Almana : Jurnal Manajemen dan Bisnis
Volume 9 No. 3/ December 2025: 444-457
p-ISSN: 2579-4892/ e-ISSN: 2655-8327
DOI: 10.36555/almana.v9i3.2914

# Smart Ecotourism: Integrating Technology into Sustainable Ecotourism Management

**Eva Susilawati[1], Wahid Hasim Sa'roni*[2], Emil Herdiana[1]**
Universitas Putra Indonesia, Indonesia[1], Sekolah Tinggi Ilmu Ekonomi Wibawa Karta Raharja, Indonesia*[2]
*Coresponding Email: wahidhasimsaroni@gmail.com

**Abstract:** This research is motivated by the challenges of ecotourism management in West Java, which, despite its great potential, still faces problems of ecosystem degradation and suboptimal destination management. This study aims to develop a technology-based smart ecotourism model by integrating environmental, social, and economic aspects simultaneously, as a novelty from previous studies that generally only emphasize one aspect of management. The method used is a quantitative approach through a survey of 150 respondents consisting of ecotourism managers, tourists, and local communities in several leading destinations in West Java. Data were collected using a 1-5 Likert scale questionnaire and analyzed using validity and reliability tests, multiple linear regression, and path analysis with the help of SPSS 22. The results showed that the use of technology has a positive and significant effect on ecotourism sustainability ($R^2 = 0.801$, $p < 0.05$), but does not have a significant effect on the socio-economic impacts of the community, and ecotourism sustainability was not proven to mediate the relationship. The research conclusion emphasizes that technology integration needs to be accompanied by community empowerment programs to make socio-economic benefits more tangible, with recommendations in the form of increasing digital literacy, developing community-based platforms, and regional policies that support technology synergy and local welfare.

**Article History:**
Submitted: August 21, 2025
Revised: December 02, 2025
Accepted: December 05, 2025
Published: December 30, 2025

**Keywords:**
Ecotourism Management
Environmental Sustainability
Smart Ecotourism
Technology

Susilawati, E., Sa'roni, W. H., & Herdiana, E. (2025). Smart Ecotourism: Integrating Technology into Sustainable Ecotourism Management. *Almana : Jurnal Manajemen dan Bisnis, 9*(3), 444-457. https://doi.org/10.36555/almana.v9i3.2914

## INTRODUCTION

Ecotourism is a tourism approach that emphasizes environmental conservation, local community empowerment, and tourist education as part of sustainable development (UNWTO, 2022). In Indonesia, particularly in West Java, ecotourism plays a strategic role due to its rich natural resources and high biodiversity, such as those found in Mount Gede Pangrango National Park, Kawah Putih (White Crater), and Ciletuh Geopark (Nugraha et al., 2021). Despite this significant potential, innovative and sustainable ecotourism management remains suboptimal. Challenges such as environmental degradation, low conservation literacy, limited digital infrastructure, and minimal community participation are still encountered in various ecotourism destinations (Kurniawan et al., 2022).

As digital transformation advances, the use of information technology offers significant opportunities to address these issues. The concept of smart ecotourism, the integration of digital technology into sustainable ecotourism management, is increasingly relevant. Technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, and Geographic Information Systems (GIS) can improve operational efficiency, support data-driven decision-making, and enhance management transparency (Gretzel et al., 2021; Li et al., 2021; Rahman, 2023). IoT, for example, enables real-time monitoring of carrying capacity and visitor numbers, while blockchain technology has the potential to create a transparent and accountable smart contract-based digital ticketing system (Rahmawati & Nurlatifah, 2022).

The increasing adoption of technology in the global tourism industry has also accelerated digitalization at the local level. Setiawan (2020) emphasized that digital transformation is a crucial prerequisite for creating smart, inclusive, and resilient destinations. Meanwhile, Dewi et al. (2019) demonstrated that interactive digital applications have been proven to enhance the tourist experience and satisfaction at ecotourism sites.

However, research in Indonesia has so far been fragmented and tends to focus on a single type of technology, such as GIS or mobile applications, without an integrative approach that simultaneously combines social, economic, and environmental dimensions (Hartono et al., 2020; Dewi et al., 2019). Furthermore, the socio-economic aspects of technology utilization have not been widely studied, although global studies emphasize the importance of digital literacy and infrastructure availability as determining factors for the successful implementation of smart tourism destinations (Gretzel et al., 2021; Buhalis & Sinarta, 2022). Local conditions also indicate a digital literacy gap among communities surrounding natural tourism destinations (Kurniawan et al., 2022).

