

Digital Technology Driving Sustainable Development in Rural Ecotourism

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Abstract

This study investigates the role of digital technologies in advancing sustainable development within rural ecotourism, focusing on integrating e-commerce, e-payment systems, and Internet marketing. While digitalization in tourism is widely discussed, its specific implications for rural ecotourism remain underexplored. This research addresses that gap by adopting a novel theoretical approach that integrates the Triple Bottom Line (TBL), Technology Acceptance Model (TAM), and Destination Management Organization (DMO) frameworks. A cross-sectional survey of 401 stakeholders—tourists, local business owners, community members, and government officials—provides empirical insights into technology adoption, perceived benefits, and implementation challenges. The findings reveal moderately positive perceptions of digital tools across stakeholder groups, with significant concerns about privacy, digital literacy, and connectivity in rural areas. Statistical analysis through descriptive statistics, Analysis of variance (ANOVA), and t-tests shows variation in perceptions by gender but limited differences across age, education, or occupation. The study contributes a new understanding of how digital platforms can enhance economic viability, environmental responsibility, and community participation in rural tourism. This research offers actionable recommendations for stakeholders aiming to implement inclusive, sustainable digital strategies. It advances the academic conversation by linking technology acceptance with sustainable tourism outcomes in rural settings, presenting a practical and theoretical framework for future digital transformation efforts in ecotourism.

Keywords:

Digital technologies, sustainable development, rural ecotourism, stakeholder perceptions, technology adoption, e-commerce, e-payment, internet marketing

1 INTRODUCTION

In recent years, considerable attention has been devoted to the relationship between digital technologies and sustainable development (Kottmeyer, 2021; Mondejar et al., 2021; Plečko & Bradac Hojnik, 2024). Rural ecotourism is an optimal setting for this fusion due to its capacity to foster economic development and conserve natural resources through the judicious application of digital tools. Sustainable development is manifested



through rural ecotourism, an industry that strikes a balance between generating profits and safeguarding the environment (Aminu Mohammed, 2022; Dang, 2023; Makian et al., 2022; Plečko & Bradac Hojnik, 2024). The visitor industry, however, is undergoing a profound transformation in the digital age. Rural ecotourism destinations have experienced both benefits and drawbacks as a result of the proliferation of digital technology, which has revolutionized business operations and consumer interaction. While modern technologies undeniably enhance visibility and accessibility, their integration must be approached with caution to prevent adverse effects on local ecosystems and cultures (Abdullah et al., 2020; Brandt & Buckley, 2018; Gabriel-Campos et al., 2021; Howitt & Mason, 2018; Zoysa, 2022).

Despite growing interest in digitalization within the tourism sector, few studies have investigated how digital tools directly contribute to the sustainability of rural ecotourism systems—particularly from the perspective of diverse stakeholders such as local businesses, tourists, and government agencies (El Archi et al., 2023; Li et al., 2022; Mondejar et al., 2021; Tang et al., 2022). Existing research focuses on urban or high-traffic destinations, leaving rural areas underrepresented in the academic discourse (Li et al., 2022; Saseanu et al., 2020; Talwar et al., 2022). This study addresses that gap by providing one of the first empirical examinations of stakeholder perceptions and usage patterns of digital technologies (e-commerce, e-payment, internet marketing) in rural ecotourism. By integrating three theoretical models—Triple Bottom Line (TBL) (Stoddard et al., 2012; Wu et al., 2019), Technology Acceptance Model (TAM) (Kalayou et al., 2020; Park et al., 2022), and Destination Management Organization (DMO) (Rodrigues et al., 2023)—this research offers a novel analytical lens to assess how digital innovation aligns with environmental, social, and economic sustainability goals.

The report is vital for all stakeholders, such as small businesses, government agencies, and conservation groups in rural ecotourism. This report outlines the advantages and disadvantages of integrating technology in rural areas. It will help in understanding and planning sustainable development strategies devoid of unique hurdles the rural regions face. In addition, the report helps widen the discussion within ecotourism by showing how some digital innovations can help promote environmental care and equitable development. The prevailing discourse surrounding the application of digital technologies in rural tourism has predominantly focused on conventional visitor destinations, neglecting the intricate dynamics that are inherent in rural ecotourism. In addition, while there is considerable research on how tourists utilize technology, relatively few studies investigate how this impacts sustainability, particularly in rural regions. Moreover, the perspectives of various stakeholders—including residents, tourists, and businesses—regarding the implementation of technology in rural ecotourism remain largely unknown. In light of these knowledge deficits, a comprehensive examination of how digital technology will impact the future of rural ecotourism is required.

This research contributes original knowledge by exploring the contextual challenges and enabling factors for technology adoption in rural ecotourism through a multi-stakeholder lens. It is among the few studies to use empirical data to connect digital transformation with inclusive and sustainable rural development. Secondly, it aims to offer practical guidance on how to enhance the inclusivity and efficacy of digital interventions in rural tourism environments through the analysis of empirical data. This initiative seeks to amplify the voices of primary stakeholders with the purpose of creating dialogue and cooperation for a more equitable and sustainable paradigm shift in the tourism industry. This study seeks to provide insight into the intricate

relationship involving the digital technologies used in rural ecotourism with the aim of providing a resilient and sustainable future for these fragile landscapes. This research will further allow policymakers and business people to comprehend the intricacies involving the adoption of technology and ecological preservation by meticulously analyzing the impact of the research.

The core uniqueness of this study can be presented under three key parts. First, it employs a rare TBL–TAM–DMO three framework integration, which provides a systematic way to study the link between stakeholders' actions and sustainability impacts. Second, it captures a wide range of 401 stakeholders' views through a powered statistical survey, which merges academic ideas with ground reality. Third, this study moves beyond proposing theoretical solutions by stating practical means of addressing the gaps in digital literacy, lack of connectivity, and privacy concerns that are prevalent in rural tourism development. With all these elements, the study significantly adds to the literature on sustainable tourism and digital development policy.

2 LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

The impact of tourism encountered a monumental shift with the introduction of new digital technologies. The role of technology is different in ecotourism because it requires an integration of a pollution-free environment, sustainability, community engagement, and active local participation. The intricate interplay between modern technologies and the emergence of sustainable rural ecotourism forms the theory framework upon which the research is built, as it elucidates the diverse ways in which technology impacts ecotourism, notably in preserving nature, empowering the community and sustained economically responsible long-term tourism (Bello et al., 2016; Hafezi et al., 2023; Zamzuki et al., 2023).

Furthermore, the remotely located businesses' automated clearing house payment systems make it easier to turn potential consumers into actual customers because more payment options are now available. These small businesses improve financial inclusion and sustainable economic growth by lowering access barriers to small enterprises. Furthermore, these systems support social cohesion and well-being by promoting better and more equal distribution of tourism's economic benefits among rural areas (Chen et al., 2022; Mondejar et al., 2021; Zhang & Qiu, 2024).

The reach of rural ecotourism sites can be optimized through Internet marketing, which fosters enhanced community engagement, boosts attendance, and improves recognition. SEO and content marketing are some examples of digital means that can be used to target audiences and promote visibility for these businesses (Afren, 2024; Hussain et al., 2024; Sangpikul, 2010). Marketing provides deeply immersive experiences by appealing to the guests with strategic storytelling and detailed merchandising, motivating them to make eco-friendly travel choices. Moreover, authentic historical encounters and astonishing natural vistas draw the attention of the public (Plečko & Bradac Hojnik, 2024; Raji et al., 2024; Riso & Morrone, 2023). Marketing assists in reaching potential clients, thus offering rural industries chances for personalized and relationship-oriented contacts. It promotes cultural preservation, environmental stewardship, responsible travel, and responsible tourism certifications by emphasizing sustainable initiatives, eco-friendly practices, and responsible tourism. Internet marketing is significantly crucial in the promotion of remote ecotourism locations (Kott-



meyer, 2021; Li et al., 2022; Makian et al., 2022; Zamzuki et al., 2023). This present study fills a regional gap by examining stakeholder-level differences in perception and use—an area largely absent in broader international literature (see Table 1 below).

Table 2.1: Comparative analysis of cross-regional similarities and differences

Aspect	Developed Regions (e.g., EU, NZ)	Developing Regions (e.g., Peru, China)	This Study (Rural Context)
Tech Infrastructure	High-speed internet, smart apps	Intermittent access, mobile-heavy	Mobile-based, moderate access
Adoption Drivers	Eco-certification, smart regulation	Economic need, digital curiosity	Convenience, efficiency
Adoption Barriers	Privacy concerns, eco-overload	Connectivity, literacy, affordability	Infrastructure, trust, digital skills
Stakeholder Role	DMO-led innovation networks	NGOs, community-driven pilots	Fragmented, role ambiguity
Sustainability Link	Integrated with green policies	Indirect or project-dependent	Theoretically framed, operationally fragmented

2.1 Digital Transformation in Global Ecotourism

Developmental regions at the international level have driven ecotourism's digital transformation by establishing strong infrastructure and joining digital systems while establishing tourism innovation centers with government support (Tang & Zhu, 2020; Zhang & Qiu, 2024). Scandinavian nations and New Zealand are using mobile booking platforms and IoT-based environmental tracking systems to help their eco-lodges fulfill sustainability objectives. Costa Rica uses mobile applications to teach tourists about biodiversity and local conservation standards, which developers view as a suitable framework for development (Raji et al., 2024; Riso & Morrone, 2023). Social media and basic e-commerce platforms allow Peru and South Africa, together with specific areas of Southeast Asia, to improve their market accessibility. Southern African tourism sector faces continuing hurdles from inconsistent internet connections, minimal digital skill levels, and inadequate regulatory functions (Hussain et al., 2024; Sangpikul, 2010). The authors of Maquera et al. (2022) investigated a rural Peruvian platform that sought to connect tourists and locals. The initiative demonstrated positive and negative aspects because it boosted attendance levels, but digital inequality and language differences inhibited fair participation.

