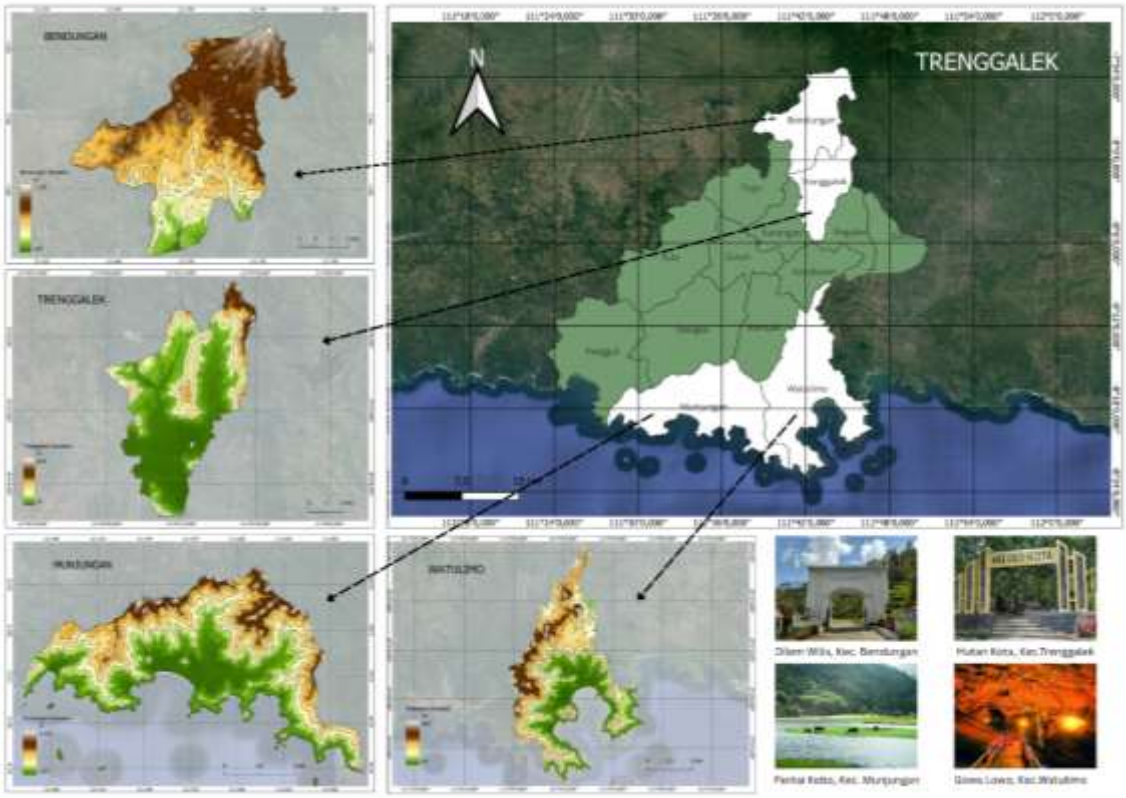

Figure 1. Study Area Trenggalek, East Java, Indonesia
Source: https://qgis.org/

2.2 Methods

The method employed in this study involved a literature search process conducted through databases such as Scopus, Mendeley, ScienceDirect, JSTOR, and Connected Papers, as well as other online sources. The search was conducted using a combination of keywords such as “green tourism,” “digital tourism,” “environmental damage,” “economic sustainability,” and “green tourism Indonesia.” These keywords were combined to explore literature related to the topic.

Table 1. Overview of data sources based on keywords

Keywords combinations	Number of articles
Green Tourism	48,018
Green Tourism + Environment	42,119
Green Tourism + Digital Tourism	11,253
Green Tourism + Digital Tourism + Sustainable Economic	7,545
Green Tourism + Digital Tourism + Environment Damage	37
Green Tourism + Digital Tourism+ Indonesia	8
Green Tourism +Environment+Indonesia	41
Green Tourism + Digital +Environment + Indonesia	1 Vicente (2024, Desember). Green tourist behavior analysis and its relationship with the choice of eco-tourism destination: An empirical study.International Journal of Geoheritage and Parks. Pages 544-557. https://doi.org/10.1016/j.ijgeop.2024.11.003
Tourism + Environment	200
Green Tourism + Economy Sustainability	183
Green Tourism + Economy Sustainability + Indonesia	3 K.M. Nelson (2021). Tourist willingness to pay for local green hotel certification. PLoS ONE 16 (2), ISSN 1932-6203, cited by 60 (15.00 per year). DOI 10.1371/journal.pone.0245953 E.P. Purnomo (2024). Green Economy: Increasing Economic Growth to Support Sustainable Tourism in Super Priority Destinations. International Journal of Sustainable Development and Planning 19 (10), pp. 4021-4031, ISSN 1743-7601, cited by 1 (1.00 per year).