Sustainable ecotourism should not only be oriented towards environmental conservation but also provide socio-economic benefits to local communities through job creation, business opportunities, and strengthening cultural identity (Nugraha et al., 2021). Therefore, smart ecotourism development needs to be analyzed not only from a technological perspective but also from how technology can drive inclusive socio-economic transformation.

Based on these conditions, this article seeks to fill the theoretical and practical gaps regarding ecotourism management in West Java by analyzing the integration of digital technology in sustainable ecotourism management. Using a systemic approach involving managers, tourists, and local communities, this research aims to develop a technology-based management model with the potential to be replicated in other ecotourism destinations in Indonesia.

The development of digital technology over the past few years has significantly transformed the way ecotourism is managed. Technologies such as the Internet of Things (IoT), big data analytics, artificial intelligence (AI), and blockchain are increasingly being implemented to improve destination management efficiency, enrich the tourist experience, and strengthen environmental conservation efforts (Gretzel, Koo, & Lee, 2021; Rahman, 2023). IoT enables real-time monitoring of environmental conditions, including air quality, humidity, temperature, and visitor density, thus helping managers maintain the carrying capacity of tourist areas and prevent overtourism, which can potentially damage ecosystems (Widodo et al., 2019).

AI and machine learning technologies are also increasingly being used to predict tourist behavior patterns, manage travel preferences, and provide personalized recommendations based on data analysis (Li, Pearce, & Low, 2021). The use of big data enables decision-makers to gain more accurate insights into visitation trends, tourist interests, and changing environmental conditions, enabling more adaptive and responsive area management policies.

On the other hand, GIS has been widely used in mapping conservation-based tourism areas to support sustainable spatial planning (Hartono et al., 2020). Digital technologies based on mobile applications, augmented reality (AR), and virtual reality

(VR) have also been shown to enrich tourist experiences and support conservation education through the presentation of interpretive information in an engaging and interactive manner (Dewi et al., 2019).

Recent studies on smart tourism destinations emphasize that information system integration, stakeholder connectivity, and real-time data utilization are key components in improving destination governance and tourism resilience (Gretzel et al., 2021). However, despite the technology's significant potential, various challenges remain in its implementation, such as the digital divide, limited infrastructure, and low technological literacy among managers and local communities (Kurniawan et al., 2022). These challenges demonstrate that the use of technology in ecotourism requires social, cultural, and institutional readiness to achieve optimal benefits.

Sustainability in the context of ecotourism emphasizes the integration of environmental conservation, social welfare, and the quality of the tourist experience as a unified destination management system (UNWTO, 2022). Destinations such as Mount Gede Pangrango National Park and Ciletuh Geopark have significant potential to serve as models for sustainable ecotourism development at the national level. However, several challenges, such as environmental degradation, limited coordination between stakeholders, and weak conservation oversight, remain obstacles to achieving this sustainability (Nugraha et al., 2021).

The integration of digital technology has emerged as a strategic approach to strengthening ecotourism sustainability. The use of big data and IoT enables more accurate carrying capacity planning, real-time monitoring of environmental conditions, and the implementation of evidence-based conservation policies (Rahman, 2023). Setiawan (2020) emphasized that technology can also expand local community participation through digital engagement, a crucial element in the success of sustainable ecotourism management.

Furthermore, ecotourism sustainability is often studied through the Triple Bottom Line approach, which in recent literature is understood as a framework that emphasizes the balance between economic, social, and environmental dimensions in every development activity (Amini & Rustiana, 2020; Alhaddi, 2019). This contemporary version of the Triple Bottom Line framework emphasizes that the goal of ecotourism is not only environmental conservation but also improving the well-being of local communities and the economic sustainability of the destination.

Ecotourism not only provides ecological benefits but also serves as a strategic instrument to improve the welfare of local communities through job creation, entrepreneurial opportunities, and strengthening community cultural identity (Nugraha et al., 2021). The use of digital technologies such as e-commerce and online marketing platforms enables communities to reach a wider consumer base, promote local products, and strengthen the creative economy based on tourism villages (Kurniawan et al., 2022). Blockchain technology also offers significant potential to promote more transparent governance through the implementation of smart contracts that can ensure equitable distribution of profits, thereby minimizing income inequality within ecotourism management communities (Rahman, 2023).

However, the benefits of technology can only be optimally realized if accompanied by sustainable capacity-building and digital empowerment programs. Without adequate mentoring and digital literacy, technology adoption risks widening social gaps between actors in destination management, especially for groups with limited access to education and technology (Rahmawati & Nurlatifah, 2022).

