

DATA-DRIVEN STRATEGY: HOW BIG DATA SAVES TOURIST DESTINATIONS FROM ENVIRONMENTAL DEGRADATION

Sugih Prakoso^{1*}, Sandi Setiadi²

Universitas Linggabuana PGRI Sukabumi

STISIP Guna Nusantara Cianjur

E-mail: sugihprakoso79@gmail.com^{1*}, setiadi442976@gmail.com²

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Abstract

This study aims to optimize digital tourism strategies in the Puncak region, West Java, in support of achieving the Sustainable Development Goals (SDGs), particularly inclusive economic growth and environmental preservation. The study uses a quantitative approach with an explanatory research design and involves 225 digital tourists as respondents. Data analysis was conducted using Structural Equation Modeling–Partial Least Squares (SEM-PLS). The findings indicate that both User-Generated Content and Digital Sentiment Analysis positively and significantly influence Tourism Sustainability, not only directly but also through the mediation of a Digital Tourism Strategy. Digital Sentiment Analysis has the most dominant influence on the formation of digital strategies, as indicated by a t-statistics value of 13.903. In addition, the model has a very strong predictive power, where Digital Tourism Strategy is able to explain 92.2% of the variance in Tourism Sustainability. Overall, these findings emphasize the importance of integrating tourist digital data and sentiment analytics as the basis for formulating adaptive, evidence-based tourism policies that are oriented towards destination sustainability and the balance of the national tourism ecosystem.

Keywords: *User-Generated Content, Sentiment Analysis, Digital Strategy, Tourism Sustainability, SDGs*

INTRODUCTION

Since the United Nations adopted the Sustainable Development Goals (SDGs), sustainable tourism development has emerged as a key global strategy. This is particularly relevant to Goal 8, which focuses on inclusive economic growth, Goal 11, which aims for sustainable cities and communities, and Goal 12, which emphasizes responsible consumption and production (Das et al., 2025; Martins et al., 2025; Setiadi et al., 2025). In this context, the tourism sector is seen not only as an economic driver, but also as a social and environmental instrument that must be managed adaptively and based on data (Dwyer, 2024; Rojabi et al., 2025). Digital transformation becomes essential for boosting the competitiveness of tourist destinations while also ensuring their sustainability (Ainin et al., 2025; Lintangesukmanjaya et al., 2025).

A prominent phenomenon in the last decade has been the shift in tourist behavior, which has become increasingly dependent on digital platforms such as social media, online travel platforms, and online reviews in searching for information, forming perceptions, and making travel decisions. User-generated content (UGC)-based data has now become the primary source for understanding tourist perceptions, emotions, and satisfaction in real time because UGC enables direct analysis of user sentiment, helps identify various aspects of the travel experience, and provides easily accessible and real-time information (Khan et al., 2023). Additionally, user-generated content such as reviews, photos, and social media posts provide rich insights into emotions and satisfaction, and can influence tourist behavior including loyalty and revisit intentions through their impact on destination image and satisfaction (Xu et al., 2021).

The UGC-based approach also enables analysis of specific aspects such as tourist experience themes and positive and negative sentiments that can be utilized for responsive and timely service improvement and destination management (Kim et al., 2021). Thus, the integration of UGC data in the context of tourism strengthens the ability to understand tourist experiences comprehensively and in real time. The Puncak area in West Java, as one of the

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nation's leading natural tourist destinations, has experienced a significant surge in digital exposure. However, this high digital visibility has been accompanied by a variety of public sentiments, ranging from appreciation for natural beauty to criticism related to traffic congestion, environmental degradation, and tourist density. The main problem that arises is the suboptimal use of digital data as a basis for formulating tourism strategies. Tourism management in West Java's Puncak region still tends to be reactive, conventional, and based on an aggregate approach, without systematic mapping of tourist sentiment. As a result, digital promotion and destination management policies are not yet fully aligned with the principles of sustainable tourism and SDG targets, particularly in controlling environmental impacts and improving the quality of the tourist experience. Several studies have found that numerous tourist spots in developing nations struggle to transform big data tourism analytics into actionable strategic policies. This suggests that digital technology is not being fully utilized to support sustainable tourism principles and achieve the SDG objectives (Khan et al., 2021; Zeqiri et al., 2025).