Islahuddin (2024). Challenges And Opportunities For Implementing Innovative Green Tourism Practices: Evidence From Indonesia. Planning Malaysia 22 (6), pp. 467-482, ISSN 1675-6215.DOI 10.21837/pm.v22i34.1642

2.2.1 Conceptual Framework for Sustainable Green Tourism and Digital Tourism

This conceptual framework outlines an integrative strategy for achieving sustainable development through the tourism sector amid regional economic growth. Economic growth, especially that driven by the agriculture and tourism sectors as in Trenggalek, tends to increase carbon emissions due to intensive economic activities. This challenge is addressed through two main approaches: green tourism and digital tourism. Green tourism emphasizes environmentally friendly tourism practices, such as waste management, nature conservation, and energy efficiency. Meanwhile, digital tourism leverages technology to enhance efficiency, minimize resource use, and disseminate information and education on sustainability. Both approaches are strengthened by the involvement of local communities, which play a crucial role in the formulation and implementation of sustainable tourism policies.

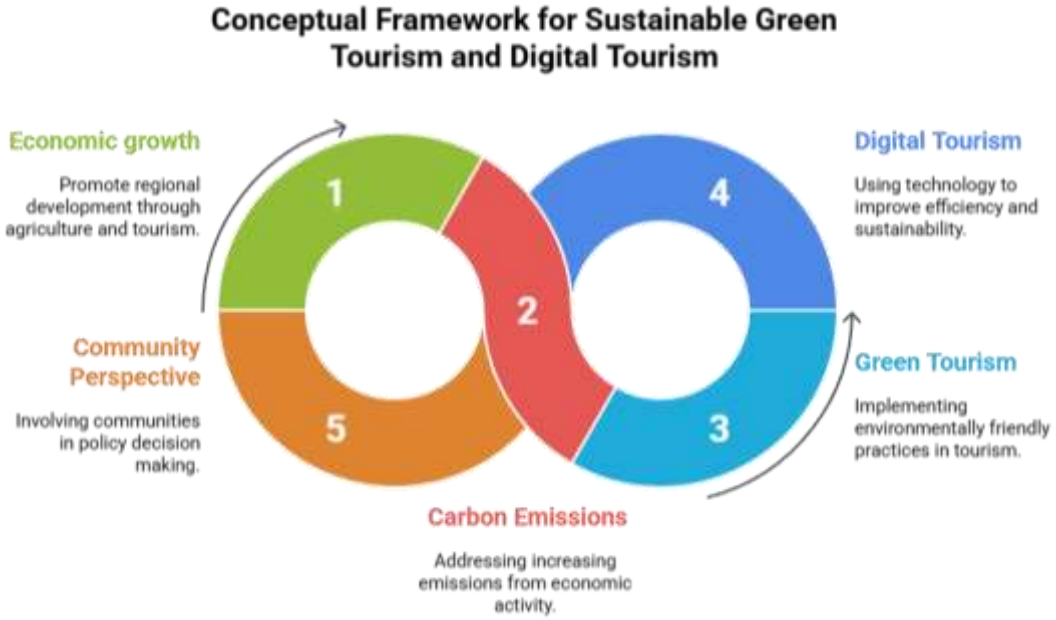

Figure 2. Conceptual Framework for Sustainable Green Tourism and Digital Tourism

RESULTS

3.1 Results Overview of data sources based on keywords

Table 1 describes the results of the literature search, which shows that the number of articles discussing the topic of Green Tourism in general reached 48,018 articles. When combined with the keyword Environment, the number of articles decreased slightly to