Several recent studies have shown efforts to integrate digital technology into ecotourism management, although most remain limited to the application of a single technology. Hartono et al. (2020), for example, examined the use of Geographic Information Systems (GIS) in mapping conservation-based ecotourism areas. GIS technology enables the identification of vulnerable zones, analysis of land cover changes, and the creation of thematic maps that can support spatial data-based management decisions.

Dewi, Sari, and Putra (2019) highlighted the importance of developing mobile-based digital applications to enhance the tourist experience at natural tourism destinations. These applications provide interactive interpretive information about flora and fauna and increase tourist engagement in conservation through a digital storytelling approach. Meanwhile, Widodo et al. (2019) focused on utilizing the Internet of Things (IoT) to monitor environmental parameters such as temperature, humidity, and air quality in real time. Their findings suggest that IoT can serve as a tool for predicting environmental damage through monitoring and early warning.

Rahman (2023) expands on this discussion by integrating more complex technologies, such as artificial intelligence (AI) and blockchain. He argues that AI can be used to analyze tourist visit patterns, predict ecosystem loads, and optimize visitor flow. Meanwhile, blockchain enables transparency in the management of conservation funds and the distribution of profits through the implementation of tamper-proof smart contracts.

However, these studies still yield conceptual and methodological gaps. Recent literature reveals that some studies focus solely on one type of technology or one aspect of ecotourism, such as the environment, tourists, or managers, without considering the systemic interrelationships between them (Gretzel, Koo, & Lee, 2021). To date, there has been no comprehensive approach that simultaneously integrates IoT, AI, big data, GIS, and blockchain within a single, intelligent ecotourism management framework that engages destination managers, local communities, and tourists.

Furthermore, the socio-economic aspects of digital transformation in ecotourism remain underexplored. Recent research emphasizes that ecotourism sustainability encompasses more than environmental conservation, but also ensures improved local community well-being through equitable benefit distribution, economic empowerment, and expanded digital access (Amini & Rustiana, 2020; Alhaddi, 2019). Recent international studies also note that the success of technology adoption in the tourism sector is heavily influenced by community readiness, policy support, and digital literacy levels (Buhalis & Sinarta, 2022).

Thus, this research makes an important contribution in filling this gap by designing a smart ecotourism model that comprehensively integrates digital technology while involving local communities, and measuring its sustainability and socio-economic impacts in a structured manner.

Based on the theory and previous research results described in the literature review, the following hypotheses are formulated:

H1: The use of technology has a positive influence on the sustainability of ecotourism in West Java.

H2: The use of technology has a positive impact on the socioeconomic well-being of local communities.

H3: The sustainability of ecotourism mediates the effect of technology use on the socioeconomic well-being of communities.

## METHODS

This study uses a quantitative approach with a survey method to analyze the influence of technology utilization on ecotourism sustainability and the socio-economic impacts of communities in West Java. A quantitative approach was chosen because it allows for objectively measurable relationships between variables through statistical analysis techniques, allowing the research results to be generalized to a wider population (Kurniawan et al., 2022). The survey method is considered appropriate because it can collect primary data directly from respondents through a questionnaire instrument and is widely used in research focusing on individual perceptions and experiences related to ecotourism management and digital technology (Rahman, 2023).

The subjects of this study were parties directly involved in ecotourism activities in West Java, namely ecotourism destination managers, tourists, and the surrounding community. The research respondents numbered 150 people, consisting of 50 ecotourism managers, 50 tourists, and 50 residents from leading destinations such as Mount Gede Pangrango National Park, Kawah Putih, and Ciletuh Geopark. These three groups of subjects were chosen because they have different roles and experiences, which complement each other in providing a comprehensive picture of the implementation of the smart ecotourism concept.

Meanwhile, the research object is the use of digital technology in sustainable ecotourism management in West Java, which is analyzed through three main variables: technology utilization, ecotourism sustainability (environmental preservation, carrying capacity management, and conservation), and socio-economic impacts (income increase, job creation, and local community involvement). This research object was chosen to assess the extent to which technology integration can encourage the creation of a sustainable ecotourism management model and provide real benefits to the environment, society, and the regional economy.

This research was conducted over three months, encompassing pre-survey stages, data collection, data analysis, and report preparation. The research locations included leading ecotourism destinations in West Java, such as Kawah Putih, Ciletuh Geopark, and Mount Gede Pangrango National Park.

The population in this study was parties directly involved in ecotourism management and activities in West Java, including ecotourism destination managers, tourists, and local communities in tourist areas such as Mount Gede Pangrango National Park, Kawah Putih, and Ciletuh Geopark (Nugraha et al., 2021).