2.2 Digitalization in Rural Ecotourism

Digital technology has exerted steady growth in rural ecotourism, although its adoption varies across different locations throughout the country. Users in China, India, and Malaysia are quickly adopting mobile payment systems and online marketing solutions thanks to their mobile-first internet penetration (Alananzeh et al., 2018; Al-Bashayreh et al., 2022; Ibrahim et al., 2021). The adoption rates happen mostly in semi-rural touristic zones because these areas have strong network coverage and high tourist traffic levels. Tourism booking through traditional paper methods remains the standard practice within remote regions (Manzoor et al., 2019; Rasool et al., 2021; Zhang et al., 2023). The local study supports the research findings by presenting the central role of perceived ease of use alongside usefulness elements from TAM, along with the necessity of sector cooperation to address implementation challenges, according to DMO (Kalayou et al., 2020; Kelly & Palaniappan, 2023).

Rural ecotourism's sustainable development relies heavily on digital technologies, one of which includes electronic payment systems. These systems electronically process payments and provide businesses and vacationers with a more secure and efficient alternative to cash transactions. These advancements promote the usability of dignified banking options and enhance rural regions' residents' ability to use them, which provides greater convenience, safety, and transparency (Aminu Mohammed, 2022; Chen et al., 2022; Zamzuki et al., 2023). Booking ecotourism activities, ordering goods and services, and receiving services can be done through contactless terminals, mobile apps, or online gateways. Achieving a streamlined revenue collection process, reducing administrative costs, and mitigating risks with currency handling in rural ecotourism enterprises is possible (Akinyemi & Mushunje, 2020; Al-Bashayreh et al., 2022; El Archi et al., 2023). In remote rural ecotourism areas, mobile-based e-payment solutions help bridge gaps in banking infrastructure, enabling local guides and homestay owners to accept secure digital payments even without formal financial institutions nearby (Chen et al., 2022; Mondejar et al., 2021; Zhang & Qiu, 2024).

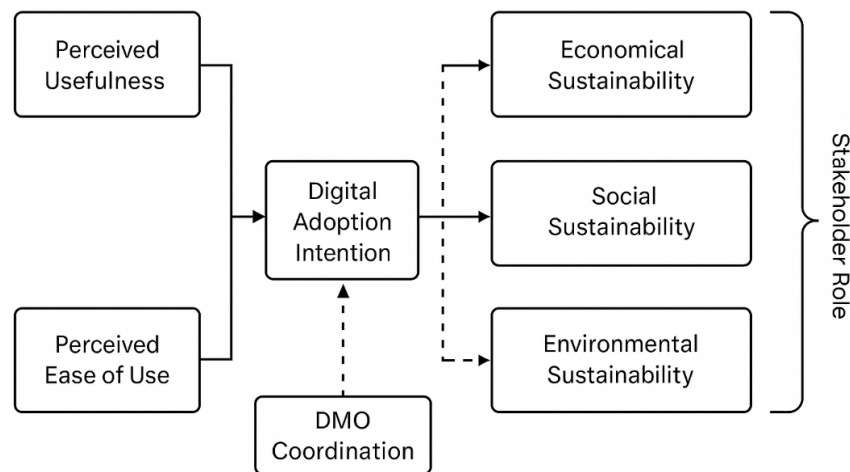


Figure 2.1: Conceptual framework

2.3 Application of Theoretical Frameworks

The integrated framework links constructs from the TAM, the TBL, and the DMO theory. Perceived Usefulness and Perceived Ease of Use influence stakeholders' intention to adopt digital technologies (see Figure 2.1). This adoption intention is hypothesized to affect sustainability outcomes across three dimensions: economic (e.g., revenue efficiency), social (e.g., community inclusion), and environmental (e.g., reduced paper use) (Nogueira et al., 2023; Stoddard et al., 2012; Wu et al., 2019). DMO Coordination is characterized as a moderating factor that either enhances or diminishes the impact of digital adoption on sustainability outcomes based on the alignment, governance, and support of stakeholders DMO Coordination support. Also, the Stakeholder Role (tourist, resident, business, government) is regarded as a moderating variable that impacts the flows of benefits and barriers (W. Tang & Zhu, 2020; S. Zhang & Qiu, 2024). This multi-level framework permits the analysis of the adoption of technologies in rural ecotourism in a more holistic way, incorporating individual behaviors and governance system-level influences (Stoddard et al., 2012; Zhang et al., 2023; Zhang & Qiu, 2024).

Using applicable psychological factors, researchers analyze data with the aid of TAM, the Theory of Ac-

ceptance Model. The perspective takes into account stakeholder technology adoption behaviors based on their assessment of its usefulness and ease of use. Results of the study showing varying rates of digital adoption among males and females support TAM as a relevant theory explaining behavioral phenomena (Dmour et al., 2021; Kalayou et al., 2020; Kelly & Palaniappan, 2023; Park et al., 2022; Qu et al., 2022). This reveals that adoption depends more on access because stakeholders consider technology value, their preexisting familiarity, and their opinion of technology (Alduais & Al-Smadi, 2022; Barkhordari et al., 2017; Dmour et al., 2021). The DMO framework provides structure by presenting an operational and management approach. The framework presents digital technology as an individual user tool and as a community asset that needs coordinated efforts from tourism operators and local governments with their community members (Adeyinka-Ojo et al., 2014; Khan et al., 2022; Rodrigues et al., 2023; Thong et al., 2022). Rural ecotourism destinations function under disjointed governance systems since neither local nor national authorities conduct the digital transformation processes. The research reveals disorganized structures while pursuing measures for enhanced policy backing to advance systematic and sustainable technology adoption (Arbogast et al., 2017; Dmour et al., 2021; Ibrahim et al., 2021; Rodrigues et al., 2023; Thong et al., 2022). This research combines TBL and TAM while incorporating DMO through a complete framework structure. None of the current studies implement these research approaches and work within rural ecotourism spaces. The combined application brings theoretical development through multi-level assessment that connects personal perceptions to organizational frameworks and overall community technology impacts, thus creating a holistic view of digital technology environments.

2.4 Existing Research Gaps

The research design addresses critical knowledge gaps within existing literature as its main research strength. Previous academic studies about technology in tourism mainly examined prominent city tourism locations along with single digital platforms. The research breaks new ground by investigating rural ecotourism instead of typical urban centers since technological capabilities and environmental impacts are relatively limited in this sector. The study focuses on rural ecotourism destinations to promote research about settings that scholars and policymakers ignore. Most of the available research investigates tourism from tourist perspectives, measuring satisfaction and usability while assessing booking convenience. Despite providing crucial insights, most research studies about rural ecotourism neglect the vital stakeholders who maintain this sector, such as local business owners, government officials, and community members. An evaluation of underrepresented views and a comprehensive ecosystem understanding is possible through this study because it surveyed 401 stakeholders from diverse categories.

Research-based on the Theory of Acceptance Model usually stops examining technological adoption intentions without extending to actual usage or performance benefits. This research expands current knowledge by monitoring the actual usage behavior of e-commerce, e-payment, and internet marketing practices in the ecotourism sector. The evaluation establishes stakeholder tool usage frequency alongside satisfaction ratings and self-reported beneficial and challenging aspects to demonstrate the effects of adoption behavior on sustainability. Very few analysts provide specific comparisons that link national and international business settings. The study utilizes examples from New Zealand, Peru, Costa Rica, and Scandinavian countries to position its results as part of global patterns. This analysis evaluates local achievements while demonstrating

their relationship to international superior standards and differentiating practices. The comparative methodology strengthens the academic validity of the research by showing distinct local characteristics that also create opportunities for enhancing policy standards.

2.5 Frontier Directions for Future Research

Digital tourism systems are developing dynamically; new researchers must examine upcoming technology trends impacting environmental sustainability, equal opportunities, and natural resource protection. Rural ecotourism can benefit from promising developments that involve artificial intelligence (AI) systems. Tourists can receive instant support through AI-based chatbots, simultaneously decreasing worker responsibilities and delivering translation services across various languages in multilingual destinations. AI-based technologies assist in the maintenance of resource management systems by assessing the behavior of visitors, information-based visitor flow management, and energy use optimization regarding eco-lodges. The use of blockchain technology opens up new avenues focused on improving the visibility of transactions and the abstraction of management systems. Information published in blockchain systems enables sponsors and fee payers to publish their transactions, thus reducing the level of conjectures in community-oriented tourism programs' conservation programs. Trust improves concerning the destination because visitors look for genuine and responsible travel.

