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Big Data Analytics with Blockchain Technology for Understanding Tourist Preferences in Ecotourism

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Abstract. This study examines the integration of big data analytics and blockchain technology to understand tourist preferences in the context of ecotourism. The research was conducted in Manado, Indonesia, and employed a mixed-methods design combining digital tourism data analysis, surveys, semi-structured interviews, and blockchain prototype implementation. The study analyzed 500 tourist reviews collected from major online platforms, involved 150 tourism SMEs as primary respondents, and piloted the proposed system with 50 selected SMEs. Big data analytics was used to identify dominant tourist preferences and segment visitors based on their behavioral patterns. At the same time, blockchain technology was implemented to improve the security, traceability, and integrity of preference data. The results revealed four major tourist segments: family travelers, solo travelers, young travelers, and international tourists, each characterized by different preference combinations related to accommodation, nature tourism, culinary experiences, and tourism services. The findings also showed that blockchain significantly strengthened data security by reducing recorded data leakage and violation cases to zero after implementation. In addition, SMEs that used preference-based insights were able to improve service personalization and reported positive business outcomes, particularly in accommodation and nature-based tourism services. User evaluation further indicated high levels of acceptance across ease of use, operational efficiency, data security, and personalization quality. Overall, the study demonstrates that integrating big data analytics and blockchain technology provides a valuable framework for delivering secure, data-driven, and personalized ecotourism services.

Keywords: Big data analytics; Blockchain; Ecotourism; Service personalization; Tourist preferences

INTRODUCTION

Ecotourism has become a strategic pathway for balancing tourism growth with environmental conservation, community participation, and long-term destination resilience (Luong, 2023; Paul & Roy, 2023). However, the success of ecotourism depends not only on protecting natural assets, but also on understanding what tourists actually value, how their preferences evolve, and which destination attributes shape environmentally responsible choices (Haron et al., 2025; Luong, 2024). Recent studies show that ecotourism intention and engagement are influenced by eco-destination image, environmental beliefs, biospheric values, personal norms, destination trust, and willingness to pay for sustainability-oriented attributes. This means that ecotourism management increasingly requires evidence-based insight into heterogeneous tourist preferences rather than relying only on conventional surveys or static segmentation models (Adam et al., 2026; Castillo-Canalejo et al., 2025; Zhang et al., 2026).

At the same time, the digitalization of tourism has generated massive volumes of user-generated and platform-based data, including online reviews, search traces, booking behavior, images, location footprints, and social media interactions (Liu et al., 2024; Pereira-Moliner et al., 2024). These data streams provide a richer and more dynamic basis for identifying tourist preferences than traditional instruments, especially in destinations where experience quality, conservation values, and local authenticity interact in complex ways (Guidotti et al., 2025; Peng

& Deng, 2024). Recent tourism studies demonstrate that big data analytics, sentiment analysis, machine learning, and review mining can reveal preference structures, segment-specific expectations, destination perceptions, and behavioral patterns at a scale that was previously unattainable. In the context of ecotourism, such methods are particularly valuable because they can capture nuanced expressions related to nature experience, environmental awareness, service expectations, and responsible behavior embedded in digital traces (Höpken et al., 2026; Rao et al., 2025; Yap et al., 2025).

However, the growing reliance on big data in tourism also raises major governance challenges. Tourist preference data are often fragmented across platforms, vulnerable to manipulation, weakly auditable, and difficult to govern in ways that preserve privacy, authenticity, and trust (Muharam et al., 2024; Toufaily & Zalan, 2024; Treiblmaier, 2025). These limitations are especially problematic in ecotourism, where sustainable decision-making depends on credible information, transparent stakeholder interactions, and the responsible use of visitor data. In response, blockchain has been increasingly discussed as a complementary technology capable of improving data integrity, traceability, transparency, decentralized trust, and automated transactions through smart contracts (Dhiraj et al., 2023; Maythu et al., 2024; Sarnacchiaro et al., 2024). Recent tourism and hospitality studies suggest that blockchain can reduce information asymmetry, improve review credibility, support secure payment and identity processes, strengthen peer-to-peer interactions, and create more trusted digital ecosystems; however, adoption remains uneven because organizational readiness, user trust, perceived security, and implementation barriers still matter substantially (Balasubramanian et al., 2022; Prados-Castillo et al., 2023; Puri et al., 2023; Raluca-Florentina, 2022).