Because the exact population size is unknown, this study used a purposive sampling technique, which selects samples based on respondents' involvement and relevance to the research topic (Kurniawan et al., 2022). The sample size was determined based on the recommendations of Hair et al. (2019), who suggest a minimum sample size of 5-10 times the number of research indicators. With 15-20 indicators in the research variables, a sample size of 150 respondents is considered representative. This sample consisted of 50 ecotourism managers, 50 tourists, and 50 local community respondents.

This approach is expected to provide a comprehensive picture of the perceptions and experiences of all key actors involved in smart ecotourism in West Java (Setiawan, 2020; Rahman, 2023).

Data collection techniques were carried out through: Closed questionnaires based on a Likert scale of 1-5 distributed to respondents to measure the level of technology adoption, perception of sustainability, and socio-economic impacts with research instruments in the form of questionnaires compiled based on indicators from related literature: (1) Technology Utilization (X): IoT, big data, AI, digital applications (Widodo et al., 2019; Prasetyo, 2021); (2) Ecotourism Sustainability (Y): environmental preservation, tourism carrying capacity management, and conservation (UNWTO, 2022); (3) Socioeconomic Impact (Z): increased income, community engagement, and job creation (Kurniawan et al., 2022; Nugraha et al., 2021); (4) Validity and reliability tests will be conducted to ensure the research instruments are suitable for use.

Data were analyzed using SPSS 22 with the following steps: (1) Validity and Reliability Test (using Cronbach's Alpha); (2) Descriptive Statistical Analysis to describe respondent profiles and data distribution; (3) Multiple Linear Regression Test to examine the effect of independent variables on the dependent variable; (4) Path Analysis to examine direct and indirect influences between variables.

## RESULTS AND DISCUSSION

**Table 1. Descriptive Statistics**

| | N | Range | Minimum | Maximum | Sum | Mean | | Std. Deviation | Variance |
|---|---|---|---|---|---|---|---|---|---|
| | Statistic | Statistic | Statistic | Statistic | Statistic | Statistic | Std. Error | Statistic | Statistic |
| Utilization of Technology | 150 | 52.00 | 23.00 | 75.00 | 8973.00 | 59.8200 | .98039 | 12.00731 | 144.175 |
| Ecotourism Sustainability | 150 | 51.00 | 24.00 | 75.00 | 9235.00 | 61.5667 | 1.07867 | 13.21095 | 174.529 |
| Socio-Economic Impact | 150 | 32.00 | 43.00 | 75.00 | 9367.00 | 62.4467 | .76761 | 9.40123 | 88.383 |
| Valid N (listwise) | 150 | | | | | | | | |

Source: Output SPSS 22 (2025)

### Technology Utilization Condition Variables

The average technology utilization score of 59.82 indicates that most respondents rated technology utilization in ecotourism management as high. However, the relatively large range (52 points) and relatively large standard deviation (12.01) indicate varying levels of technology utilization across locations and by various ecotourism actors.

Thus, the use of technology in ecotourism is quite good, but not yet evenly distributed. This indicates an opportunity for capacity building and wider technology adoption across the region.

### Conditions of Ecotourism Sustainability Variables

The average score for ecotourism sustainability was 61.57, higher than the average score for technology utilization. This indicates that the sustainability dimensions (environmental, social, and economic) performed relatively well. However, the high standard deviation (13.21) and variance indicate highly variable levels of perception among respondents.

Thus, ecotourism in West Java has generally demonstrated sustainable practices, but there are significant differences in their implementation across locations. This underscores the importance of policy standardization and increased participation of all stakeholders.

### Condition of Socio-Economic Impact Variables

With an average score of 62.45, perceptions of the socio-economic impacts of ecotourism are high and positive. The lowest standard deviation among the three variables (9.40) indicates a more consistent perception among respondents.
Conclusion:

Thus, ecotourism has significant social and economic impacts on local communities. The relatively uniform perceptions of respondents indicate that the benefits are broad and tangible.

**Table 2. Information (X)**

| Statement | R Count | R Table | Status | Information |
|---|---|---|---|---|
| X1 | 0,763 | 0,159 | > | Valid |
| X2 | 0,843 | 0,159 | > | Valid |
| X3 | 0,850 | 0,159 | > | Valid |
| X4 | 0,771 | 0,159 | > | Valid |
| X5 | 0,936 | 0,159 | > | Valid |
| X6 | 0,816 | 0,159 | > | Valid |
| X7 | 0,897 | 0,159 | > | Valid |
| X8 | 0,722 | 0,159 | > | Valid |
| X9 | 0,807 | 0,159 | > | Valid |
| X10 | 0,856 | 0,159 | > | Valid |
| X11 | 0,805 | 0,159 | > | Valid |
| X12 | 0,842 | 0,159 | > | Valid |
| X13 | 0,882 | 0,159 | > | Valid |
| X14 | 0,910 | 0,159 | > | Valid |
| X15 | 0,746 | 0,159 | > | Valid |

Source: Output SPSS 22 (2025)

The 15 items of the technology utilization variable (X1-X15) show correlation coefficients (r-count) ranging from 0.722 to 0.936, all of which are greater than the r-table value of 0.159. This indicates that each item is valid and accurate in measuring the intended construct. The high coefficient range, especially values above 0.80 for most items, indicates strong internal consistency and strong indicator loadings for the technology utilization construct.