From an academic perspective, there is a clear research gap. Previous studies generally place digital marketing, social media, or destination image as independent variables that are tested for their influence on tourist visitation decisions or satisfaction (Jebbouri et al., 2022; Sharafuddin et al., 2024; Zaitul et al., 2022). Sentiment analysis studies have indeed been conducted extensively in the context of tourism, but most of them still focus on measuring sentiment polarity (positive–negative) without integrating it with clustering techniques to identify tourist segments in a more granular (Al-Bakri et al., 2022; Chu et al., 2022; Flores-Ruiz et al., 2021). Furthermore, the direct link between digital sentiment analysis results and the SDGs agenda is still rarely discussed explicitly, especially in the context of natural tourist destinations in Indonesia. The innovation of this study stems from addressing the existing gap by combining sentiment analysis with clustering techniques using digital tourist data, which serves as the basis for developing digital tourism strategies aligned with the Sustainable Development Goals (SDGs). This approach not only identifies tourists' emotional perceptions but also maps the patterns and characteristics of tourist clusters based on preferences, complaints, and sustainability expectations. Thus, the resulting digital strategy is not generic, but adaptive and contextual to economic, social, and environmental issues in the Puncak region of West Java.

The importance of this research is twofold. On a practical level, the findings are anticipated to form the foundation for evidence-based policy development by local authorities and destination managers. This will aid in crafting digital marketing strategies, managing visitor numbers, and educating tourists in accordance with sustainable tourism principles. The importance of this research is twofold. On a practical level, the findings are anticipated to form the foundation for evidence-based policy development by local authorities and destination managers. This will aid in crafting digital marketing strategies, managing visitor numbers, and educating tourists in accordance with sustainable tourism principles (Šoltésová et al., 2025). This research theoretically enhances the digital tourism field by expanding the role of tourism analytics. It moves beyond merely serving as a marketing evaluation tool and positions it as a strategic approach to achieving the Sustainable Development Goals (SDGs). Thus, optimizing digital tourism strategies through sentiment analysis and clustering is not only relevant but also urgent to address the challenges of sustainable tourism in the digital era.

LITERATURE REVIEW DAN HYPOTHESIS DEVELOPMENT

User-Generated Content

User-generated content (UGC) refers to digital material that individuals or travelers willingly produce and distribute across various online channels, including social media, review websites, travel blogs, and online travel platforms (Setiadi, 2025). UGC reflects the real experiences, perceptions, emotions, and evaluations of tourists towards a destination. In the context of tourism, UGC plays an important role as a credible real-time data source for understanding destination image, tourist satisfaction, and visiting preferences and behavior, making it relevant for data-driven decision making (Wang & Yan, 2022; Xu et al., 2021). In this study, according to (Geng & Chen, 2021), the indicators used for user-generated content (UGC) include: (1) Content intensity. (2) Content credibility. (3) Information quality. (4) Emotional expression. (5) Experience relevance. (6) Influence power.

H1 : User-generated content impacts digital tourism strategies

H3 : User-generated content affects the sustainability of tourism

H6 : The effect of user-generated content on sustainability is mediated by digital tourism strategies

Digital Sentiment Analysis

Digital sentiment analysis involves using computational methods to detect, categorize, and understand the emotional expressions, opinions, and attitudes of users found in digital text data, such as online reviews, social media comments, and content created by users. In tourism, sentiment analysis is employed to gauge tourists' real-time perceptions of destinations, identify the positive and negative elements of their experiences, and offer a data-driven foundation for developing destination management strategies and sustainable tourism policies (Zhang., 2022; Chu et al., 2022) (Chu et al., 2022). This research utilizes indicators for analyzing digital sentiment within the tourism sector : (1) Sentiment polarity (positive, negative, neutral). (2) Sentiment intensity, which indicates the strength of emotion. (3) Sentiment based on destination aspects such as facilities, accessibility, cleanliness, price, safety, and environment. (4) Digital sentiment volume reflecting the amount of data analyzed. (5) Sentiment occurrence frequency. (6) Sentiment trends over time to observe changes in perception. (7) Sentiment source credibility affecting data reliability. (8) Consistency of sentiment across digital platforms as a measure of opinion uniformity. (9) Location-based spatial sentiment (geo-tagged sentiment) that links sentiment to geographical locations. (10) Temporal sentiment describing before, during, and after visits. (11) Sentiment toward travel experiences, service quality, sustainability and the environment, and destination image. (12) Sentiment towards satisfaction and intention to revisit (Ameur et al., 2023; Borrajo-Millán et al., 2021; Carvache-Franco., 2022; Elshaer et al., 2024; Wu., 2024).