The same can be said of immersive technologies such as virtual reality (VR) and augmented reality (AR). Tools of such kind ruin nature without any destructive impact, thus offering virtual tales of native creatures to improve ecotourism. The deployment of VR technology allows travelers to bypass actual site visits in ecologically delicate zones, which helps preserve the environment and supports economic growth among local tourism sectors. Research across various cultures must be conducted to determine how values, socioeconomic conditions, and norms affect the acceptance of rural tourism technology. Tools within digital technology succeed in some cultural environments yet fail, potentially damaging results in different ones. Studies that analyze rural ecotourism regions in different parts of the Global South can unveil strategies for broad implementation while demonstrating avoidable mistakes. Policy research must be conducted to establish how national digital strategies support sustainable tourism objectives. Several nations create digital transformation plans, but most frameworks fail to include tourism, specifically rural ecotourism, as an element of their objectives. Future research should study the combined effects of digital infrastructure spending, regulatory reform efforts, and educational programs that aim to optimize sustainability in ecotourism development. This research establishes the basics of digital adoption in rural ecotourism, yet numerous further explorations are still possible. The digital world engagement of rural destinations undergoes permanent transformations because of advancing technologies alongside changing governance models and societal culture. This research establishes preliminary guidance for academic development through which researchers can support the creation of an inclusive tourism future with innovative and ecologically sustainable practices.

3 RESEARCH METHODOLOGY

This study employs a quantitative methodology and a cross-sectional survey structure to examine the impact of digital technologies on the advancement of sustainable rural ecotourism. The research integrates ex-



isting theories such as DMO, TAM, and TBL to assess the relationship among marketing, e-commerce, and online payment systems (Ahmad et al., 2018; Arbogast et al., 2017; Hasni et al., 2021; Ladipo et al., 2021; Stoddard et al., 2012). This study addresses the gap in the literature concerning the technology acceptance model by the perceived value of information and communications technology (ICT) in rural ecotourism. This quantitative study emphasizes the critical role that digital technology could play in the sustainable development of rural ecotourism. Its rigorously analyzed results are generalizable and informative to many stakeholders.

Utilizing TBL in conjunction with TAM and DMO offered a guiding backbone for the design process. In line with TBL, the criteria within the survey construct's selection phase included the economic dimension, transaction efficiency, and pricing; for the social dimension, local community participation and stakeholder satisfaction; for the environmental dimension, ecologically conscious practices related to digital marketing. These TBL criteria predefined the construction of the questionnaire, guiding both its formulation and the evaluation of stakeholder feedback. TAM also contributed to the survey items regarding perceived usefulness and ease of use (Arbogast et al., 2017; Hasni et al., 2021; Ladipo et al., 2021). This study incorporates comfort levels of e-commerce and satisfaction with digital transactional interactions, applying frequency indicators to core TAM measurements. Quantitative approaches were applied to adoption and perception patterns, specifically in measuring intent within various stakeholder groups and actual adoption behaviors.

3.1 Hypotheses Development

This study proposes a conceptual model integrating the TAM, TBL, and DMO framework to examine how digital technologies contribute to sustainable rural ecotourism. The following hypotheses are grounded in established theory and supported by empirical literature cited in the study.

According to TAM, perceived usefulness, the degree to which a person believes that using a particular system would enhance their performance, strongly predicts technology adoption (Dmour et al., 2021; Kalayou et al., 2020). In this study, respondents indicated moderate agreement that digital tools enhanced convenience and booking experience, supporting TAM's assertion. As previous rural tourism studies also highlight improved efficiency through e-commerce and mobile booking systems (El Archi et al., 2023; Raji et al., 2024), we hypothesize a positive link between usefulness and adoption intention. Therefore, hypothesis 1 was proposed:

H1: Perceived usefulness of digital technologies positively influences the intention to adopt them.

Ease of use, defined as the degree to which a person believes using a system would be free of effort, has consistently been shown to shape behavioral intentions (Park et al., 2022). In the study, stakeholder comfort with platforms such as e-commerce and mobile booking apps aligns with TAM's ease of use construct. The strong preference for mobile apps over direct websites suggests that users favor intuitive, accessible platforms (Kelly & Palaniappan, 2023). Thus, ease of use is expected to influence the intention to adopt digital tools significantly. Hence, hypothesis 2 was suggested:

H2: Perceived ease of use positively influences the intention to adopt digital technologies.

The economic component of the TBL framework emphasizes cost efficiency, revenue generation, and ex-

panded market access (Stoddard et al., 2012). In this study, e-payment systems were reported to improve financial access and transaction security and reduce administrative costs, especially for small rural businesses. As highlighted in the literature (Akinyemi & Mushunje, 2020; Chen et al., 2022), these tools enable micro-entrepreneurs to formalize transactions and improve competitiveness. We expect adoption intention to be positively associated with economic sustainability. Thus, hypothesis 3 was proposed:

H3: Intention to adopt digital technologies positively impacts economic sustainability outcomes.

TBL's social dimension involves enhancing community engagement, inclusiveness, and participation (Wu et al., 2019). The study found that digital tools such as Internet marketing promoted storytelling and cultural preservation. In addition, online visibility enabled residents to reach wider audiences and form direct connections with travelers, reinforcing the social cohesion benefits (Gabriel-Campos et al., 2021; Riso & Morrone, 2023). As such, digital adoption fosters social sustainability by strengthening local networks and inclusive participation. Therefore, hypothesis 4 was suggested:

H4: Intention to adopt digital technologies positively impacts social sustainability outcomes.

TBL's environmental pillar addresses the ecological footprint of tourism activities. Respondents linked digital marketing and e-payment systems to reduced paper use and lower energy waste (Stoddard et al., 2012). Literature cited in the study supports this, noting that digital channels reduce reliance on physical materials and facilitate environmentally responsible tourism behavior (Zhang & Qiu, 2024). Thus, adoption intention is expected to support environmental sustainability through eco-efficient practices. Hence, hypothesis 5 was proposed:

H5: Intention to adopt digital technologies positively impacts environmental sustainability outcomes.

The DMO framework posits that destination-level planning and stakeholder collaboration enhance tourism system performance (Rodrigues et al., 2023). This study observed fragmented governance and role ambiguity in rural ecotourism contexts, which weakened coordinated implementation. Prior studies (Adeyinka-Ojo et al., 2014; Arbogast et al., 2017) confirm that without institutional support, the full benefits of digital tools cannot be realized. We hypothesize that the presence or absence of DMO coordination moderates the strength of the relationship between digital adoption and sustainability results. Therefore, hypothesis 6 was proposed:

H6: DMO coordination moderates the relationship between digital adoption and sustainability outcomes.

Stakeholders in rural ecotourism, tourists, business owners, residents, and government officials have differing access, priorities, and capacities (El Archi et al., 2023). The study revealed variation in perceived benefits and challenges by group, especially concerning digital literacy and privacy. For example, residents expressed stronger concerns about over-commercialization and digital exclusion, while tourists showed higher satisfaction with e-booking and marketing. Previous research highlights that stakeholder segmentation affects how technology is received (Dmour et al., 2021; Zamzuki et al., 2023). Hence, the stakeholder role is expected to moderate how adoption intention translates into perceived sustainability outcomes. Thus, hypothesis 7 was suggested:

H7: Stakeholder type moderates the perception of the benefits and challenges of digital technology.



3.2 Research Population and Sampling

In consideration of the response variability of the population, 401 respondents were selected as the sample size to ensure the findings' statistical reliability and generalizability. A stratified random sampling method was employed to ensure representative inclusion across four key stakeholder strata: (1) tourists, (2) local business owners/operators, (3) community residents, and (4) government officials. The final sample of 401 respondents was proportionally distributed as follows: tourists (120, 29.9%), business owners/employees (52, 13.0%), and community members (229, 57.1%). Government officials were underrepresented despite outreach, which is noted as a limitation. Stratification ensured that each group had sufficient representation to allow subgroup comparisons in ANOVA and t-test analyses. Using this methodology, one can meticulously gather a holistic compilation of viewpoints and narratives on how digital technology aids sustainable rural ecotourism. With a 95% confidence level, the sample of 401 respondents meets the requirements of a 5% margin of error for the population, ensuring highly accurate parameter estimation. Furthermore, greater sample size bolsters statistical power, enabling sharper, more reliable analyses and findings. It is also notable to add that a suitable sample size enables the study to capture subtle changes and relationships between characteristics, thereby deepening the understanding of factors at play (Andrade, 2020; Asiamah et al., 2017; Vasileiou et al., 2018). To provide robust data about sustainable rural ecotourism and achieve the objectives of the study, a sample of 401 participants was rigorously selected. For the segmentation of the stakeholders, the DMO framework served as the principal operational component. Recognizing the significance of cooperative interplay for destination development, the study incorporated representatives of tourists and business owners, local community members, and government officials. These survey segments underpin DMO's stakeholder-centered model and provide more systematic insights regarding the governance and co-management by digital technology of a destination.