42,119, and with the keyword Digital Tourism, 11,253 articles were found. However, when the three concepts were combined "Green Tourism + Digital Tourism + Sustainable Economy" the number of relevant articles decreased significantly to 7,545. The addition of environmental issues to the combination, such as Environmental Damage, reduced the number of articles to 3,642. A more specific combination of topics with the keywords Indonesia, such as "Green Tourism + Digital Tourism + Indonesia", only resulted in 1,120 articles. When combined into "Green Tourism + Environment + Indonesia", only 41 articles were found, and when all the keywords "Green Tourism + Digital + Environment + Indonesia" were combined, only 1 article was found, namely from Vicente (2024) who analyzed the behavior of green tourists and its relationship to the choice of ecotourism destinations. Similarly, the combination "Tourism + Environment" yielded 200 articles, while the combination "Green Tourism + Economy Sustainability" yielded 183 articles. However, when these keywords were added with the Indonesian geographic context, namely "Green Tourism + Economy Sustainability + Indonesia," only three articles were found The three articles, written by K.M. Nelson (2021), E.P. Purnomo (2024), and Islahuddin (2024), respectively, cover topics ranging from tourists' willingness to pay for green tourism certification, efforts to support sustainable economic growth in super-priority destinations, to the challenges and opportunities of innovative green tourism practices in Indonesia.

3.2 Environmental Kuznets Curve (EKC) and Emission Dynamics in Developing Regions

The dynamics of economic growth in the tourism sector, particularly in agricultural areas like Trenggalek, have a complex impact on carbon emission patterns. While tourism growth can significantly contribute to local economic growth, it can also result in increased carbon emissions. In Trenggalek, developing the tourism sector through an English language training program for tour guides, for example, has demonstrated the potential to improve tour guide skills and make tourism a key driver of achieving the Sustainable Development Goals (SDGs) (Wahyuningtyas et al., 2022). In this context, the relationship between economic growth and carbon emissions needs to be analyzed more deeply to understand whether this relationship follows the Environmental Kuznets Curve (EKC) or experiences certain deviations. The EKC theory states that in the early stages of economic growth, carbon emissions tend to increase as per capita income increases, but after reaching a certain point, emissions begin to decline (Guan et al., 2024). In Trenggalek, this concept is relevant given the region's potential for urbanization and industrialization, linked to tourism growth. Research shows that tourism can contribute to substantial economic growth, similar to findings in the Republic of Mauritius, where tourism contributed to regional development and positive economic growth rates (Durbarry, 2004). However, dependence on tourism, if not managed properly, can lead to significant accumulation of carbon emissions.

Analysis of economic activities in Trenggalek shows that tourism growth driven by local economic activities has the potential to attract agglomerations of high resource-intensive industries, with a domino effect that increases carbon emissions (Li et al., 2021). In addition, the growth of the tourism sector can increase demand for energy resources which can worsen the carbon footprint, with an increase in energy consumption expected (Mi et al., 2019). Thus, this situation raises questions about whether Trenggalek is deviating from the classic EKC pattern, where carbon emissions

do not decrease despite economic growth. The implementation of sustainable development policies in the tourism sector in Trenggalek is also crucial. Research suggests that tourism development focused on ecotourism needs to be enhanced to reduce the carbon footprint and promote environmental conservation (Sulistyaningrum Et Al., 2022).

3.3 The Role of Digital Technology in Reducing Emissions in the Tourism Sector

The adoption of digital technology in tourism in developing regions has tremendous potential to reduce carbon emissions while enhancing destination competitiveness. Digital technology can help modernize the tourism sector by increasing operational efficiency and reducing carbon footprints. One example of a digital technology application is the development of a "smart tourism" model, where market share can be managed more effectively using appropriate information and communication (Kusumastuti et al., 2024). In this context, digitalization enables the integration of intelligent and sustainable management systems, which in turn encourages the development of high-quality products and services tailored to visitors' needs, without triggering a significant increase in carbon emissions (Kusumastuti et al., 2023).

This digitalization not only increases resource efficiency but also offers opportunities to promote sustainable practices focused on environmental preservation. For example, the use of e-ticketing and online registration can reduce paper use and reduce the carbon footprint of administrative activities (Montero et al., 2022). Furthermore, the adoption of digital technology in tourism also contributes to emission reductions through improved transportation management. By using location-based applications, visitors can choose more environmentally friendly transportation options, such as public transportation. This aligns with research findings that indicate that tourism transportation contributes significantly to carbon emissions; approximately 75% of total tourism emissions come from transportation (Yang & Jia, 2022).