H2 : There is an influence of digital sentiment analysis on digital tourism strategies

H4 : There is an influence of digital sentiment analysis on tourism sustainability

H7 : There is an influence of digital sentiment analysis on sustainability mediated by digital tourism Strategy

Digital Tourism Strategy

Digital tourism strategy is an integrated approach to managing and developing tourist destinations that utilizes digital technology, big data, and online platforms to improve destination competitiveness, the quality of tourist experiences, and tourism sustainability. This strategy utilizes social media, data analytics, digital content, and tourism information systems to facilitate data-driven decision-making, improve targeted marketing, manage the reputation of destinations, and create adaptive policies in response to the changing behavior of digital tourists (Torre & Vega, 2025; Wang et al., 2025; Zeqiri et al., 2025). In this study, the indicators used for digital tourism strategies include: (1) Social media utilization. (2) Quality and consistency of digital content. (3) Tourist interaction and engagement. (4) Tourism data analytics. (5) Digital platform integration. (6) Online image management. (7) Use of UGC. (8) Personalization of services. (9) Accessibility of information. (10) Responsiveness to feedback. (11) Smart technology. (12) Service digitization. (13) System security. (14) Digital collaboration. (15) Support for sustainability (Paul et al., 2024; Urbinati et al., 2021; Zoupos & Spais, 2022; Żymkowska & Zachurzok-Srebrny, 2025).

H5: There is an influence of digital tourism strategies on tourism sustainability

Tourism Sustainability

Tourism sustainability refers to a method of managing tourism that seeks to fulfill the current needs of tourists and destinations while ensuring that future generations can also meet their needs. This approach highlights the importance of maintaining a balance among economic, socio-cultural, and environmental aspects by using resources responsibly, protecting the environment and local traditions, and enhancing the well-being of local communities. This approach is in line with the sustainable development framework and sustainable tourism principles developed by the UNWTO and UNEP as the basis for long-term destination development (Dwyer, 2024; Toubes & Araújo-Vila, 2022). The indicators used in this study to measure tourism sustainability include: (1) Environmental protection and biodiversity. (2) Destination carrying capacity management. (3) Resource and energy efficiency. (4) Waste and pollution reduction. (5) Preservation of local culture. (6) Community participation. (7) Economic benefit distribution.

(8) Creation of sustainable jobs. (9) Quality of tourist experience. (10) Transparent destination governance. (11) Compliance with regulations. (12) Support for achieving the SDGs (Coscieme et al., 2021; Mohan, 2022).

Research framework

This research is based on the data-driven sustainable tourism management paradigm, which views digital tourist data as a strategic resource to support sustainable tourism policy-making. Conceptually, the research framework integrates User-Generated Content (UGC) as the main input, which is analyzed through sentiment analysis and tourist clustering. The is then converted into a digital strategy, and ultimately evaluated for its contribution to the achievement of SDGs in the tourism sector(Alz... & Alghamdi, 2025) .(Figure 1).

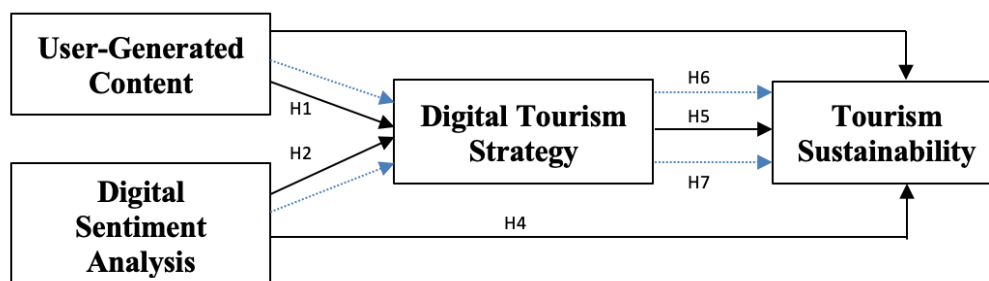


Figure 1. Research Framework
Source: Processed by Researchers, 2026

METHOD

This research employs a quantitative method driven by data, utilizing an explanatory research design (Setiadi et al.,2025), seeking to clarify the cause-and-effect link involving user-generated content (UGC), digital sentiment analysis, digital tourism strategies, and tourism sustainability (Im et al., 2023; Lim, 2024). This approach is relevant for testing complex conceptual models and mediation mechanisms in the context of digital transformation-based sustainable tourism(Bentouhami et al.,2021; Kalia et al., 2022)(Bentouhami et al., 2021; Kalia et al., 2022). This study focuses on digital tourists, specifically those who create or engage with digital content about the Puncak area in West Java via social media and online platforms.