Although research on smart, sustainable, and blockchain-enabled tourism systems has expanded rapidly, the intersection of big data analytics and blockchain for understanding tourist preferences in ecotourism remains underdeveloped. Existing studies tend to examine either ecotourism behavior and sustainable intention, or blockchain adoption and digital trust, or big-data-driven tourism intelligence in isolation. As a result, there is still limited understanding of how a blockchain-supported big data architecture can be used not merely to store or secure data, but to generate reliable, preference-based intelligence for ecotourism planning, personalization, and governance. Recent reviews on sustainable smart ecotourism, digital technologies in nature-based tourism, sustainable tourism analytics, and blockchain-based tourism management all point to the need for more integrated frameworks that connect technological capability with sustainability outcomes and destination-level decision support (Parra-Sanchez & Viviescas-Jaimes, 2024; Rahimian et al., 2025; Zhang & Deng, 2024).

Therefore, this study proposes a big data analytical perspective, supported by blockchain technology, to understand tourists' preferences within the ecotourism concept. Specifically, the study is positioned on the argument that ecotourism destinations need a more trustworthy, scalable, and data-driven mechanism for capturing, validating, and analyzing visitor preferences from diverse digital sources. By integrating big data analytics with blockchain-based data governance, the study seeks to contribute in three ways. First, it extends ecotourism research by moving from generic sustainability intention toward fine-grained preference intelligence. Second, it introduces blockchain not only as a transaction technology but also as an infrastructure for trust, provenance, and secure preference management. Third, it offers a foundation for destination managers, tourism SMEs, and policymakers to design more personalized, transparent, and sustainable ecotourism services. In this sense, the study addresses a timely gap in the tourism literature and responds to the increasing need for secure digital intelligence in sustainable destination development.

MATERIALS AND METHODS

Study area

This study was conducted in Manado City, North Sulawesi, Indonesia, where tourism SMEs play an important role in local tourism development and service provision. Manado was selected as the study area because of its tourism potential and the growing need for secure, transparent, and data-driven tourism services. Within the ecotourism perspective adopted in this study, the destination context includes nature-based activities, accommodation services, local culinary experiences, and tourism-support services that shape the overall visitor experience.

The study focused on tourism SMEs operating in accommodation, restaurants, travel services, and related tourism activities. These businesses were considered appropriate units of observation because they interact directly with tourists and are in a position to use tourist preference data for service improvement and personalization.

Research design

This study employed a mixed-methods research design integrating big data analytics, survey-based assessment, semi-structured interviews, and the implementation of a blockchain prototype. The quantitative component was used to identify patterns of tourist preferences from digital tourism data. In contrast, the qualitative component examined how tourism SMEs perceived, adopted, and utilized blockchain-supported preference intelligence. This design enabled the study to capture both large-scale behavioral signals from online tourism platforms and managerial perspectives from tourism service providers.

The research design was developed to address two main objectives. The first objective was to extract and classify tourist preferences from digital traces, such as online reviews, booking platform content, and social media signals. The second objective was to assess whether a blockchain-based preference-management system could improve data security, trust, and service personalization among tourism SMEs. The analytical framework, therefore, combined digital data extraction, machine-learning-based segmentation, and prototype-based validation.

Data sources

The study used both primary and secondary data sources. Primary data were obtained through questionnaires and interviews with tourism SME owners or managers. Secondary data were collected from major tourism and digital platforms, including TripAdvisor, Google Reviews, Instagram, Airbnb, and Agoda. These platforms were selected because they contain user-generated content that reflects tourist evaluations, travel experiences, and service preferences across different stages of the tourism journey.