**Table 3. Reliability Statistics**

| Cronbach's Alpha | N Item |
|---|---|
| .962 | 15 |

Sumber: Output SPSS 22 (2025)

The Cronbach's Alpha coefficient was 0.962, exceeding the minimum threshold of 0.7. This value confirms that the items have excellent internal reliability, meaning the scale consistently measures the concept of technology utilization in ecotourism.

**Table 4. Results of the Validity Test of the Ecotourism Sustainability Variable (Y)**

| Statement | R Count | R Table | Status | Information |
|---|---|---|---|---|
| Y1 | 0,798 | 0,159 | > | Valid |
| Y2 | 0,873 | 0,159 | > | Valid |
| Y3 | 0,902 | 0,159 | > | Valid |
| Y4 | 0,863 | 0,159 | > | Valid |
| Y5 | 0,915 | 0,159 | > | Valid |
| Y6 | 0,905 | 0,159 | > | Valid |
| Y7 | 0,348 | 0,159 | > | Valid |
| Y8 | 0,734 | 0,159 | > | Valid |
| Y9 | 0,914 | 0,159 | > | Valid |
| Y10 | 0,957 | 0,159 | > | Valid |
| Y11 | 0,874 | 0,159 | > | Valid |
| Y12 | 0,900 | 0,159 | > | Valid |
| Y13 | 0,896 | 0,159 | > | Valid |
| Y14 | 0,916 | 0,159 | > | Valid |
| Y15 | 0,884 | 0,159 | > | Valid |

Source: Output SPSS 22 (2025)

The correlation coefficients (r-count) for items Y1-Y15 ranged between 0.348 and 0.957, all exceeding the critical value of 0.159. This indicates that each item is valid. However, item Y7, with the lowest correlation (0.348), while still valid, may need to be reviewed for potential improvements in future research to strengthen the overall measurement of the construct.

**Table 5. Reliability Statistics**

| Cronbach's Alpha | N Item |
|---|---|
| .973 | 15 |

Sumber: Output SPSS 22 (2025)

Cronbach's Alpha of 0.973 indicates a very high level of reliability, reflecting excellent internal consistency among the items measuring ecotourism sustainability.

**Variable Z**

**Table 6. Results of the Validity Test of the Socio-Economic Impact Variable (Z)**

| Statement | R Count | R Table | Status | Information |
|---|---|---|---|---|
| Z1 | 0,818 | 0,159 | > | Valid |
| Z2 | 0,886 | 0,159 | > | Valid |
| Z3 | 0,660 | 0,159 | > | Valid |
| Z4 | 0,703 | 0,159 | > | Valid |
| Z5 | 0,635 | 0,159 | > | Valid |
| Z6 | 0,594 | 0,159 | > | Valid |
| Z7 | 0,897 | 0,159 | > | Valid |
| Z8 | 0,855 | 0,159 | > | Valid |
| Z9 | 0,622 | 0,159 | > | Valid |
| Z10 | 0,839 | 0,159 | > | Valid |
| Z11 | 0,747 | 0,159 | > | Valid |
| Z12 | 0,705 | 0,159 | > | Valid |
| Z13 | 0,798 | 0,159 | > | Valid |
| Z14 | 0,850 | 0,159 | > | Valid |
| Z15 | 0,811 | 0,159 | > | Valid |

Source: Output SPSS 22 (2025)

Validity tests for the socio-economic impact variables (Z1-Z15) showed r-values ranging from 0.594 to 0.897, all above the threshold of 0.159. This indicates that each item validly captures aspects of the socio-economic impact. Items Z3, Z5, Z6, and Z9 have relatively lower coefficients (0.594-0.660), implying slightly weaker but still acceptable validity.

**Table 7. Reliability Statistics**

| **Cronbach's Alpha** | **N Item** |
|---|---|
| .948 | 15 |

Sumber: Output SPSS 22 (2025)

With a Cronbach's Alpha of 0.948, the socio-economic impact scale demonstrated excellent reliability, ensuring consistent measurement across items.