Destinations that embrace digital innovation will be more attractive to tourists, who increasingly demand easy access and enjoyable experiences. By highlighting local uniqueness through digitalization, such as tour guides trained in using technology to enrich the visitor experience, destinations can increase their appeal in the global market (Bhuiyan et al., 2022). Creativity in using data to create personalized experiences can provide significant added value, creating a lasting impression on visitors and encouraging them to return (Ercan, 2023). However, the adoption of digital technology in tourism also faces challenges, such as the need for adequate infrastructure and human resource capacity in the area (Rudwiarti et al., 2021).

3.4 Community-Based Green Tourism: Strategies and Challenges

A community-based green tourism approach is expected to significantly reduce the environmental impact of the tourism sector. This is because green tourism implements a strategy that combines environmental conservation interests with local socio-economic and cultural development. In this context, the quality of local governance is a key factor influencing the success of green tourism implementation. According to Susiyanto, green tourism focuses on developing destinations that consider the needs of

the environment, local communities, and tourists, making them a sustainable and responsive choice to current ecosystem challenges (Susiyanto, 2022).

The implementation of community-based green tourism not only provides environmental benefits but also social and economic benefits for local communities. For example, research by Anh et al. shows that green tourism has had significant positive impacts on the Hmong community in Vietnam, both in terms of environmental and socio-cultural benefits (Anh et al., 2023). In this area, awareness of the importance of green tourism practices helps strengthen community commitment to sustainable tourism development. This suggests that the higher the quality of governance and community participation in program planning and implementation, the greater the positive impact.

In this regard, the top-down governance that often dominates the tourism sector can present challenges. Conversely, a community-based approach that encourages the participation of local actors in decision-making can create strategies that are more responsive and relevant to environmental and social needs at the local level (Eyisi et al., 2020b). Agreement and coordination between related parties, from the government, local communities, to business actors are very important to create a tourism ecosystem that supports green tourism initiatives well (Liu et al., 2023).

The quality of local governance also influences the practical sustainability of green tourism. Hidayat et al. emphasize the importance of environmental management and community involvement in the development of environmentally friendly infrastructure (Hidayat et al., 2023). When communities have a voice in decision-making, they are more likely to have a sense of ownership and responsibility for environmental sustainability, which directly reduces the negative impacts of tourism. Conversely, community dissatisfaction with externally imposed initiatives can lead to resistance, which can actually be detrimental to the desired sustainability goals. Research by Duc and Thanh suggests that the quality of community awareness and commitment to participating in green tourism models is closely related to their understanding of the environmental and socio-economic benefits of education (Duc & Thanh, 2023).

3.5 The Role of Public Policy in Accelerating the Green Tourism and Digital Tourism Transition

The role of fiscal policy and government incentives is crucial in accelerating the transition to green and digital tourism. Fiscal policy encompasses various instruments, such as subsidies, tax incentives, and government spending, aimed at supporting the development of the tourism sector with a more sustainable and environmentally friendly approach. For example, the government can provide tax incentives to tourism businesses that implement sustainable practices, such as the use of renewable energy and efficient waste management, to encourage the adoption of green technologies (Oktarini et al., 2023). In the context of digital tourism, fiscal policy can also support initiatives to improve the digital infrastructure needed to strengthen the tourism industry.

The successful integration of digital technology into tourism is closely linked to the availability of adequate infrastructure. Therefore, allocating government budgets to

develop IT and communications infrastructure not only supports digital tourism development but also enhances the competitiveness of tourist destinations (Hendrasmo et al., 2022). Munawar pointed out that the quality of governance and existing infrastructure must be improved so that the incentives provided can be utilized optimally (Munawar, 2021). For example, if there is no adequate internet access, tourism digitalization initiatives will not be successful even if there are attractive incentives (Hendrasmo et al., 2022). On the other hand, technological literacy also plays a key role in determining the success of this policy.

Effective policies should include training programs for local tourism industry players so they can utilize digital technologies to improve their services and build rapport with visitors (Koroy et al., 2022). A study by Sutawijaya and Lestari explains that sustainable resource management must be an integral part of government fiscal policies. By prioritizing spending on environmental initiatives, such as waste management and conservation, the government can create a more supportive environment for green tourism. (Koroy et al., 2022).