The study involved two complementary units of analysis. The first unit consisted of digital tourist data, including publicly accessible online reviews and tourism-related platform content. The second unit consisted of tourism SMEs operating in tourism-related sectors. A total of 150 tourism SMEs were included as primary respondents, and 50 were selected to participate in the prototype simulation phase. To clarify the data origin and the role of each source in the analytical process, Table 1 presents the main data sources used in this study, along with their corresponding data types and analytical purposes.

Table 1 shows that the study relied on a combination of platform-based digital traces and organizational data from tourism SMEs. This combination was essential because digital platforms provided large-scale behavioral evidence of tourist preferences. At the same time, questionnaires, interviews, and system logs supported the evaluation of managerial use, implementation challenges, and system performance.

Table 1. Data sources and analytical purposes

Data source	Type of data	Analytical purpose
TripAdvisor	Tourist reviews	Identification of destination and service preferences
Google Reviews	Tourist reviews	Assessment of tourist perceptions of service quality
Instagram	Social media content	Extraction of experience-related and behavioral signals
Airbnb	Booking-platform content	Analysis of accommodation-related preferences
Agoda	Booking-platform content	Analysis of accommodation and service preferences
SME questionnaires	Structured responses	Evaluation of the use of preference data in service improvement
SME interviews	Qualitative responses	Exploration of trust, adoption, and implementation issues
Blockchain transaction logs	System-generated records	Evaluation of system security and usage performance

Data collection

A purposive sampling technique was used to select tourism SMEs that were directly involved in visitor services and had the potential to utilize tourist preference data in their business operations. This was complemented by a snowball sampling approach to identify additional relevant respondents within the tourism network. For the digital-data component, only publicly accessible, tourism-related, text-based content with sufficient informational value was included in the analysis. Duplicate records, irrelevant content, and incomplete entries were excluded during preprocessing.

Data collection was conducted in five stages. In the first stage, an initial survey and interview process was carried out with tourism SME owners and managers to identify operational challenges, digital transaction issues, and the relevance of tourist preference information for service improvement. In the second stage, digital tourism data were collected from online platforms over 2 months. This stage focused on harvesting tourist reviews and related digital content from TripAdvisor, Google Reviews, Instagram, Airbnb, and Agoda.

In the third stage, the collected data were processed and analyzed over three months using machine learning and text analytics. This stage was intended to identify tourist segments, detect dominant preferences, and classify review content into major tourism-related categories. In the fourth stage, the preference data generated from the analytics process were integrated into a blockchain-based system over two months using Ethereum and smart contracts. In the fifth stage, the system was piloted with 50 selected SMEs over two months, followed by a final evaluation and reporting stage lasting one month.

Several research instruments were used throughout the study. Web-scraping tools were employed to collect tourism-related digital content from online platforms. The original research design specified the use of Python-based technologies, including BeautifulSoup and Scrapy, for web data extraction. Questionnaires were administered to tourism SMEs to assess the practical use of tourist preference data. Semi-structured interviews were conducted to obtain in-depth information on perceived usefulness, trust, and adoption readiness. In addition, machine-learning algorithms were used for preference segmentation, while a blockchain platform built on the Ethereum network and smart contracts was developed to secure tourist preference data. To summarize the methodological tools applied at each stage of the study, Table 2 presents the research instruments, their primary functions, and the outputs generated from each instrument.

Table 2 indicates that the study combined computational, qualitative, and system-based instruments in order to address both analytical and implementation objectives. The use of multiple instruments strengthened the overall research design by enabling the extraction of tourist preferences from digital content and the assessment of business adoption, trust, and

prototype performance.

Table 2. Research instruments and functions

Instrument	Function	Output
Python scraping tools (BeautifulSoup, Scrapy)	Collection of tourism-related digital content	Raw review and platform dataset
Python and R	Data cleaning and analytics	Structured dataset and analytical outputs
Natural Language Processing (NLP)	Text processing and sentiment interpretation	Sentiment categories and thematic patterns
K-means clustering	Tourist segmentation	Preference-based tourist clusters
SME questionnaire	Structured organizational assessment	Quantitative evaluation of SME responses
Semi-structured interview	Qualitative inquiry	Contextual insights on adoption and implementation
Ethereum blockchain	Secure data management	Immutable and traceable data records
Smart contracts	Automated data verification and control	Controlled access and auditability
Transaction logs and satisfaction survey	Prototype evaluation	System performance and user evaluation

The procedural sequence of the research is illustrated in Figure 1, which outlines the workflow from the initial survey stage to final evaluation and reporting.