**Results of the Classical Assumption TestNormality**
X against Y:

**Table 8. One-Sample Kolmogorov-Smirnov Test**

| | | Unstandardized Residual |
|---|---|---|
| N | | 150 |
| Normal Parameters[a,b] | Mean | .0000000 |
| | Std. Deviation | 4.95387520 |
| Most Extreme Differences | Absolute | .162 |
| | Positive | .162 |
| | Negative | -.089 |
| Test Statistic | | .162 |
| Asymp. Sig. (2-tailed) | | .000[c] |

Source: Output SPSS 22 (2025)

X and Y against Z:

**Table 9. One-Sample Kolmogorov-Smirnov Test**

| | | Unstandardized Residual |
|---|---|---|
| N | | 150 |
| Normal Parameters[a,b] | Mean | .0000000 |
| | Std. Deviation | 10.23798558 |
| Most Extreme Differences | Absolute | .134 |
| | Positive | .085 |
| | Negative | -.134 |
| Test Statistic | | .134 |
| Asymp. Sig. (2-tailed) | | .000[c] |

Source: Output SPSS 22 (2025)

Normality Test (Tables 8 & 9)

For X versus Y (Table 8), the Kolmogorov-Smirnov test yielded a p-value of 0.000, indicating that the residuals were not normally distributed.

For X and Y versus Z (Table 9), the p-value was also 0.000, confirming a similar non-normal distribution of the residuals.

Although the assumption of normality is not met, regression models often tolerate mild deviations from normality, especially with larger sample sizes (N=150).

**Multicollinearity**
X against Y:

**Table 10. Coefficientsa**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 3.524 | 1.686 | | 2.091 | .038 | | |
| | Utilization of Technology | .922 | .038 | .895 | 24.404 | .000 | 1.000 | 1.000 |

Source: Output SPSS 22 (2025)

X and Y against Z:

**Table 11. Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 41.431 | 3.546 | | 11.682 | .000 | | |
| | Utilization of Technology | .024 | .176 | .026 | .139 | .890 | .199 | 5.024 |
| | Ecotourism Sustainability | -.013 | .170 | -.014 | -.074 | .941 | .199 | 5.024 |

Source: Output SPSS 22 (2025)

Multicollinearity Test (Tables 10 & 11)

X against Y (Table 10): The VIF is 1.000, and the tolerance is 1.000, showing no multicollinearity, meaning technology utilization is a strong and independent predictor of ecotourism sustainability.

X and Y against Z (Table 11): The VIF values of 5.024 for both predictors indicate high multicollinearity, suggesting that technology utilization and ecotourism sustainability are highly correlated when predicting socio-economic impact, which may affect the regression accuracy for variable Z.

**Heteroscedasticity**

X against Y:

**Table 12. Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 2.277 | .993 | | 2.294 | .023 |
| | Utilization of Technology | .039 | .022 | .143 | 1.755 | .081 |

Source: Output SPSS 22 (2025)

X and Y against Z:

**Table 13. Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 9.007 | 1.800 | | 5.004 | .000 |
| | Utilization of Technology | -.041 | .089 | -.085 | -.460 | .646 |
| | Ecotourism Sustainability | .036 | .087 | .077 | .414 | .679 |

Source: Output SPSS 22 (2025)

Heteroscedasticity Test (Tables 12 & 13)

X against Y (Table 12): The p-value of 0.081 (> 0.05) indicates no heteroscedasticity, meaning the variance of residuals is consistent.

X and Y against Z (Table 13): Both predictors have p-values of 0.646 and 0.679 (> 0.05), confirming the absence of heteroscedasticity in the second regression model.

**Table 14. Results of Correlation Coefficient Test**

| | | Utilization of Technology | Ecotourism Sustainability | Socio-Economic Impact |
|---|---|---|---|---|
| Utilization of Technology | Pearson Correlation | 1 | .895** | .013 |
| | Sig. (2-tailed) | | .000 | .871 |
| | N | 150 | 150 | 150 |
| Ecotourism Sustainability | Pearson Correlation | .895** | 1 | .009 |
| | Sig. (2-tailed) | .000 | | .910 |
| | N | 150 | 150 | 150 |
| Socio-Economic Impact | Pearson Correlation | .013 | .009 | 1 |
| | Sig. (2-tailed) | .871 | .910 | |
| | N | 150 | 150 | 150 |

Source: Output SPSS 22 (2025)

The correlation between technology utilization and ecotourism sustainability is very strong ($r = 0.895$, $p < 0.01$), indicating a strong positive relationship. In contrast, the correlation between the two variables (X and Y) and socio-economic impacts (Z) is very weak and insignificant ($r = 0.013$ and $r = 0.009$, $p > 0.05$), indicating a minimal direct relationship.