The study's population consists of all digital tourists in West Java Province who actively engage with digital tourism platforms, including social media, online review sites, and online travel platforms. As a result, the population's characteristics are not limited, and the exact number cannot be precisely determined. The sampling method employed was purposive sampling, targeting individuals who had either accessed or created user-generated content (UGC) about tourist spots, utilized digital tourism services, and possessed a sufficient level of digital literacy. The sample size was calculated following the guidelines set by Hair et al., which involve multiplying the number of indicators by the minimum number of respondents required for each indicator(Hu et al., 2022). With a total of 45 indicators and a minimum requirement of 5 respondents per indicator, the minimum sample size required in this study was 225 respondents.

This study involved four latent variables measured using 45 manifest variables (indicators). The data was gathered using a questionnaire that relied on variable indicators derived from existing literature. All indicators were measured using a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). Data analysis was conducted using Structural Equation Modeling–Partial Least Squares (SEM-PLS) because the research model is predictive, involves complex latent variables, and aims to explore both direct and indirect (mediating) effects(Sarstedt & Moisescu, 2023).

RESULTS AND DISCUSSION

Measurement Model and Structural Model

This research examines 45 observable variables and 4 underlying variables through the use of Partial Least Square-based Structural Equation Modeling (SEM-PLS) to thoroughly evaluate the connections between constructs. The analysis encompasses both measurement and structural models. The measurement model is designed to evaluate the validity and reliability of hidden constructs by utilizing observable indicators through a confirmatory factor analysis approach. To assess validity, both convergent and discriminant validity were examined. Convergent validity was determined by evaluating factor loadings and the Average Variance Extracted (AVE). Ideal factor loadings were above 0.70, though values above 0.60 were still considered acceptable, and the AVE needed to exceed 0.50. Composite Reliability and Cronbach's Alpha are utilized to evaluate reliability, with values above 0.70 indicating robust internal consistency. The SEM-PLS method was selected due to its adaptability and strength in evaluating intricate research models (Baharum et al., 2023; Mohd Dzin & Lay, 2021).

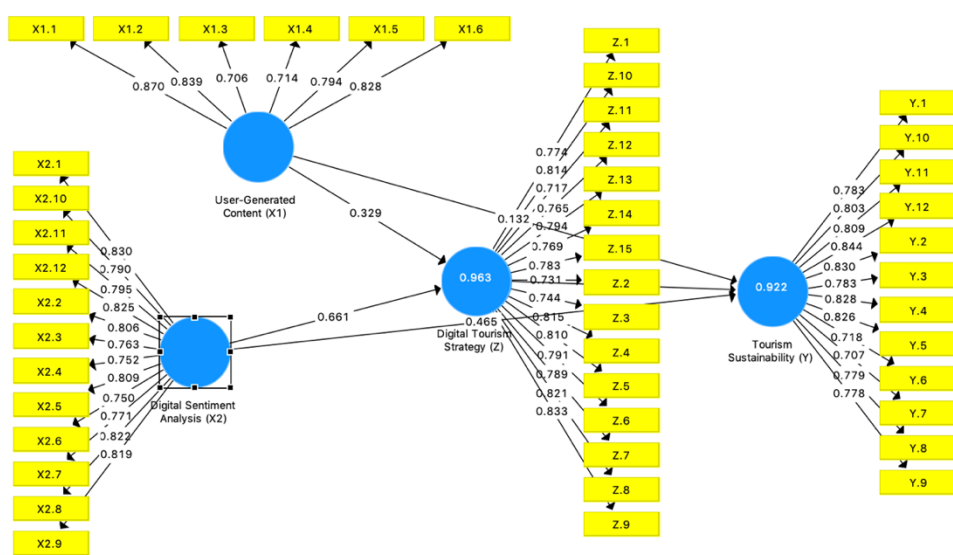


Figure 2. Outer Model
Source: Processed by Researchers, 2026

Figure 2 illustrates the outcomes of convergent validity assessment using the PLS approach by analyzing loading factor values and the Average Variance Extracted (AVE). A construct is deemed valid when the loading factor is above 0.70 and the AVE surpasses 0.50. The results indicate that all indicators have satisfied the established criteria for convergent validity.