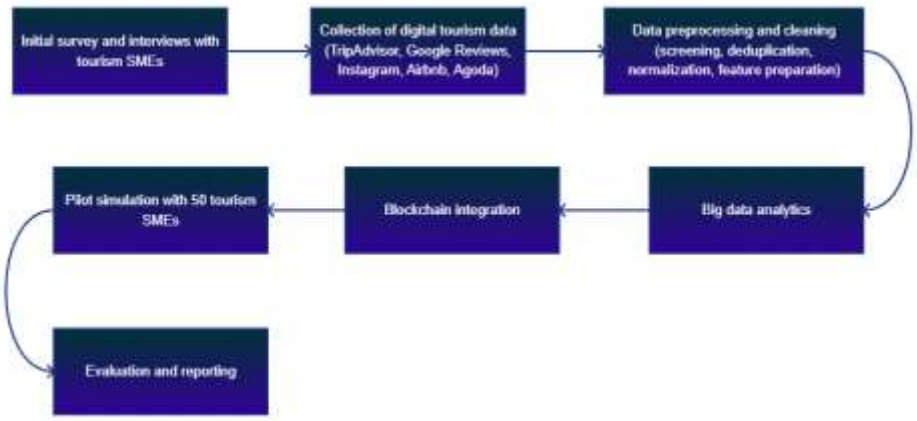

Figure 1. Research workflow

Figure 1 illustrates that the study followed a sequential, integrated methodological approach. The process began with organizational input from tourism SMEs, continued through digital data extraction and analytical modeling, and ended with blockchain integration and prototype evaluation. This workflow reflects the study's logic, treating preference identification and secure data governance as interconnected components within a single research framework.

Data analysis

Before analysis, the digital dataset was cleaned and standardized to ensure consistency and analytical reliability. The preprocessing stage included removing duplicate and irrelevant entries, screening incomplete records, normalizing textual content, tokenization, and eliminating stop words and punctuation. This procedure transformed the raw online data into a structured corpus suitable for computational analysis.

The analytical stage combined sentiment analysis and K-means clustering. Sentiment analysis was used to identify evaluative polarity in tourist reviews and to capture perceptions related to accommodation, nature tourism, culinary experiences, and tourism services. K-means

clustering was then applied to group tourists into segments based on the dominant preference patterns extracted from the digital dataset. The analysis generated four major segments: family travelers, solo travelers, young travelers, and international tourists. These segments were interpreted based on their dominant preferences, including accommodation and culinary interests, nature and outdoor activities, and service quality.

Quantitative data were analyzed using statistical and computational approaches. Descriptive analysis was used to summarize the composition of the review dataset and the distribution of tourist preference categories. Statistical processing and computational modeling were conducted using Python, R, and related analytical tools. Qualitative data from interviews and open-ended feedback were analyzed using content analysis to identify themes related to trust, adoption readiness, perceived usefulness, and implementation barriers. The integration of quantitative and qualitative evidence enabled a more comprehensive interpretation of both tourist behavior and organizational responses. To present the main analytical stages systematically, Table 3 summarizes the inputs, methods, and outputs for each stage of the data analysis process.

Table 3. Analytical stages and outputs

Analytical stage	Input	Method	Output
Digital data extraction	Online reviews and platform content	Web scraping	Raw tourism dataset
Text preprocessing	Raw review corpus	Cleaning, normalization, and tokenization	Structured textual dataset
Sentiment analysis	Cleaned review corpus	NLP	Sentiment polarity and thematic categories
Tourist segmentation	Review-based feature patterns	K-means clustering	Preference-based tourist segments
Preference interpretation	Cluster profiles	Comparative analysis	Dominant tourist preference categories
Qualitative interpretation	Interviews and SME feedback	Content analysis	Adoption, trust, and implementation themes

Table 3 shows that the analytical framework moved from raw data extraction to structured interpretation through several interrelated stages. The table also demonstrates that the study did not rely on a single analytical method; instead, it combined computational analysis and qualitative interpretation to produce a broader understanding of tourist preferences and their managerial implications.