3.3 Data Collection

A systematic survey questionnaire was conducted between November and December of 2023. The survey was conducted through both online and offline platforms, and participants were reached through email, social media, and contacts with relevant tourism organizations and businesses in rural ecotourism areas. To ensure access for all, especially those without internet access, printed questionnaires were distributed and filled out in person. Gathering diverse perspectives on rural ecotourism was the primary aim, and participants were provided with multiple information collection channels to maximize range and impact. The study incorporated both offline and online media to accommodate diverse levels of digital skills and internet access (Taherdoost, 2022). This methodology has been designed within the context of the study that emphasizes sustainable rural ecotourism development, capturing participants' voices, engaging the community, and acknowledging the value of inclusiveness in sustainable development.

In addition, the study aimed to establish direct contacts with tourism companies and organizations in order to gain perspectives from prominent stakeholders who might have in-depth knowledge of the impacts of digitization on the functioning of ecotourism (Adeyinka-Ojo et al., 2014; Aminu Mohammed, 2022). The credibility and rigor of the research findings were enhanced due to the thorough methodology employed for data collection, which provided ample and multifaceted insight.

To assess the reliability of the instrument, the internal consistency was measured through each themed aspect: digital adoption, e-commerce usage, e-payment systems, and internet marketing, all tested with Cronbach's alpha. All sections were above 0.75, which is considered acceptable to high-reliability levels, with the instrument overall scoring $\alpha = 0.81$. This suggests that all items within each construct reliably measure the concept proposed. For content validity, the structure of the questionnaire was formulated along the comprehensive models (TAM, TBL, DMO) and contained adapted validated frameworks from previous studies in the field of tourism and technology adoption. Prior to full deployment, a pilot study involving 30 participants was conducted. Feedback was solicited on item clarity, structure, and relevance, and minor revisions were made to enhance comprehensibility and contextual appropriateness for rural ecotourism stakeholders.

Furthermore, two tourism academics and one digital marketing specialist conducted the expert review to confirm the alignment between theoretical constructs and operational questions. Regarding construct validity, exploratory factor analysis (EFA) was performed on the main sections. Factors loaded cleanly onto theoretically aligned domains (e.g., ease of use, perceived benefits, sustainability impacts), with factor loadings exceeding 0.60, confirming the questionnaire's structural coherence.

3.3.1 Controlling for Confounding Variables and Potential Biases

This study acknowledges several potential sources of deviation and bias in data collection and interpretation. First, social desirability bias may have influenced responses to sustainability and technology usage, as participants may have overstated their engagement with digital tools or their concern for environmental issues. In addition, reverse-coded items were included to reduce acquiescence bias, and indirect questioning techniques were applied to sensitive items (e.g., asking about perceptions of peers rather than self). The pilot test ($n=30$) confirmed improved clarity and reduced response inflation. No strong skewness was observed in Likert responses, suggesting that social desirability effects were acceptably minimized. Second, digital literacy varied among participants. While the survey was available online and in print to increase inclusivity, individuals with higher digital exposure may have been more likely to respond online, introducing a self-selection bias. This was partially offset by targeted in-person distribution in areas with low internet penetration.

Third, although a stratified sampling method was used to represent key stakeholder groups (tourists, business owners, residents, government), uneven distribution among subgroups (e.g., fewer government respondents) may affect subgroup-level analyses. This is acknowledged in the limitations and informs cautious interpretation of generalizability. Additionally, confounding variables such as education level, income, and length of residence may have influenced respondents' perceptions of technology. These variables were collected as part of the demographic section and controlled during ANOVA and t-test analyses to detect whether demographic factors significantly affected key outcome variables.

3.4 Variables

This research focuses on the relationship between online commerce, e-payment systems, and online marketing in the context of ecotourism in rural regions. The survey assesses individuals' frequency of online booking platform usage, their level of awareness regarding digital marketing initiatives, and their perception of the impact that these advertisements have on sustainable development. The control variables are demographic and ecotourism experience factors, including visitation frequency, activity participation, and age,



gender, education level, income, and profession.

3.5 Data Analysis

Data obtained from the survey questionnaires was analyzed using the statistical software Package for the Social Sciences (SPSS). To sample the traits of the sample, descriptive statistics were calculated. These included data such as frequencies and percentages, averages alongside standard deviations. In addition to these steps, an analysis of variance (ANOVA) was performed to examine potential relationships and test the formulated hypotheses. It was important to know the data very well prior to adopting this methodology in order to study trends, patterns, and relationships, which meant that data was collected from many different sources. The calculated descriptive statistics helped paint a portrait of the population being studied by portraying the central tendencies of the sample along with the variation in responses. To test the formulated hypotheses regarding the effect of digital technologies on the development of sustainable rural ecotourism, group differences were tested, and ANOVA was used to determine if these differences were significant. As outlined in the theoretical underpinnings of this study, SPSS was chosen as the main software for data analysis because the primary focus of the study involved exploring several defined relationships between certain variables, which are quantitative in nature.

The study seeks to enhance existing literature through the application of ANOVA, aiming to deepen understanding of how digital technologies influence data-driven decisions about sustainable rural ecotourism development, building upon foundational research conducted by Asiamah et al. (2017), Manzoor et al. (2019), Plečko & Bradac Hojnik (2024), and Taherdoost (2022). These theories provided invaluable insight with regard to the Explanation of the Information Integrated Systems and the Theory of Value Adoption Models. Through the TAM, demographic disparities in electronic device usage were explained and attributed to an overly complex system among certain users through isolating minimal engagement tiers. The study analyzed community concerns about over-commercialization and technological exclusion by incorporating the social aspects of TBL together with DMO collaboration principles.

4 RESULTS AND DISCUSSION

4.1 Data Analysis and Interpretation

Table 1 presents demographic information about the respondents participating in the study. The data encompasses variables such as gender, age distribution, education level, occupation, and length of residence in the study area. The majority of respondents were female, constituting 55.10% of the total sample, while males accounted for 44.90%. This distribution suggests a relatively balanced representation of gender within the study, providing insights into the perceptions of both male and female participants. The age distribution of respondents indicates a diverse representation. The largest age group falls within the 25-34 range, comprising 37.40% of the sample. This suggests that the study captures the perspectives of a significant number of individuals in the age bracket who often engage in ecotourism activities. A substantial portion of the respondents hold a Bachelor's degree (46.10%), followed by those with Some College/Associate's Degree (33.90%). This educational diversity ensures a varied perspective among participants, considering the potential influence of education on the perception of digital technologies in ecotourism.

The respondents represent various occupational backgrounds. The majority are local community members (57.10%), while ecotourism business owners/employees and tourists make up 13.00% and 29.90%, respectively. This diversity in occupation ensures insights from different stakeholders within the ecotourism context. The length of residence in the study area varies among respondents. A significant proportion has resided for more than 10 years (41.10%), suggesting a mix of long-term and relatively newer residents. This diversity can provide nuanced insights into the impact of digital technologies on both established and newer community members. This demographic overview sets the foundation for understanding the diverse perspectives that will be explored in subsequent sections of the analysis.

Table 1: Respondent Demographics

Gender	N	%
Male	180	44.90%
Female	221	55.10%
Age		
Under 18	32	8.00%
18-24	77	19.20%
25-34	150	37.40%
35-44	86	21.40%
45-54	47	11.70%
55-64	9	2.20%
Education Level		
High School or Lower	64	16.00%
Some College/Associate's Degree	136	33.90%
Bachelor's Degree	185	46.10%
Postgraduate Degree	16	4.00%
Occupation		
Ecotourism Business Owner/Employee	52	13.00%
Tourist	120	29.90%
Local Community Member	229	57.10%
Length of Residence		
Less than 1 year	97	24.20%
1-5 years	41	10.20%
6-10 years	98	24.40%
More than 10 years	165	41.10%

Table 2 presents the mean scores and standard deviations of respondents' perceptions regarding the adoption of digital technology in the context of ecotourism. The items assess the frequency of digital technology use for booking, its impact on planning and overall experience, comfort with e-commerce platforms, and satisfaction with the convenience of digital transactions. Respondents, on average, indicated a moderate agreement (Mean = 3.64) regarding the frequent use of digital technology for booking or reserving ecotourism activities. The standard deviation of 1.101 suggests a relatively moderate level of variability in responses. This implies that a substantial portion of respondents frequently utilize digital tools for ecotourism-related transactions. Participants demonstrated a moderate agreement (Mean = 3.60) regarding the perception that digital technology has made it easier to plan and book ecotourism activities. The standard deviation of 1.139



indicates some variability in responses, suggesting differing levels of agreement among respondents.

The mean score of 3.62 suggests a moderate level of agreement concerning respondents' comfort in using e-commerce platforms for ecotourism bookings. The standard deviation of 1.137 indicates some variability in comfort levels, reflecting differing degrees of acceptance among participants. On average, respondents moderately agreed (Mean = 3.66) that digital technology enhances their overall ecotourism experience. The standard deviation of 1.149 suggests varied opinions among participants, indicating a range of perceptions regarding the impact of technology on their overall ecotourism experience. Participants, on average, expressed a moderate level of satisfaction (Mean = 3.72) with the convenience of using digital technology for ecotourism-related transactions. The relatively low standard deviation (1.066) suggests a more consistent level of satisfaction among respondents.