**Linear Regression and Path Analysis**
X against Y:

**Table 15. Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .895[a] | .801 | .800 | 4.97058 |

Source: Output SPSS 22 (2025)

**Table 16. ANOVA[a]**

| | Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 14714.004 | 1 | 14714.004 | 595.547 | .000[b] |
| | Residual | 3656.591 | 148 | 24.707 | | |
| | Total | 18370.595 | 149 | | | |

Source: Output SPSS 22 (2025)

**Table 17. Coefficients[a]**

| | Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 3.524 | 1.686 | | 2.091 | .038 |
| | Utilization of Technology | .922 | .038 | .895 | 24.404 | .000 |

Source: Output of SPSS 22 (2025)

Linear Regression and Path Analysis for X → Y (Tables 15, 16, 17)

The Model Summary (Table 15) shows $R = 0.895$ and $R^2 = 0.801$, indicating that 80.1% of the variance in ecotourism sustainability is explained by technology utilization.

The ANOVA (Table 16) confirms the model's significance with $F = 595.547$, $p < 0.001$, meaning the predictor variable significantly explains variations in Y.

The Coefficients Table (Table 17) shows a highly significant positive coefficient (B = 0.922, $p < 0.001$), reinforcing the strong impact of technology utilization on enhancing ecotourism sustainability.

X and Y against Z:

**Table 18. Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .015[a] | .000 | -.013 | 10.30740 |

Source: Output of SPSS 22 (2025)

**Table 19. ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 3.396 | 2 | 1.698 | .016 | .984[b] |
| | Residual | 15617.636 | 147 | 106.242 | | |
| | Total | 15621.032 | 149 | | | |

Source: Output of SPSS 22 (2025)

**Table 20. Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 41.431 | 3.546 | | 11.682 | .000 |
| | Utilization of Technology | .024 | .176 | .026 | .139 | .890 |
| | Ecotourism Sustainability | -.013 | .170 | -.014 | -.074 | .941 |

Source: Output of SPSS 22 (2025)

Linear Regression and Path Analysis for X & Y → Z (Tables 18, 19, 20)

The Model Summary (Table 18) reveals an $R^2$ of 0.000, indicating that technology utilization and ecotourism sustainability together explain almost no variance in socio-economic impacts.

The ANOVA (Table 19) supports this finding, showing a non-significant F-value (F = 0.016, p = 0.984).

The Coefficient Table (Table 20) confirms that neither technology utilization (p = 0.890) nor ecotourism sustainability (p = 0.941) significantly impacts socio-economic impacts, suggesting that other factors may play a more dominant role in shaping socio-economic outcomes.

**Descriptive Statistical Analysis of Key Variables**

Descriptive analysis showed that all three main variables, technology utilization, ecotourism sustainability, and socioeconomic impacts, received high average scores. This reflects respondents' generally positive perceptions of technology integration, sustainable practices, and the resulting benefits to local communities.

However, the wide range and high standard deviation for technology utilization and sustainability scores indicate a lack of uniformity in implementation across locations. This variation is likely due to disparities in technological infrastructure, digital literacy, and policy implementation across ecotourism destinations. These findings emphasize the need for policy harmonization and capacity building to ensure the benefits of smart ecotourism are more equitably distributed.

**Validity and Reliability of Instruments**

Validity and reliability tests confirmed that all measurement instruments used in this study were highly reliable and valid. For all three variables—Technology Utilization (X), Ecotourism Sustainability (Y), and Socioeconomic Impact (Z), Cronbach's Alpha values exceeded 0.90, indicating excellent internal consistency (Hair et al., 2019). This ensures that the indicators used accurately capture the intended constructs and can be confidently applied in future research and practical assessments.

**The Relationship Between Technology Utilization and Ecotourism Sustainability**

The results of the regression and correlation analyses indicate a very strong and significant positive relationship between technology utilization and ecotourism sustainability ($r = 0.895$; $R^2 = 0.801$; $p < 0.01$). This finding indicates that approximately 80.1% of the variation in ecotourism sustainability can be explained by the level of technology integration in destination management. The regression model $Y = 3.524 + 0.922X$ implies that each increase in technology adoption contributes to a 0.922 unit increase in sustainability scores. These results are consistent with the findings of Gretzel, Koo, and Lee (2021), Setiawan (2020), and Rahman (2023), which emphasize that the use of technologies such as IoT, big data, AI, and GIS can improve operational efficiency, strengthen data-driven decision-making, and expand stakeholder involvement in sustainable destination management.