3.6 Role of Green Tourism in Emission Reduction

The relationship between economic growth and carbon emissions in Trenggalek Regency can be analyzed using the Environmental Kuznets Curve (EKC) framework. The EKC proposes that in the early stages of economic growth, carbon emissions increase along with increased economic activity. However, after reaching a certain level of per capita income, emissions begin to decline even as economic activity continues (Majumdar & Paris, 2022). In Trenggalek, which is a developing district with the development of tourism and agricultural sectors, this pattern can be found, where the initial growth of emissions may be in line with economic growth.

Several factors influence this relationship, particularly in the context of the tourism and agriculture sectors. First, in the tourism sector, growth in tourist numbers can increase carbon emissions due to increased demand for transportation, accommodation, and various other services (Bekun et al., 2022). Research shows that the tourism sector has a significant contribution to global carbon emissions, with the sector contributing between 5-8% of total emissions (Bekun et al., 2022). In Trenggalek, the increasing flow of tourists can result in a heavier burden on infrastructure, increasing energy consumption and resource expenditure, potentially increasing carbon emissions.

Second, in the agricultural sector, traditional farming practices are often not environmentally friendly and can produce significant methane and nitrous oxide emissions (Kusuma et al., 2024). As people's incomes increase, there is a tendency to use more intensive agricultural techniques, which can also result in higher emissions (Qi et al., 2023). Innovative steps in agricultural technology, such as the use of sustainable farming techniques and renewable energy, can help reduce the carbon footprint in this sector (Qi et al., 2023). For example, the use of efficient and environmentally friendly technologies in agriculture can reduce carbon emissions associated with the processing and distribution of agricultural products (Yong-lian et al., 2021).

Policies that promote investment in sustainable agricultural practices and the development of a greener tourism sector are essential for managing the carbon emissions impact of economic growth in Trenggalek. By using green technologies and adopting emission reduction initiatives, such as improved waste management and environmental conservation, the negative impacts of these sectors can be minimized and more closely aligned with the expected EKC pattern. Therefore, a comprehensive and strategic policy analysis is crucial to achieving a balance between economic growth and carbon emission mitigation in Trenggalek Regency.

CONCLUSION

This study examines the relationship between economic growth, carbon emissions, and the tourism sector in Trenggalek Regency within the framework of the Environmental Kuznets Curve (EKC) theory. The results indicate that while tourism contributes to local economic growth, it also risks increasing carbon emissions if not balanced with sustainability strategies. A green tourism approach based on conservation and community participation has been proven to reduce environmental impacts while strengthening the social and economic resilience of local communities. Furthermore, digital tourism holds significant potential in supporting efficient destination management, environmental education, and reducing emissions from the transportation and accommodation sectors. The strategic integration of green tourism and digital tourism offers an opportunity to accelerate the transition to low-carbon tourism development. However, the success of this transformation depends heavily on the availability of digital infrastructure, the quality of local governance, and the support of public policies that support sustainability. Overall, this study emphasizes the importance of a holistic and adaptive approach to tourism to address environmental challenges, particularly in developing regions like Trenggalek Regency in Indonesia. These findings provide an important contribution to the development of sustainable tourism policies and practices that can be broadly applied in similar regions.

Implication

The findings of this study have important implications for the development of theory, practice, and policy in the sustainable tourism sector. Theoretically, this study extends the application of the Environmental Kuznets Curve (EKC) framework by highlighting the strategic role of green and digital tourism in balancing economic growth and carbon emission reduction. In practice, community-based approaches and the use of digital technology have proven effective in improving destination management efficiency and empowering local communities. From a policy perspective, fiscal incentives, digital infrastructure investment, and cross-sector synergies are needed to accelerate the transition to low-carbon tourism, especially in areas vulnerable to environmental crises like Trenggalek.

Limitation and Future Direction

This study is limited by its reliance on secondary data from literature sources, which may constrain the depth of contextual analysis and empirical validation specific to Trenggalek in Indonesia. The generalizability of findings to other regions may also be restricted due to the unique geographic and socio-economic characteristics of the study

area. Furthermore, the study does not incorporate quantitative modeling to test the EKC framework or measure carbon reduction impacts directly. Future research should consider primary data collection through surveys or participatory mapping to assess community perceptions, digital adoption rates, and actual emission metrics. Comparative case studies across similar rural and coastal regions in Indonesia or Southeast Asia are also recommended to validate and refine the conceptual model proposed in this study.

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