Table 2: Digital Technology Adoption Survey Results

Items	Mean	SD
I frequently use digital technology (e.g., websites and mobile apps) to book or reserve ecotourism activities.	3.64	1.101
Digital technology has made it easier for me to plan and book ecotourism activities.	3.6	1.139
I am comfortable using e-commerce platforms for ecotourism bookings.	3.62	1.137
Digital technology enhances my overall ecotourism experience.	3.66	1.149
I am satisfied with the convenience of using digital technology for ecotourism-related transactions.	3.72	1.066

Figure 1 illustrates the distribution of respondents' usage of different e-commerce platforms for booking ecotourism activities. The options include Online Travel Agencies (e.g., Expedia, Booking.com), Direct Booking on Ecotourism Business Websites, and Mobile Apps (e.g., Airbnb, TripAdvisor). Online Travel Agencies (OTAs) are a popular choice, with 268 respondents indicating that they have used platforms like Expedia and Booking.com for booking ecotourism activities. This suggests a significant reliance on third-party services for making travel arrangements. Direct booking on ecotourism business websites is also a prevalent choice, with 248 respondents utilizing this option. This indicates a substantial number of individuals who prefer booking directly through the official websites of ecotourism providers, potentially seeking a more direct and personalized experience. Mobile apps, including popular platforms like Airbnb and TripAdvisor, stand out as the most widely used option, with 302 respondents selecting this choice. The dominance of mobile apps suggests a shift towards convenient, on-the-go booking experiences, aligning with the increasing reliance on mobile technology in travel planning.

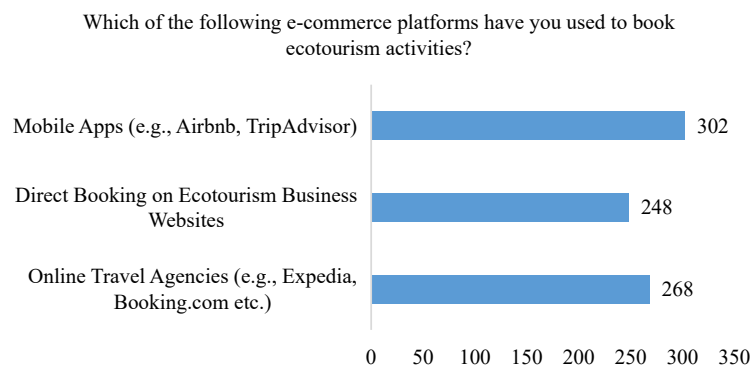


Figure 1: E-commerce Platforms Usage

Table 3 presents the mean scores and standard deviations reflecting respondents' perceptions about using e-commerce platforms for booking ecotourism activities. The items assess convenience, the variety of options, pricing competitiveness, trust in security, and the user-friendliness of e-commerce platforms. Respondents, on average, moderately find it convenient (Mean = 3.40) to use e-commerce platforms for booking ecotourism activities. The standard deviation of 1.229 indicates varied opinions among respondents, suggesting differing levels of agreement regarding the convenience offered by these platforms. The mean score of 3.46 indicates a moderate level of agreement among respondents regarding the perception that e-commerce platforms offer a wide range of ecotourism options in the study area. The standard deviation of 1.193 suggests variability in the extent to which respondents perceive the diversity of options. Participants, on average, moderately agree (Mean = 3.51) that e-commerce platforms provide competitive pricing for ecotourism bookings. The standard deviation of 1.175 suggests varying levels of agreement among respondents, indicating diverse perceptions regarding the competitiveness of pricing. On average, respondents moderately trust (Mean = 3.42) the security of e-commerce transactions for booking ecotourism activities. The standard deviation of 1.202 implies some variability in trust levels, reflecting differing degrees of confidence in the security measures implemented by these platforms. The mean score of 3.42 suggests a moderate level of agreement concerning the perception that e-commerce platforms offer user-friendly interfaces for ecotourism booking. The standard deviation of 1.231 indicates varied opinions among respondents, reflecting differences in their experiences with the user interfaces.

Table 3: E-commerce Platform Perceptions Survey Results

Items	Mean	SD
I find it convenient to use e-commerce platforms for booking ecotourism activities.	3.4	1.229
E-commerce platforms offer a wide range of ecotourism options in the study area.	3.46	1.193
E-commerce platforms provide competitive pricing for ecotourism bookings.	3.51	1.175
I trust the security of e-commerce transactions for booking ecotourism activities.	3.42	1.202
E-commerce platforms offer user-friendly interfaces for ecotourism booking.	3.42	1.231

Table 4 presents the mean scores and standard deviations reflecting respondents' perceptions about the usage of e-payment systems for ecotourism transactions. The items assess the adoption of e-payment systems, convenience, financial accessibility, security, and overall satisfaction with the e-payment experience. Respondents, on average, indicated a moderate level of agreement (Mean = 3.41) regarding the use of e-payment systems for ecotourism transactions. The standard deviation of 1.18 suggests a moderate level of variability in the adoption of e-payment systems among respondents. The mean score of 3.42 suggests a moderate level of agreement among respondents regarding the perception that e-payment systems have made ecotourism transactions more convenient. The standard deviation of 1.168 indicates variability in the extent to which respondents perceive the convenience offered by e-payment systems. Participants, on average, moderately agree (Mean = 3.43) that e-payment systems have improved financial accessibility for ecotourism transactions. The standard deviation of 1.211 suggests varying levels of agreement among respondents, indicating diverse perceptions regarding the impact of e-payment systems on financial accessibility. On average, respondents moderately trust (Mean = 3.42) the security of e-payment systems for ecotourism transactions. The standard deviation of 1.173 implies some variability in trust levels, reflecting differing degrees of confidence in the security measures implemented by e-payment systems. The mean score of 3.51 indicates a moderate level



of satisfaction among respondents with the overall experience of using e-payment systems for ecotourism transactions. The standard deviation of 1.198 suggests variability in the satisfaction levels, indicating diverse experiences and opinions among respondents.

Table 4: E-payment Systems Perceptions Survey Results

Items	Mean	SD
I have used e-payment systems (e.g., mobile wallets and online banking) for ecotourism transactions.	3.41	1.18
E-payment systems have made ecotourism transactions more convenient.	3.42	1.168
E-payment systems have improved financial accessibility for ecotourism transactions.	3.43	1.211
E-payment systems provide a secure way to conduct ecotourism transactions.	3.42	1.173
I am satisfied with the overall experience of using e-payment systems for ecotourism transactions.	3.51	1.198

Table 5 presents the mean scores and standard deviations reflecting respondents' perceptions about the role of internet marketing in promoting ecotourism. The items assess the frequency of encountering online marketing efforts, the influence on decision-making, the provision of valuable information, the creation of an appealing image, and the enhancement of the overall ecotourism experience. Respondents, on average, moderately agree (Mean = 3.44) that they frequently encounter online marketing efforts promoting ecotourism in the study area. The standard deviation of 1.159 indicates a moderate level of variability in responses, suggesting diverse experiences in encountering online marketing. The mean score of 3.42 suggests a moderate level of agreement among respondents regarding the perception that internet marketing has influenced their decision to visit ecotourism destinations in the study area. The standard deviation of 1.181 indicates variability in the extent to which respondents perceive the influence of internet marketing on their decisions. Participants, on average, moderately agree (Mean = 3.45) that internet marketing provides valuable information about ecotourism options in the study area. The standard deviation of 1.199 suggests varying levels of agreement among respondents, indicating diverse perceptions regarding the informational value of internet marketing. The mean score of 3.51 indicates a moderate level of agreement among respondents regarding the perception that internet marketing efforts create an appealing image of ecotourism in the study area. The standard deviation of 1.196 indicates variability in the extent to which respondents perceive the appeal created by internet marketing efforts. On average, respondents moderately agree (Mean = 3.42) that internet marketing enhances their overall ecotourism experience in the study area. The standard deviation of 1.204 implies some variability in opinions, reflecting differing degrees of agreement regarding the overall enhancement of the ecotourism experience through internet marketing.