Blockchain architecture

A blockchain layer was implemented to enhance the security, traceability, and integrity of tourist preference data. The system was developed using Ethereum and smart contracts, enabling automated validation and controlled access to preference data records. The blockchain architecture functioned as a governance layer supporting secure data management, reducing the risk of unauthorized modification, and providing an auditable record of data-related transactions. This structure was particularly important for maintaining trust in a system designed to support personalized tourism services.

The blockchain architecture was integrated after the big data analysis stage to record and manage the generated preference insights securely. Rather than functioning solely as a storage mechanism, the system was designed to support verification, traceability, and access control in the handling of tourist preference data. This made the system suitable for a tourism environment in which trust, data protection, and service transparency are essential.

Evaluation metrics

The blockchain-enabled preference management system was piloted with 50 selected tourism SMEs. During the pilot phase, SMEs used tourist preference insights generated by the analytical system to support service personalization. System performance was then evaluated using four main indicators: ease of use, operational efficiency, data security, and personalization quality. These indicators were measured through user satisfaction surveys and supported by transaction-based system observations.

Ease of use reflected the system's interface and workflow. Operational efficiency referred to the extent to which the system supported faster or more effective business processes. Data security was assessed based on the protection and integrity of tourist preference information. Personalization quality was measured by the system's ability to support service adaptation for identified tourist segments. Together, these metrics provided an integrated framework for evaluating the system's technical and practical performance. To make the assessment criteria explicit, Table 4 presents the evaluation metrics used to assess the performance of the blockchain-enabled preference management system.

Table 4. Evaluation metrics

Dimension	Description	Source of evidence
Ease of use	Usability of the blockchain-enabled system	User satisfaction survey
Operational efficiency	Support for more effective operational processes	Survey and transaction analysis
Data security	Protection and integrity of tourist preference data	Survey and security records
Personalization quality	Ability to tailor services to tourist segments	Survey and pilot feedback

Table 4 indicates that the evaluation framework covered both technical performance and user-centered outcomes. This is important because the effectiveness of a digital tourism system depends not only on its technical reliability but also on its practical usefulness to tourism SMEs in enabling secure, personalized service delivery.

RESULTS AND DISCUSSION

The empirical findings were derived from analyses of 500 digital tourist reviews, participation by 150 tourism SMEs, and a pilot implementation involving 50 selected SMEs. The results are organized into five parts: distribution of tourist review data, tourist preference segmentation, blockchain-based data security, outcomes of SME service personalization, and system evaluation. Overall, the findings indicate that big data analytics can effectively identify tourist preferences in the ecotourism context. At the same time, blockchain technology enhances the security, traceability, and practical usability of preference data for tourism SMEs.

Distribution of tourist review data

The first stage of the analysis examined the distribution of tourist-generated content collected from TripAdvisor, Google Reviews, Instagram, Airbnb, and Agoda. A total of 500 reviews were analyzed and classified into four main categories: accommodation, nature tourism, local culinary experiences, and tourism services. The highest number of reviews was in the accommodation category, with 180, followed by nature tourism with 150, local culinary experiences with 100, and tourism services with 70. These results show that tourists evaluate their travel experiences across environmental, service-related, and consumption-based dimensions. To present the composition of the digital review dataset more clearly, Table 5 summarizes the number of reviews per experience category.

Table 5. Distribution of tourist reviews by experience category

Experience category	Number of reviews
Accommodation	180
Nature tourism	150
Local culinary experiences	100
Tourism services	70
Total	500

Table 5 shows that accommodation-related reviews accounted for the largest share of the dataset, with 180 entries, followed by nature tourism with 150 entries. Local culinary experiences and tourism services accounted for 100 and 70 reviews, respectively. This distribution suggests that although ecotourism is strongly associated with environmental attractions, tourists also place substantial importance on comfort, food, and supporting services when evaluating their experiences. The dominance of accommodation-related reviews suggests that lodging remains a central component of the overall tourism experience, even within an ecotourism setting. This indicates that ecotourism demand should not be interpreted solely through the lens of environmental attractions. Instead, tourists appear to assess ecotourism experiences through an integrated service bundle that includes physical comfort, nature-based activities, local food, and supporting services. The large number of nature tourism reviews underscores the importance of environmental and outdoor experiences. However, the simultaneous prominence of accommodation and culinary aspects demonstrates that ecotourism experiences are multidimensional and shaped by both ecological and service-related factors.