Table 1. AVE, Cronbach's Alpha, and Composite Reliability Values

Variable	Average Variance Extracted (AVE)	Cronbach's Alpha	Composite Reliability
User-Generated Content (X1)	0.631	0.881	0.911
Digital Sentiment Analysis (X2)	0.632	0.947	0.954
Digital Tourism Strategy (Z)	0.614	0.955	0.960
Tourism Sustainability (Y)	0.627	0.946	0.953

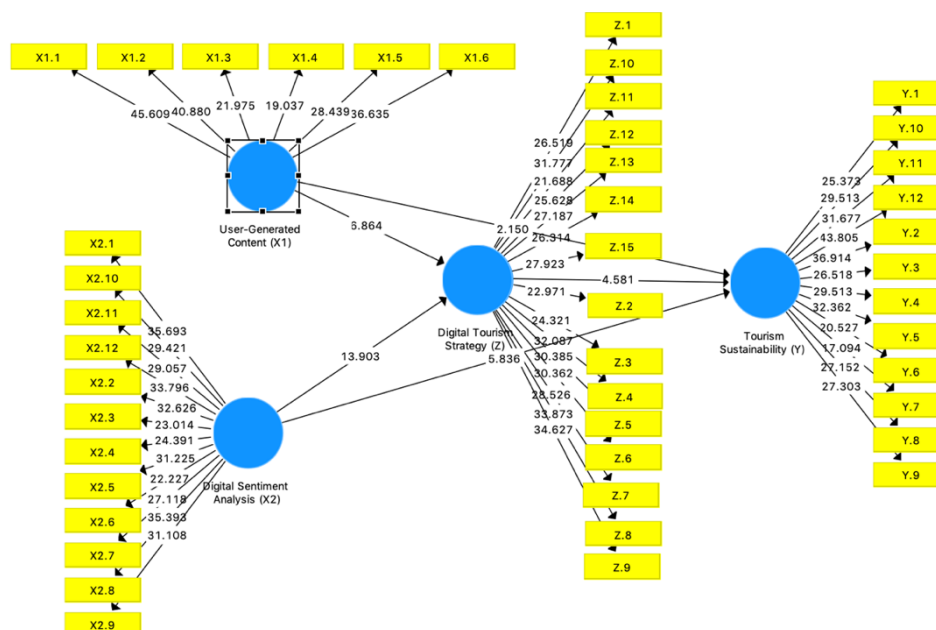
Source: Processed by Researchers, 2026

The test outcomes reveal that each construct possesses an Average Variance Extracted (AVE) value exceeding 0.50, signifying the indicator's capability to effectively represent latent constructs. The values for Cronbach's Alpha and Composite Reliability for all variables exceeded the 0.70 benchmark, demonstrating the instrument's excellent internal consistency and reliability. Consequently, the concepts of user-generated content, digital sentiment analysis,

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digital tourism strategy, and tourism sustainability were confirmed to be valid and reliable for subsequent structural analysis. PLS-based structural model testing seeks to assess the connections between latent variables by employing path coefficient analysis through bootstrapping. This approach assesses the direction and significance of the influence between constructs (Méndez-Suárez, 2021).



Source: Processed by Researchers, 2026

Figure 3 presents the SEM-PLS analysis results, indicating that all the model's construct relationships are both positive and significant, as evidenced by the t-statistics values derived from bootstrapping. User-generated content (X1) significantly influences digital tourism strategy (Z), evidenced by a t-value of 6.864. In contrast, digital sentiment analysis (X2) exerts an even greater impact, with a t-value of 13.903. Moreover, user-generated content (X1) significantly impacts tourism sustainability (Y), evidenced by a t-value of 2.150, while digital sentiment analysis (X2) has an even greater influence, with a t-value of 5.836, on tourism sustainability. The impact of digital tourism strategy (Z) on tourism sustainability (Y) is substantial, as indicated by a t-value of 4.581. All indicators in each construct also have t-statistics values above 1.96, which confirms the validity of the indicators in reflecting the latent construct. The results underscore the crucial role that digital data plays in advancing the sustainability of tourism.