Table 5: Internet Marketing Perception Survey Results

Items	Mean	SD
I frequently encounter online marketing efforts (e.g., social media, website content) promoting ecotourism in the study area.	3.44	1.159
Internet marketing has influenced my decision to visit ecotourism destinations in the study area.	3.42	1.181
Internet marketing provides valuable information about ecotourism options in the study area.	3.45	1.199
Internet marketing efforts create an appealing image of ecotourism in the study area.	3.51	1.196
Internet marketing enhances my overall ecotourism experience in the study area.	3.42	1.204

Table 6 presents the mean scores and standard deviations reflecting respondents' perceptions about the impact of digital technology on rural ecotourism. The items assess the perceived improvement in ecotourism experience, the positive impact on local communities, and the contribution to the long-term sustainability of rural ecotourism. Respondents, on average, moderately agree (Mean = 3.45) that digital technology has significantly improved the ecotourism experience in the study area. The standard deviation of 1.214 indicates a moderate level of variability in perceptions, suggesting diverse opinions regarding the extent of improvement. The mean score of 3.41 suggests a moderate level of agreement among respondents regarding the perception that the integration of digital technologies in rural ecotourism positively impacts local communities. The standard deviation of 1.184 indicates variability in the extent to which respondents perceive the positive impact on local communities. Participants, on average, moderately agree (Mean = 3.43) that digital technology has contributed to the long-term sustainability of rural ecotourism in the study area. The standard deviation of 1.221 suggests varying levels of agreement among respondents, indicating diverse perceptions regarding the contribution to sustainability.

Table 6: Stakeholder Perceptions Survey Results

Items	Mean	SD
Digital technology has significantly improved the ecotourism experience in the study area.	3.45	1.214
The integration of digital technologies in rural ecotourism positively impacts local communities.	3.41	1.184
Digital technology has contributed to the long-term sustainability of rural ecotourism in the study area.	3.43	1.221

Figure 2 illustrates the distribution of respondents' selections regarding the main challenges or concerns related to the use of digital technologies in rural ecotourism development. The options include Lack of internet access, Privacy and security issues, and Technological barriers for local communities, and Over-commercialization of ecotourism. A notable challenge highlighted by respondents is the lack of Internet access, with 135 individuals identifying it as a concern. This suggests that a significant portion of the surveyed population recognizes the potential hindrance posed by inadequate internet connectivity in rural areas for the effective implementation of digital technologies in ecotourism. Privacy and security concerns emerged as a prominent challenge, with 226 respondents expressing apprehensions. This high number reflects a widespread recognition of the importance of addressing issues related to the protection of personal information and ensuring secure transactions in the context of rural ecotourism development. The most frequently selected challenge is technological barriers for local communities, with 238 respondents identifying this concern. This suggests a strong awareness among respondents regarding the potential difficulties that local communities may face in adopting and adapting to digital technologies in the context of ecotourism. Over-commercialization of ecotourism emerged as a substantial concern, with 203 respondents highlighting this challenge. This indicates a shared recognition of the need to balance economic development through ecotourism with preserving the natural and cultural integrity of rural areas, preventing excessive commercialization.

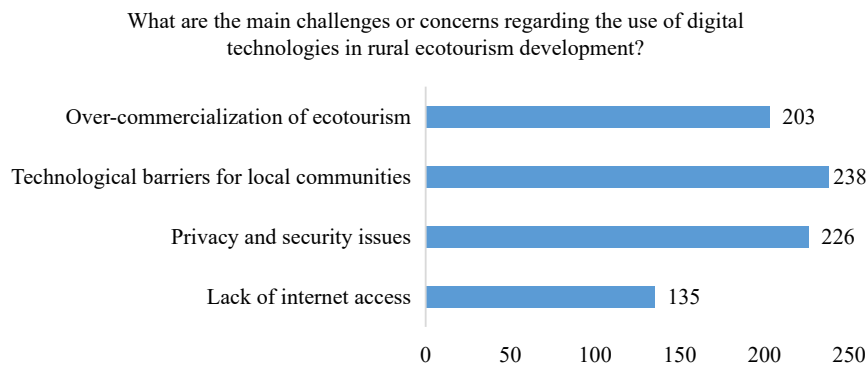


Figure 2: Main Challenges in Digital Technology for Rural Ecotourism

Table 7 presents the results of independent sample t-tests conducted to compare the weighted mean scores based on gender in different sections, namely Digital Technology Adoption, E-commerce and Booking, E-payment Systems, Internet Marketing, and Stakeholder Perceptions. The analysis aims to identify any statistically significant differences in perceptions between male and female respondents. The t-test results indicate a statistically significant difference in the weighted mean scores between male and female respondents ($t = -2.028$, $p = 0.043$). The negative mean difference of -0.18386 suggests that, on average, male respondents have a slightly lower weighted mean score in digital technology adoption compared to female respondents. The t-test results for e-commerce and booking show no statistically significant difference between male and female respondents ($t = -0.646$, $p = 0.519$). The mean difference of -0.06573 is relatively small, indicating a similar weighted mean score for both genders in this section. Similarly, there is no statistically significant difference between male and female respondents in the weighted mean scores for e-payment systems ($t = -0.492$, $p = 0.623$). The mean difference of -0.05002 is small, suggesting a comparable perception of e-payment systems between the two gender groups. The t-test results for internet marketing indicate no statistically significant difference between male and female respondents ($t = 0.302$, $p = 0.763$). The positive mean difference of 0.03026 suggests a slightly higher weighted mean score for male respondents, but the difference is not significant. The t-test results for stakeholder perceptions show no statistically significant difference between male and female respondents ($t = -0.419$, $p = 0.675$). The mean difference of -0.04392 is relatively small, indicating a similar perception of stakeholder roles in rural ecotourism between both genders.

While statistical significance (p-values) indicates whether group differences are unlikely to have occurred by chance, it does not convey the magnitude of those differences. Therefore, we report effect sizes using Cohen's d for independent samples t-tests and partial eta squared (η^2) for ANOVA results. These values help assess the substantive importance of group differences. For instance, the gender difference in digital technology adoption ($t = -2.028$, $p = 0.043$) yields a small effect size (Cohen's $d = 0.22$). Across ANOVAs, η^2 values ranged from 0.001 to 0.016, indicating negligible to small practical differences by age, education, occupation, and residence length. Although statistically significant, the small effect indicates that while gender may influence digital adoption, it does not explain a large proportion of variance. Practically, this suggests that gender-targeted interventions may be helpful but not sufficient—broader digital inclusion strategies should also address other variables like age, education, or digital exposure. In the case of the one-way ANOVA for age groups and internet marketing ($F = 2.093$, $p = 0.065$), partial eta squared was calculated at $\eta^2 = 0.016$,

which also reflects a small effect size. This reinforces that while some trends exist (e.g., lower ratings among older age groups), they are not strong enough to suggest substantial generational divides in digital perception within this context. Other ANOVA results showed no statistically significant differences, and correspondingly, effect sizes were minimal—typically below $\eta^2 = 0.01$ —indicating negligible practical differences across education levels, occupations, and length of residence.

Table 7: Independent Sample T-test for Gender Comparison

t-test for Equality of Means (Equal Variances not assumed)				
Variable	t	Sig. (2-tailed)	Mean Difference	Cohen's d
Digital Technology Adoption	-2.028	0.043	-0.18386	0.22 (small)
E-commerce and Booking	-0.646	0.519	-0.06573	0.07 (negligible)
E-payment Systems	-0.492	0.623	-0.05002	0.05 (negligible)
Internet Marketing	0.302	0.763	0.03026	0.03 (negligible)
Stakeholder Perceptions	-0.419	0.675	-0.04392	0.04 (negligible)

Note: Cohen's *d* represents standardized mean difference. Interpretation thresholds: $d < 0.20 = \text{negligible}$, $0.20\text{--}0.49 = \text{small}$, $0.50\text{--}0.79 = \text{medium}$, $\geq 0.80 = \text{large}$ (Cohen, 1988).

Table 8 presents the results of a one-way ANOVA conducted to compare the weighted mean scores based on age in different sections: Digital Technology Adoption, E-commerce and Booking, E-payment Systems, Internet Marketing, and Stakeholder Perceptions. The analysis aims to identify any statistically significant differences in perceptions across different age groups. The one-way ANOVA results indicate no statistically significant difference in the weighted mean scores for Digital Technology Adoption across different age groups. The p-value of 0.917 suggests that respondents' age does not have a significant impact on their perceptions in this section. E-commerce and Booking ($F = 1.372$, $p = 0.234$): Similarly, there is no statistically significant difference in the weighted mean scores for E-commerce and Booking across different age groups ($p = 0.234$). The lack of significance indicates that perceptions in this section are comparable among respondents of different age groups. The one-way ANOVA results for E-payment Systems reveal no statistically significant difference in the weighted mean scores across different age groups ($p = 0.339$). The findings suggest that respondents' age does not significantly influence their perceptions of e-payment systems. The one-way ANOVA results for Internet Marketing show a p-value of 0.065, which is close to the conventional significance threshold (0.05). This suggests a marginally significant difference in the weighted mean scores across different age groups. Further investigation may be warranted to explore potential differences. The Post Hoc Test indicates that the age group 55-64 has a lower rating compared to other age groups in Internet Marketing. Although not statistically significant, this observation may warrant attention and further exploration. The one-way ANOVA results for Stakeholder Perceptions indicate no statistically significant difference in the weighted mean scores across different age groups ($p = 0.587$). This suggests that respondents' age does not significantly impact their perceptions of stakeholder roles in rural ecotourism.