Tourist preference segmentation

The second stage of the analysis applied K-means clustering to identify tourist segments based on dominant preference patterns derived from the digital review dataset. The clustering process generated four major groups: family travelers, solo travelers, young travelers, and international tourists. Family travelers accounted for the largest segment, with 180 cases, and were mainly associated with accommodation and culinary experiences. Solo travelers accounted for 150 cases and showed the strongest orientation toward nature tourism and outdoor activities. Young travelers represented 100 cases and were linked to tourism services and local culinary experiences, while international tourists accounted for 70 cases and were primarily associated with service quality and nature tourism. To illustrate the clustering output and the dominant preference profile of each tourist group, Table 6 presents the tourist segments identified through the analytical model.

Table 6. Tourist preference segmentation based on K-means clustering

Tourist segment	Dominant preference	Number of tourists
Family travelers	Accommodation and culinary experiences	180
Solo travelers	Nature tourism and outdoor activities	150
Young travelers	Tourism services and local culinary experiences	100
International tourists	Service quality and nature tourism	70
Total		500

Table 6 indicates that family travelers formed the largest segment, with preferences centered on accommodation and culinary experiences. Solo travelers were primarily associated with nature tourism and outdoor activities, while young travelers were more strongly linked to tourism services and local culinary experiences. International tourists showed a combined interest in service quality and nature-based attractions. These results demonstrate that tourist preferences vary across market segments and that each group responds to distinct configurations of tourism attributes. These results also indicate that tourist preferences in ecotourism are

heterogeneous rather than uniform. The family traveler segment appears to prioritize comfort, convenience, and food-related experiences, which suggests that family-oriented ecotourism products should include accessible accommodation and integrated local culinary offerings.

In contrast, the solo traveler segment is more strongly motivated by direct engagement with nature and outdoor activities, making this group particularly relevant for ecotourism packages centered on exploration, adventure, and immersive environmental experiences. The young traveler segment highlights the importance of service design and local lifestyle experiences. In contrast, the international tourist segment suggests a combination of service expectations and interest in nature-based attractions.

From an ecotourism perspective, this segmentation shows that nature remains a key attraction, but it is not the only determinant of tourist interest. Tourists evaluate ecotourism offerings through different combinations of destination attributes, and these combinations vary by segment. As a result, ecotourism service providers need to move beyond a one-size-fits-all approach and adopt more targeted service configurations based on segment-specific preferences. The segmentation results also demonstrate the practical value of big data analytics for identifying behavioral differences that might not be captured through conventional survey methods alone.

Blockchain-based data security performance

The third stage of the study assessed the role of blockchain in securing tourist preference data generated through big data analytics. Two security indicators were used: preference-data leakage and data violations. Before blockchain implementation, the system recorded five cases of data leakage and three cases of data violations. After integrating Ethereum and smart contracts, both indicators decreased to zero. This result demonstrates a substantial improvement in data protection and confirms the effectiveness of blockchain as a mechanism for securing tourist preference information. To compare the security condition before and after blockchain integration, Table 7 presents the observed values for the two main security indicators.

Table 7. Data security performance before and after blockchain implementation

Security indicator	Before blockchain	After blockchain
Preference-data leakage	5 cases	0 cases
Data violations	3 cases	0 cases

Table 7 shows a complete reduction in recorded cases of preference data leakage and data violations after the blockchain layer was implemented. Before adoption, the system experienced 5 data leakage incidents and 3 data violation incidents. After the implementation of Ethereum-based smart contracts, both indicators fell to zero. This pattern suggests that blockchain significantly improved the protection and governance of tourist preference data. The reduction of both indicators to zero suggests that blockchain contributed not only to data storage security but also to the broader governance of preference information. In a tourism environment where customer data is increasingly used for service personalization, data security becomes a fundamental requirement for trust. The blockchain layer improved the integrity and traceability of preference data management by creating a more secure and verifiable system architecture. This is particularly important in ecotourism and sustainable tourism contexts, where long-term stakeholder trust and responsible data governance are essential.