R-Square Test

Inner model testing with SmartPLS 3 was conducted to evaluate the relationship between latent constructs. The R-Square value was employed to assess how well exogenous variables could account for endogenous variables, thus indicating the robustness and precision of the structural model formulated in this research (Channa et al., 2021). The estimated R-Square values obtained through the analysis process are presented in detail in the following table.

Table 2. R Square Results

Variable	R Square
Digital Tourism Strategy (Z)	0.963
Tourism Sustainability (Y)	0.922

Source: Processed by Researchers, 2026

The R-Square value shows that the digital tourism strategy (Z) can be explained by exogenous variables by 96.3%, while tourism sustainability (Y) can be explained by 92.2%. This value indicates that the explanatory power of the structural model is very strong, so that the relationship between constructs has a very high predictive ability.

Predictive Relevance

In PLS, the Q^2 value is utilized to assess how well the model can predict empirical data. A model is deemed to have strong predictive capabilities if the Q^2 value is positive. A value above 0.25 indicates moderate relevance, while a value exceeding 0.50 indicates strong predictive ability (Sofwan et al., 2024).

Table 3. Q-square

Variable	SSO	SSE	$Q^2 (=1-SSE/SSO)$
Digital Tourism Strategy (Z)	3375,000	1,398,025	0.586
Tourism Sustainability (Y)	2,700,000	1,157,428	0.571

Source: Processed by Researchers, 2026

The results of the Q^2 value calculation show that the digital tourism strategy (Z) has a Q^2 value of 0.586 and tourism sustainability (Y) has a value of 0.571. Both values are above 0.50, which indicates the model's strong and significant predictive ability. This confirms that the SEM-PLS model has high predictive relevance in explaining the variation in observational data on both endogenous variables.

Evaluation of Model Goodness of Fit

The GoF value reflects how well the model can represent empirical data, with a score of 0.10 considered low, 0.25 regarded as moderate, and a score of 0.36 or higher seen as high. Additionally, the SRMR is employed to evaluate model fit, where a value under 0.08 signifies a good fit (Zheng & Bentler, 2024).

Table 4. SRMR

	Saturated Model	Estimated Model
SRMR	0.035	0.035

Source: Processed by Researchers, 2026

An SRMR value of 0.035 for both the saturated and estimated models signifies an outstanding model fit. Given that this value is significantly below the 0.08 benchmark, it demonstrates that the SEM-PLS model exhibits a strong alignment between the model's correlation matrix and the observed data.

Table 5. GoF Index

Average AVE	Average R Square	Goodness of fit index
0.626	0.943	0.768

Source: Processed by Researchers, 2026

The model demonstrates an excellent fit with a GoF value of 0.768, significantly surpassing the minimum threshold of ≥ 0.36 . This suggests that the SEM-PLS model effectively captures empirical data and exhibits robust structural and measurement quality.

Hypothesis Testing

The bootstrapping method in SmartPLS 3 is extensively utilized for hypothesis testing due to its adaptability, lack of reliance on normality assumptions, and suitability for relatively small sample sizes. This method produces accurate estimates of path coefficients and t-statistic or p-value values to assess the significance of relationships between variables in the research model (Kostanek et al., 2024).

Table 6. Path Significance Test

Variable	Original Sample (O)	T Statistics (O/STDEV)	P Values	Description
User-Generated Content (X1) -> Digital Tourism Strategy (Z)	0.329	6.864	0.000	Influential
Digital Sentiment Analysis (X2) -> Digital Tourism Strategy (Z)	0.661	13,903	0.000	Influential
User-Generated Content (X1) -> Tourism Sustainability (Y)	0.132	2.150	0.032	Influential
Digital Sentiment Analysis (X2) -> Tourism Sustainability (Y)	0.465	5.836	0.000	Influential
Digital Tourism Strategy (Z) -> Tourism Sustainability (Y)	0.372	4.581	0.000	Influential
User-Generated Content (X1) -> Digital Tourism Strategy (Z) -> Tourism Sustainability (Y)	0.122	3.762	0.000	Influential
Digital Sentiment Analysis (X2) -> Digital Tourism Strategy (Z) -> Tourism Sustainability (Y)	0.246	4.354	0.000	Influential