Table 8: Analysis of Variance (ANOVA) for Age Comparison

Variable	F	Sig.	η^2 (Partial Eta Squared)	Effect Size
Digital Technology Adoption	0.292	0.917	0.002	Negligible
E-commerce and Booking	1.372	0.234	0.007	Small
E-payment Systems	1.140	0.339	0.006	Small
Internet Marketing	2.093	0.065	0.016	Small
Stakeholder Perceptions	0.749	0.587	0.004	Negligible

Note: Partial eta squared (η^2) indicates the proportion of variance in the dependent variable explained by group differences. Interpretation thresholds: $\eta^2 < 0.01 = negligible$, $0.01-0.059 = small$, $0.06-0.139 = medium$, $\geq 0.14 = large$ (Cohen, 1988).

In comparison to various educational levels, the Digital Technology Adoption, E-Commerce and Booking, E-Payment Systems, Internet Marketing, and Stakeholder Perceptions sections are analyzed in a one-way ANOVA, the weighted means of each segment provided in Table 9. The analysis seeks to discern whether the differences in educational attainment have any statistically significant influence on the perceptions held. The results of the one-way ANOVA showed that there is no statistically significant difference in the weighted mean scores for Digital Technology Adoption as grouped by educational levels. The p-value of 0.985 indicates that respondents' levels of education greatly moderated their perceptions in this section. A similar statement can be made regarding E-Commerce and Booking: there is no statistically significant difference in weighted mean scores by educational level ($p = 0.613$). Because there is no statistically significant difference in the weighted mean scores for perceptions, it can be concluded that perceptions in this section are level, irrespective of varied educational backgrounds. According to the one-way ANOVA results concerning E-Payment Systems, there is also no statistically significant difference in the weighted mean scores by educational level ($p = 0.927$). Overall, the results indicate that the levels of education of the respondents did not have a considerable effect on their perceptions of e-payment systems.

The results from the one-way ANOVA for Internet Marketing show that there is no statistically significant difference in the weighted mean scores for different education levels ($p = 0.743$). This indicates that the respondents' educational backgrounds do not markedly influence their understanding of Internet marketing as it relates to rural ecotourism. For Stakeholder Perceptions, one-way ANOVA results also show no significant differences ($p = 0.443$) in the weighted mean scores for different education levels. This means that the respondents' perceived education level did not significantly determine their perceptions about the stakeholders' roles in rural ecotourism.

Table 9: One-Way ANOVA for Educational Level Comparison

Variable	F	Sig.	η^2 (Partial Eta Squared)	Effect Size
Digital Technology Adoption	0.051	0.985	0.000	Negligible
E-commerce and Booking	0.603	0.613	0.003	Negligible
E-payment Systems	0.154	0.927	0.001	Negligible
Internet Marketing	0.414	0.743	0.002	Negligible
Stakeholder Perceptions	0.896	0.443	0.005	Negligible

Note: Partial eta squared (η^2) indicates the proportion of variance in the dependent variable explained by group differences. Interpretation thresholds: $\eta^2 < 0.01 = negligible$, $0.01-0.059 = small$, $0.06-0.139 = medium$, $\geq 0.14 = large$ (Cohen, 1988).

In Table 10, the outcomes of one-way ANOVA testing are highlighted to evaluate the weighted mean scores about occupations for five sections: Digital Technology Adoption, E-commerce and Booking, E-payment Systems, Internet Marketing, and Stakeholder Perceptions. The objective of the analysis is to discover any identifiable statistically significant disparities regarding perceptions across various occupational clusters. As per the findings from one-way ANOVA, there is no statistically significant difference in the weighted mean scores for Digital Technology Adoption across different occupations. The p-value of 0.429 points out that respondents' occupations do not have any meaningful bearing on their perceptions in this section. The same applies to E-commerce and Booking. There is no statistically significant difference in the weighted mean scores across occupations ($p = 0.644$). The absence of significance suggests that perceptions in this section are homogeneous among respondents with differing occupations. From the one-way ANOVA results regarding E-payment Systems, there is no statistically significant difference in the weighted mean scores across occupations ($p = 0.672$). The respondents' occupations do not considerably impact their perceptions concerning e-payment systems.

The findings from the one-way ANOVA for Internet Marketing show that there is no significant difference in the weighted mean scores for different occupations ($p = 0.473$). This indicates that the respondents' occupations do not greatly affect their perceptions of internet marketing concerning rural ecotourism. The one-way ANOVA results for Stakeholder Perceptions also show no significant differences in the weighted mean scores for different occupations ($p = 0.824$). This indicates that the respondents' occupations do not greatly affect their perceptions of the stakeholders' functions within rural ecotourism.

Table 10: One-Way ANOVA for Occupation Comparison

Variable	F	Sig.	η^2 (Partial Eta Squared)	Effect Size
Digital Technology Adoption	0.847	0.429	0.004	Negligible
E-commerce and Booking	0.441	0.644	0.002	Negligible
E-payment Systems	0.398	0.672	0.002	Negligible
Internet Marketing	0.751	0.473	0.004	Negligible
Stakeholder Perceptions	0.193	0.824	0.001	Negligible

Note: Partial eta squared (η^2) indicates the proportion of variance in the dependent variable explained by group differences. Interpretation thresholds: $\eta^2 < 0.01 = \text{negligible}$, $0.01\text{--}0.059 = \text{small}$, $0.06\text{--}0.139 = \text{medium}$, $\geq 0.14 = \text{large}$ (Cohen, 1988).

The conducting of the one-way ANOVA test based on the length of residence in different sections: Digital Technology Adoption, E-commerce and Booking, E-payment Systems, Internet Marketing, and Stakeholder Perceptions is given in Table 11. It shows the average scores from each section and tests if there are any differences across various categories. Once again, the results of one-way ANOVA revealed no significant difference in the average score of Digital Technology Adoption as the weighted mean score computed remained the same across various lengths of residence. This is further supported by a p-value of 0.412, which indicates that respondents' residence duration impacted their perception in this section minimally, if at all. Likewise, no significant difference in mean scores of E-commerce and Booking was found over differing lengths of residence ($p = 0.758$). The notion that there is no significant difference means perceptions are uniform in this section regardless of the respondent's residence duration. About E-payment Systems, one-way ANOVA produced a p-value of 0.116, which, although above 0.05, is still considered significant. Thus, relying on means



of different lengths of residence for comparison would skew results in this case. More analysis is necessary to understand the discrepancy observed.

In the context of Internet Marketing, the one-way ANOVA findings reveal that there is no significant difference in the weighted mean scores for different lengths of residence ($p = 0.298$). This indicates that the length of residence does not influence the perceptions of the respondents with regard to Internet marketing in the rural ecotourism framework. Regarding Stakeholder Perceptions, the one-way ANOVA results also show no significant difference in the weighted mean scores for various lengths of residence ($p = 0.621$). This means that, regarding the respondents' perceptions of the stakeholder functions in rural ecotourism, the length of residence does not have a strong impact.

Table 11: One-Way ANOVA for Length of Residence Comparison

Variable	F	Sig.	η^2 (Partial Eta Squared)	Effect Size
Digital Technology Adoption	0.959	0.412	0.005	Negligible
E-commerce and Booking	0.393	0.758	0.002	Negligible
E-payment Systems	1.980	0.116	0.010	Small
Internet Marketing	1.232	0.298	0.006	Small
Stakeholder Perceptions	0.591	0.621	0.003	Negligible

Note: Partial eta squared (η^2) indicates the proportion of variance in the dependent variable explained by group differences. Interpretation thresholds: $\eta^2 < 0.01 = \text{negligible}$, $0.01\text{--}0.059 = \text{small}$, $0.06\text{--}0.139 = \text{medium}$, $\geq 0.14 = \text{large}$ (Cohen, 1988).

4.2 Discussion

The findings of the current study offer valuable insights into the intricate interplay among demographic influences, stakeholder perspectives, and digital technology implementation within the ecotourism sector. The substantial proportion of females (55.10%) in comparison to males (44.90%) in the sample population demonstrates a broad representation. The majority of the participants are members of the local community aged 25 to 34. This demographic diversity is crucial because the TBL method places equal emphasis on the interdependence of the social, economic, and environmental components of sustainability. Consistent with the emphasis of the TBL on community welfare and participation in ecotourism initiatives, a significant proportion of members of the local community emphasize the value of social sustainability (Adeyinka-Ojo et al., 2014; Wu et al., 2019).

Furthermore, the integrated framework not only structured the research instrument but also strengthened the interpretive depth of the findings. For example, the observed preference for mobile apps over business websites among tourists can be interpreted through TAM (user-friendly interfaces and mobility) (Dmour et al., 2021; Kelly & Palaniappan, 2023; Ladipo et al., 2021). However, it also reflects a DMO's failure to unify digital branding across rural operators—indicating weak destination-level coordination. The TBL framework helped explain why business owners viewed certain technologies (e.g., e-payments) more favorably—they enhanced revenue tracking (economic), reduced theft risk (social), and decreased reliance on printed receipts (environmental). Similarly, concerns about over-commercialization and digital exclusion expressed by long-term residents were discussed using TBL's social lens and DMO's emphasis on inclusive planning (Gbongli et al., 2019; Kalayou et al., 2020; Park et al., 2022).