These findings also highlight the complementary role of blockchain in relation to big data analytics. While big data analytics can reveal preference patterns and behavioral insights, its practical value may be limited if users and service providers do not trust the underlying system. The present results show that blockchain can function as a trust-enabling infrastructure

that strengthens the reliability of data-driven decision-making. In this sense, the study's technological contribution lies not only in detecting tourist preferences but also in establishing a more secure framework for handling them in practice.

Effects of preference-based personalization on tourism SMEs

The fourth stage of the study evaluated how tourism SMEs used preference-based insights to personalize services and improve their business performance. The pilot implementation involved 50 selected SMEs, and the findings show that businesses using the system were able to adapt their offerings according to identified tourist segments. The strongest result was observed in the accommodation category, where 20 SMEs reported increased sales after applying personalized services. This was followed by 15 SMEs in nature-based tourism services, 10 in culinary services, and 5 in integrated tourism services. To show the distribution of reported business improvements across service categories, Table 8 presents the number of SMEs that experienced increased sales after implementing preference-based personalization.

Table 8. SME performance after preference-based service personalization

Personalized service category	Number of SMEs reporting increased sales
Accommodation	20
Nature tourism	15
Culinary services	10
Integrated tourism services	5
Total	50

Table 8 shows that accommodation services recorded the highest number of SMEs reporting increased sales, with 20 businesses indicating positive outcomes. Nature-tourism services followed with 15 SMEs, while culinary services and integrated tourism services accounted for 10 and 5 SMEs, respectively. This distribution suggests that preference-based personalization was most immediately effective in service categories that are closely linked to direct tourist decision-making and consumption. These findings indicate that preference-based personalization can generate tangible operational benefits for tourism SMEs. The highest gains in accommodation suggest that lodging providers were particularly effective at translating customer insights into marketable, relevant service adjustments. This may reflect the central role of accommodation in tourist decision-making, as well as the flexibility of accommodation businesses in tailoring packages, amenities, or bundled offers. The positive outcomes in nature tourism and culinary services also show that preference intelligence can support more accurate matching between tourist expectations and service delivery.

The broader implication is that big data analytics can move beyond descriptive tourism monitoring and support real business adaptation. SMEs that understand the preferences of different tourist segments are better positioned to design more relevant offerings, improve the customer experience, and differentiate themselves in a competitive market. In the ecotourism context, this means that service personalization can be aligned with both visitor needs and destination characteristics, for example, by developing family-friendly eco-accommodation, solo-traveler nature packages, or culturally embedded culinary experiences.

System evaluation and user perception

The final stage of the study examined user perceptions of the blockchain-enabled system. Four evaluation dimensions were measured: ease of use, operational efficiency, data security, and personalization quality. The system received high average scores across all indicators: 4.6 for ease of use, 4.7 for operational efficiency, 4.8 for data security, and 4.5 for

personalization quality, on a five-point scale. To summarize user perceptions of the system, Table 9 presents the mean score for each evaluation dimension on a five-point scale.

Table 9. User evaluation of the blockchain-enabled preference management system

Evaluation dimension	Mean score (1–5)
Ease of use	4.6
Operational efficiency	4.7
Data security	4.8
Personalization quality	4.5

Table 9 indicates that the highest score was recorded for data security, followed by operational efficiency and ease of use. Personalization quality also received a high score, although it was slightly lower than the other dimensions. Overall, the results suggest that users considered the system reliable, practical, and supportive of service improvement. The highest score was recorded for data security, indicating that respondents regarded the system as highly reliable in protecting tourist preference information. This result is consistent with the reduction in leakage and violation cases observed in the security analysis. The strong score for operational efficiency suggests that the system was not perceived merely as a technical innovation, but as a practical tool capable of supporting daily business processes. Meanwhile, the slightly lower score for personalization quality, although still high, suggests that the quality of personalized service outcomes depends not only on system performance but also on SMEs' readiness to translate preference insights into actual service strategies.