Source: Processed by Researchers, 2026

The SEM-PLS bootstrapping analysis results for hypotheses H1–H7 indicate that all the variable relationships in the model are both positive and significant. H1 and H2 prove that User-Generated Content (X1) and Digital Sentiment Analysis (X2) have a significant effect on Digital Tourism Strategy (Z), with X2 having a more dominant effect. H3 and H4 show that X1 and X2 also have a direct effect on Tourism Sustainability (Y), although the effect of UGC is relatively more moderate than that of digital sentiment. H5 confirms that Digital Tourism Strategy plays an important role in promoting tourism sustainability. Additionally, H6 and H7 validate the importance of a Digital Tourism Strategy as a crucial intermediary that facilitates the impact of User-Generated Content and Digital Sentiment Analysis on the sustainability of tourism. Overall, these findings indicate that the integration of user-generated content and digital sentiment analysis through an effective digital tourism strategy is a key mechanism in enhancing tourism sustainability.

DISCUSSIONS

The study's outcomes verify that leveraging big data for digital transformation is a key factor in promoting sustainable tourism in West Java's Puncak area. The research indicates that user-generated content (X1) and digital sentiment analysis (X2) significantly and positively affect the development of digital tourism strategies (Z), with sentiment analysis exerting a notably stronger influence, as evidenced by a t-statistics value of 13.903. This indicates that a deep understanding of tourists' emotional perceptions and opinions through digital platforms provides a stronger basis for destination managers to design responsive policies rather than simply looking at content intensity alone. The role of Digital Tourism Strategy (Z) as a mediating variable is proven to be significant (H6 and H7) in channeling the influence of digital data towards Tourism Sustainability (Y). With a sustainability variable R-Square value of 92.2%, this model proves that effective digital strategies can convert tourist complaints and appreciation into concrete actions that support SDG targets, particularly in destination carrying capacity management and environmental protection. This data-driven strategy enables tourism management to shift from a reactive to a proactive and adaptive approach. These findings are consistently supported by global literature. Khan et al. (2023) state that UGC is the primary source for understanding tourist satisfaction in real-time, which is crucial for destination management. In line with this, Zeqiri et al. (2025) highlight that digital tourism platforms play an instrumental role in advancing SDGs in the Industry 4.0 era. The integration of sentiment analysis in this study also reinforces the argument of Zhang et

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al. (2022), who emphasize the use of online reviews to reveal a comprehensive image of a destination. Finally, the success of this mediation model addresses the concerns of Das et al. (2025) regarding obstacles in developing countries in transforming tourism analytics into operational strategic policies. Thus, optimizing data-driven digital strategies is not only an option but a necessity to maintain economic and environmental balance in leading tourist areas.

CONCLUSION

This study successfully achieved its main objective by proving that the integration of digital sentiment analysis and user-generated content (UGC) through the formulation of a Digital Tourism Strategy is a key mechanism in accelerating Tourism Sustainability in the Puncak Region, West Java. These findings make a significant contribution to the development of tourism management science by shifting the paradigm from simply using digital analytics as a marketing tool to a strategic instrument for achieving SDG targets, particularly points 8, 11, and 12. This work advances current knowledge by filling a research gap through the combination of in-depth sentiment analysis with a systematic mediation strategy, going beyond previous studies that generally focused only on simple sentiment polarity or tourist satisfaction in isolation. The scientific justification for this model is reinforced by a very high R-Square value, where digital strategies can explain 92.2% of the variance in tourism sustainability, supported by strong predictive relevance (Q^2) and excellent model fit (SRMR). Practically, this research provides a framework for policymakers to transform tourism governance from a conventional-reactive approach to adaptive evidence-based policy that responds to the dynamics of digital tourist behavior. The application of this research can be extended to the management of similar natural tourist destinations in developing countries facing the challenge of environmental degradation due to a surge in visits. Future experiments are recommended to integrate more advanced artificial intelligence (AI) technology for real-time sentiment monitoring and involve more precise spatial (geo-tagged) data to map environmental loads at specific points. Currently, research development is focused on strengthening multi-stakeholder collaboration, including the role of food MSMEs in supporting a sustainable tourism ecosystem, to ensure more inclusive economic benefits around digital destinations.

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