In agreement with stakeholder views, the TBL strategy indicates that digital technology may enhance ecotourism and positively benefit the local population. As outlined by El Archi et al. (2023), Nogueira et al. (2023), and Wu et al. (2019), digital technology can deliver three important benefits to ecotourism sites: higher profits, enhanced social participation, and lower environmental impact. The achievement of the triple-bottom-line objectives of sustainability is made much easier by the incorporation of digital technologies. Additionally, within the context of DMOs, stakeholders are critical in determining the success of destination development and management (Arbogast et al., 2017; Dmour et al., 2021). This study describes positive stakeholder attitudes, which demonstrates the need for partnership between technology vendors, destination management organizations, and local populations to harness digital tools for sustainable destination management. Rural ecotourism is more sustainable as a result of greater competitiveness and fulfillment of stakeholder expectations, which is increasingly enabled by technological advancement (Arbogast et al., 2017; Dmour et al., 2021).

The TBL framework, which translates to social, environmental, as well as economic aspects being interdependent, is useful in studying the effects of over-commercialization and digital exclusion in rural ecotourism. Stakeholders were not happy with the lack of spatial equity in the digital divide as well as with the rising commercialization of community-based tourism services. This is alongside an increasing governance gap whereby existing apex structures meant to stimulate some level of digital engagement are completely devoid of safeguarding provisions aimed at ensuring sustainability. E-commerce or mobile apps help in attaining visibility and streamlining processes, but the swift adoption of these technologies in rural areas threatens to deepen social divides among lower-income groups or those with limited digital skills, which would harm social cohesion (Dmour et al., 2021; Wu et al., 2019).

International examples provide direction on how to resolve these problems. For example, Costa Rica's Certification for CST implements a bounded deployment of digital tools in strict conjunction with environmental and socio-community impact standards, designed to ensure that technological innovation will not outpace sustainable practices (Howitt & Mason, 2018; Raji et al., 2024). In the same vein, Taobao villages in China, especially those situated in Zhejiang Province, illustrate the proprietary and sustainable-driven community relations that can result from investing in digital infrastructure when held under local control, equitable profit-sharing, and sustainable governance (Zhang & Qiu, 2024; El Archi et al., 2023). These examples further demonstrate the unchecked consequences of digital expansion on exacerbating inequality or environmental decline, but with managed steady infrastructures guiding these growths, all the TBL can be supported. (Abdo, 2020; Hussain et al., 2024; Stoddard et al., 2012; Zamzuki et al., 2023). Likewise, safeguarding ecotourism experiences and maintaining visitors' confidence—factors that influence the social and economic sustainability of destinations—requires that privacy and security concerns be resolved.

Turning to measures to overcome technology-related issues and privacy and security concerns will change perceptions of its usefulness, and technology will be easier to operate. In the context of Mkalian et al. (2022), data protection measures, infrastructure improvement, and adequate user training have been identified as key steps and, alongside other user education measures, will facilitate embracing digital technology in ecotourism. Furthermore, ecotourism destinations have to deal with the risk of over-commercialization and conflict between stakeholders within the destination marketing organization system in order to foster cooperative destination management and ensure enduring ecological sustainability (Arbogast et al. 2017). In order to foster



responsible tourism, destination management organizations aim to manage the negative impacts of tourism by balancing economic development, environmental sustainability, and community well-being.

The results of this study confirm the investigations conducted on the role of digital technology in the improvement of ecotourism and the sustainability of the destinations (Akinyemi & Mushunje, 2020; Gbongli et al., 2019; Ladipo et al., 2021; Maquera et al., 2022; Wu et al., 2019). Our results also support prior research that focuses on the ecotourism infrastructure planning needs, which is construction-responsible inclusiveness to all the ecotourism stakeholders. This study has added value to existing research by analyzing the less studied area of demographic factors concerning the adoption of digital technologies and stakeholder ecosystems. Our research underscores the significance of implementing focused interventions and inclusive approaches to ensure equitable participation and access to digital tourism initiatives for all. This is achieved through the identification of potential gender disparities and variations in participation based on length of residence.

These small effect sizes highlight a key insight for both theory and practice. While TAM often emphasizes demographic factors (such as age, gender, and education) as potential influences on technology adoption, the weak effect sizes found here suggest that contextual and systemic variables (e.g., internet access, trust in platforms, or institutional support) may have a more substantial influence than individual characteristics alone (Hussain et al., 2024; Zamzuki et al., 2023). This has implications for applying TAM in rural ecotourism, where structural inequalities may override attitudinal readiness.

Regarding TBL, the limited group differences reinforce the broad relevance of digital technologies across all stakeholders, supporting the argument that these tools offer economic and social benefits not confined to specific demographics. However, concerns about over-commercialization and privacy suggest trade-offs with sustainability's environmental and cultural dimensions. Therefore, practical importance stems from community values that need to be aligned with the expectations and norms, as well as measurable behavior changes that should be incorporated into the technology rollout plans (Arbogast et al., 2017; Dmour et al., 2021). For the DMO framework, the less pronounced intergroup variability reinforces the case for destination-level centralized coordination as opposed to targeted segmentation-based marketing. Because age or educational differentials are modest, comprehensive digital training curricula and cross-provider consolidated platform integration may exceed the benefits of more bespoke initiatives (Dmour et al., 2021).

5 RESEARCH IMPLICATIONS

The outcomes of this particular study suggest some fundamental steps that can be taken by the policymakers, DMOs, and community planners in integrating digital technologies in a TBL focused manner. First, about impact assessment methodologies, more attention should be paid to more advanced structured evaluation frameworks. Furthermore, specialized content aimed at specific groups, like postgraduate and entrepreneur classes, as well as hospitality workers and rural dwellers, should be developed. Such programs must go beyond training to include the socio-cultural and environmental factors regarding sustainable digitization. Stakeholders who are trained digitally are more likely to promote and adopt green innovations. Support for conservation-oriented innovations should also be provided through incentive-based funding, targeted grants, or zero-interest loans. Conservation-oriented innovations include mobile reservation systems that eliminate

paper usage, solar-powered wifi, and storytelling tools that foster conservation ethics. To address issues of unengaged elderly residents or women and part of the less digitally inclined population, DMOs, alongside regional planners, should conduct audits of digital non-participation gaps.

These audits may assist in designing public access portals or trust-bridging hybrid systems that are analog-digital, which can foster trust and counter exclusion in digital systems. Lastly, these DMOs, together with regional planners, should be charged with formulating regulations on zoning digitally for the destinations to mitigate cultural erosion and oversaturation. Some of these may include restrictions on the surpassing exposure of advertisements on the internet, limited access for off-site tour aggregators, or prior community consultation before commercial engagement. If sustainability criteria are integrated into the digital phasing strategy, the rural ecotourism industry will flourish while preserving the culture and environment of the region.

6 CONCLUSION

This research explores an emerging area of impact, which is the role of digital technologies on the sustainability of rural ecotourism. Unlike prior studies, which either focus on the impact of tourism or digital technologies, this study applies a combination of three theories, TBL, TAM, and DMO, to construct an integrated model linking stakeholder participation, technology adoption, and sustainability. The research is based on a survey of 401 stakeholders from different sectors, which provides empirical evidence on the perception, adoption, and challenges of digital tools, especially e-commerce, e-payment systems, and internet marketing in rural ecotourism. This study contributes primarily to the gap in understanding how attitudes towards the use of technology and the perceived ease of use of its application influence the incorporation of technology into rural tourism. The study reveals significant gaps in digital literacy, basic infrastructure, privacy, and security concerns, exacerbating limited access to the full potential of digital ecotourism.

Furthermore, this study shows that the lack of a sustainable digitally driven transformation is an issue of social equity combined with neglect of planning and capacity-building beyond technology. With a combination of theoretical and practical evidence, this research provides a policy framework for practitioners and stakeholders in ecotourism to advance and integrate more effective policies towards building digital resilience. This work has interdisciplinary relevance by contributing to global debates on sustainable tourism development in the context of digital transformation while simultaneously providing a replicable framework for investigating the phenomenon of digital adoption in comparatively ☐ ☐ more marginalized rural spaces. The subsequent recommendations for stakeholders in rural ecotourism are derived from the findings and ramifications of this research:

- One way to ensure equitable access to digital benefits for rural ecotourism destinations is to allocate resources towards enhancing digital infrastructure, including mobile network coverage and internet connectivity.
- Enhance the digital literacy of ecotourism operators and local communities by developing educational programs and training activities. If individuals possess the requisite digital competencies, their inclination to engage in digital initiatives will be further enhanced.



· It is imperative to foster collaboration among technology providers, local communities, and ecotourism stakeholders to devise innovative digital solutions that address the distinctive challenges encountered by rural ecotourism.

· To safeguard visitor information and ensure the integrity of digital transactions within ecotourism destinations, stringent privacy regulations and data protection methods are required. To ensure the continued adoption and utilization of digital platforms, it is imperative to establish their reliability and credibility.

· Enact policies that achieve a harmonious coexistence of environmental preservation, public welfare, and private sector interests. Advocate for environmentally conscious travel that contributes to the growth of local economies while preserving our abundant cultural and environmental heritage.

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