These results show that the integrated use of big data and blockchain was positively received by users and perceived as beneficial in both technical and operational terms. The system performed particularly well in dimensions directly associated with trust and efficiency, which are critical factors in the adoption of digital tourism technologies. At the same time, the findings suggest that personalization outcomes can be further strengthened through better business integration, staff capability development, and more refined recommendation mechanisms.

General discussion

Taken together, the results demonstrate that the combination of big data analytics and blockchain technology offers a viable framework for understanding tourist preferences in ecotourism and applying these insights in practice. The review analysis confirmed that tourist experiences are shaped by multiple dimensions, especially accommodation, nature-based attractions, culinary experiences, and supporting services. The clustering results further showed that tourists form distinct segments with different preference structures, indicating that ecotourism demand is diverse and should be managed accordingly.

The integration of blockchain added an important governance function to the analytical framework. The elimination of recorded leakage and violation cases demonstrates that blockchain can improve the security and accountability of tourist preference management. This is particularly relevant in digitally mediated tourism environments, where personal data, booking records, and service histories are increasingly used to support customization and competitive positioning. The results suggest that blockchain should be understood not only as a technical security layer but also as a mechanism for strengthening trust in data-driven tourism systems.

The pilot implementation also confirmed that preference intelligence can be translated into practical service benefits for tourism SMEs. Businesses that used segmented preference data were able to personalize their services and improve performance, especially in the

accommodation and nature tourism categories. This finding is important because it shows that the analytical outputs were not merely descriptive but operationally relevant. In the context of ecotourism, this relevance is crucial because sustainable tourism development depends on local businesses' ability to respond to visitor expectations while maintaining destination attractiveness and competitiveness.

Overall, the findings support the argument that ecotourism management can benefit from an integrated digital framework in which big data analytics generates preference insights, and blockchain secures the resulting information infrastructure. This combination enables tourism SMEs to move toward more personalized, secure, and data-driven services. At the same time, the results indicate that the effectiveness of this model depends on SMEs' readiness to adopt digital tools and to convert analytical outputs into meaningful service innovations.

CONCLUSION

This study demonstrates that integrating big data analytics and blockchain technology provides a robust framework for understanding tourists' preferences in the context of ecotourism. By analyzing digital tourist reviews from multiple online platforms, the study identified key preference patterns related to accommodation, nature-based tourism, culinary experiences, and tourism services. The findings also confirmed that tourist preferences are heterogeneous, as reflected in the emergence of distinct segments, including family travelers, solo travelers, young travelers, and international tourists.

The results further show that big data analytics can generate meaningful, preference-based insights that are useful for tourism SMEs in designing more targeted, personalized services. At the same time, the blockchain layer strengthened the security, traceability, and integrity of tourist preference data, as indicated by the elimination of recorded data leakage and violation cases after implementation. This suggests that blockchain can serve not only as a technical security mechanism but also as a governance infrastructure that increases trust in data-driven tourism systems.

The pilot implementation involving tourism SMEs also indicates that the proposed framework has practical value. Businesses that used preference-based insights improved service relevance and reported positive performance outcomes, particularly in accommodation and nature-tourism services. In addition, the user evaluation results showed high levels of acceptance across ease of use, operational efficiency, data security, and personalization quality. These outcomes confirm that the combination of big data and blockchain can support the development of more secure, responsive, and intelligent tourism services.

Overall, this study contributes to the growing literature on digital transformation in tourism by linking tourist preference analytics, secure data governance, and ecotourism service innovation within a single framework. The findings suggest that ecotourism management can benefit significantly from the use of integrated digital technologies that not only capture visitor preferences but also ensure the trustworthy management of the resulting data. Such an approach is particularly important for tourism SMEs seeking to improve competitiveness while supporting more sustainable and visitor-oriented destination development.

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