The strong relationship between these variables confirms that digital transformation is a crucial prerequisite for improving ecotourism sustainability. Therefore, policies that support digital infrastructure development, technological capacity building, and training programs for managers and local communities are needed to ensure that technology utilization can optimally impact the environmental, social, and economic sustainability of destinations.

**The Relationship Between Technology Utilization, Ecotourism Sustainability, and Socioeconomic Impacts**

A multiple regression analysis examining the effect of technology utilization (X) and ecotourism sustainability (Y) on community socio-economic impacts (Z) showed insignificant results ($R^2 = 0.000$; $F = 0.016$; $p = 0.984$). Neither technology utilization ($p = 0.890$) nor ecotourism sustainability ($p = 0.941$) had a significant direct effect on improving socio-economic conditions. These findings indicate that technological advancements and the implementation of sustainable practices alone are not sufficient to generate tangible socio-economic benefits for communities surrounding ecotourism destinations.

These results also confirm that other external factors play a more dominant role in determining the socio-economic success of local communities. Recent research indicates that public policy support, equitable distribution of benefits, destination governance capacity, and the community's digital literacy level are important factors influencing the success of technology-based ecotourism (Gössling & Hall, 2019; Buhalis & Sinarta, 2022). Without social and institutional readiness, even the implementation of advanced technology will not produce significant socio-economic impacts.

From a practical perspective, these results underscore the need to integrate technology initiatives with local community empowerment programs, including digital literacy development, entrepreneurship training, and collaborative governance between government, destination managers, and communities. Such an integrated approach is crucial for strengthening the socio-economic resilience of local communities while ensuring the long-term sustainability of ecotourism operations.

## CONCLUSION

This study concludes that technology is a crucial catalyst for ecotourism sustainability, but its impact on socio-economic well-being will only be optimal if integrated with community empowerment policies, participatory governance, and an inclusive digital ecosystem. This research provides a strong theoretical and empirical basis for local governments, destination managers, and other stakeholders to formulate smart ecotourism development strategies that are holistic, equitable, and sustainable.

## REFERENCES

Alhaddi, H. (2019). A contemporary interpretation of the Triple Bottom Line and its relevance to sustainability. *Journal of Business Ethics and Sustainability*, *8*(1), 45-58.

Amini, R., & Rustiana, D. (2020). Triple Bottom Line framework in sustainable tourism development. *Journal of Sustainable Development Studies*, *12*(2), 55-68.

Buhalis, D., & Sinarta, Y. (2022). Smart tourism transformation and community readiness. *Tourism Management*, 91, 104534.

Dewi, M., Sari, A., & Putra, R. (2019). Mobile-based digital applications for ecotourism interpretation. *Tourism Innovation Journal*, *11*(3), 200-215.

Gössling, S., & Hall, C. M. (2019). Tourism, resilience, and sustainable development. *Journal of Sustainable Tourism*, *27*(7), 1075-1092.

Gretzel, U., Koo, C., & Lee, J. (2021). Smart tourism ecosystems and destination resilience. *Journal of Destination Marketing & Management*, 20, 100622.

Hartono, L., Syahputra, D., & Anwar, S. (2020). GIS-based ecotourism mapping for conservation planning. *Geospatial Journal*, *9*(1), 33-48.

Kurniawan, T., Hasan, M., & Sutopo, D. (2022). Digital empowerment and technology adoption in community-based tourism. *Journal of Sustainable Tourism Research*, *18*(1), 55-70.

Li, J., Pearce, P. L., & Low, D. (2021). AI applications in digital tourism environments. *Tourism Management*, 83, 104248.

Nugraha, B., Lestari, F., & Widodo, R. (2021). Sustainable ecotourism management and community welfare in West Java. *Indonesian Tourism Journal*, *10*(2), 45-60.

Rahman, A. (2023). Blockchain and AI integration for sustainable ecotourism management. *Journal of Ecotourism and Technology*, *5*(4), 99-113.

Rahmawati, I., & Nurlatifah, E. (2022). Digital literacy barriers in rural tourism communities. *Journal of Tourism and Technology*, *14*(2), 112-124.

Setiawan, R. (2020). Digital transformation and community participation in smart tourism. *Tourism Research Journal*, *15*(3), 102-118.

UNWTO. (2022). *Sustainable tourism development: A global perspective*. United Nations World Tourism Organization.

Widodo, S., Pranata, H., & Kusuma, A. (2019). IoT-based environmental monitoring for natural tourism destinations. *Journal of Environmental Science*, *12*(4), 78-90.