sustainability

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Blockchain and NFTs in Tourism: Trending Paradigm for Sustainable Growth and Digital Transformation

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Abstract: Non-fungible tokens (NFTs) represent a promising application of blockchain technology that can potentially disrupt various sectors, mainly tourism. While there have been conceptual discussions regarding the opportunities and challenges of utilizing NFTs for purposes such as digital souvenirs, ticketing, loyalty programs, and conservation initiatives, there remains a significant need for a robust methodological framework to assess the impact of real-world NFT implementations empirically. This paper presents the methodological foundation of ongoing research. It proposes a comprehensive approach to researching NFT initiatives within the tourism sector, which includes data collection methods, analytical techniques, and the design of a workbench for monitoring key performance indicators (KPIs). The proposed framework combines quantitative and qualitative measures to capture the complex nature of NFT adoption, including financial performance, visitor engagement, user experience, and operational efficiency. By establishing standardized protocols and metrics, the proposed methodology aims to enable cross-study comparisons and contribute to developing the best practices for leveraging NFTs in the tourism industry. The work highlights the potential of NFTs to enhance visitor experiences, generate new revenue streams, and promote destinations as tech-savvy hubs, while also addressing ethical and sustainability concerns. The conclusion emphasizes the importance of a structured approach to evaluating NFTs initiatives, which can provide valuable insights for tourism organizations seeking to innovate and remain competitive in a digital landscape. Future research should focus on validating the framework through real-world case studies, exploring additional applications of NFTs in tourism, and addressing challenges related to data availability, technological integration, and stakeholder collaboration.

Keywords: blockchain; NFT; tourism

Academic Editors: Eduardo Parra-López, Almudena Barrientos-Báez and David Caldevilla Domínguez

Received: 11 January 2025
Revised: 21 March 2025
Accepted: 24 March 2025
Published: 27 March 2025

Citation: Folgieri, R.; Gričar, S.; Baldigara, T. Blockchain and NFTs in Tourism: Trending Paradigm for Sustainable Growth and Digital Transformation. *Sustainability* **2025**, *17*, 2976. https://doi.org/10.3390/su17072976

1. Introduction

Despite tourism having recovered from the crisis caused by the pandemic, stabilizing the industry has become an important topic to make it resilient to possible future challenges. Although Europe faces the challenge of overtourism, requiring concrete tailored solutions, the tourism industry must consider climate changes as well as security issues. The strategic orientation of modern tourism is sustainable development. The principles of sustainable tourism development relate to the ecological, economic, and socio-cultural implications of tourism development, and it is important to establish a balanced combination of these

dimensions to ensure sustainability in the long term [1] (p. 8). A prerequisite for development is a green and digital transformation aimed at preserving and sustainably valorizing nature and actively using digitalization to create a new tourist experience (virtual reality, machine learning, artificial intelligence). The implementation of digitalization is based on the level of use of digital channels throughout the travel phases, the level of digital knowledge and skills, and the level of digital accessibility and synergy.

Besides "green tourism", digital transformation suggests new sustainable development trends, replacing physical travel during the COVID-19 pandemic and consequently proposing further development in the post-pandemic period. Based on market data, some scholars consider the introduction of NFTs and the blockchain in the tourism sector and the related uncertainty. In fact, in 2021 the NFT market exploded, reaching over 40 billion US dollars [2]. In the same year, NFT transactions for about 17 billion US dollars generated incomes of around 5 billion US dollars, suggesting that they could be successfully applied in several sectors. At their peak during 2021 and 2022, NFTs were traded in large volumes, reaching up to 2.8 billion US dollars per month (at the height of the frenzy in August 2021) [3,4]. However, in recent periods, almost all this activity has simply stopped. Blockchain data show that NFT trading is currently down by 97% compared to its peak, with a dramatic drop following the initial surge. Projects can no longer sell as well; investors who once bought NFTs struggle to eliminate them, and most are pessimistic about the future. The global NFT market boomed in 2020, and high activity continued into part of 2021, but interest dropped by about 90% afterwards. In 2024, the NFT market is waking up again. NFT prices are determined by market supply and demand, with their value stemming from uniqueness. This fall can also be related to the high sensitivity to environmental problems. NFT transactions generate significant energy consumption, equivalent to a household's usage for a day and a half because they use the energy-intensive proof-of-work protocol.

In this scenario, non-fungible tokens (NFTs) could virtually represent any asset also in tourism, such as digital art and collectable items, content like videos or audios, in-game items and virtual world items as well as event tickets, being Not interchangeable, Unique, Non-divisible [5,6]. NFTs are unique digital assets linked to specific online or real-world assets, mainly related to the blockchain, art, and collectable markets. Several factors determine their value, including rarity, associated value, market potential, and the asset's significance.

Generally, NFTs is associated with provisions so that original owners will receive a percentage of price each time at each NFTs future transaction. Assets are stored in digital wallets as any record related to them is permanently stored on the blockchain, allowing anyone to verify but not to alter. Usually, NFTs are unique and part of a collection or part of a limited series, and they are labeled by a unique identification code [7] so that purchasing an NFT consists of buying the "right to sell" or the right to trade further, which is recorded on the blockchain system mentioned above. NFTs differ from a typical database since information is stored in blocks and linked together in chains. As new data arrive, the NFT is entered into a new block. To better understand the links between NFTs and the blockchain, it is worth illustrating that once the block is associated with data, it is linked to the previous block in the chain, and the data are organized chronologically. Various types of information can be stored on a blockchain, but transactions are the most common. Once it is "digitally signed" in the system mentioned above, a virtual image (in the form of an NFT) represents a unique image that can be placed on the sales market. One of the pros is related to the visibility of "ownership", sale prices, and purchase trajectories. The spatial storage is also significant because NFTs only require a virtual "wallet".

Following Swan [8], the blockchain, based on NFTs, is expected "to become the fifth disruptive computing paradigm after mainframes, OCs, the Internet and mobile/social

networking". To better understand the power of this technology, the authors wish to recall the basic principles on which blockchain philosophy is based [9]:

- Distributed database—accessible by each involved party and allowing for the verification of transaction records without intermediaries;
- Peer-to-peer transmission—through a central node where information is stored, communication flows to all other nodes;
- Pseudonymous transformations—all transactions are visible to anyone with access;
- Irreversibility of records—these records are updated once transactions are entered into the database and cannot be altered, being part of a chain registering each transaction that preceded the current one;
- Computational logic—meaning that blockchain transactions can be tied to computational logic and essentially programmed.

Dogru et al. [10] point out that the strength of the blockchain consists of four features: shared ledger, security, efficiency, and smart contracts. Additionally, blockchain-based marketplaces are characterized by the shared network infrastructure, the low cost of the verification process, no intermediary on the platform as would be the case in traditional two-sided markets, increased competition, as well as low entry barriers and risks related to privacy [11]. A blockchain is a distributed database of records containing all public transactions and events. Participants in the system cannot erase or modify the information but they can verify the integrity of the chain [12].

The tourism industry, emphasizing unique experiences and personalization, benefits significantly from adopting NFTs. For example, NFTs can create digital souvenirs, streamline ticketing processes, enhance loyalty programs, and support conservation efforts [13] by providing verifiable proof of donations. Some key papers specifically highlight the benefits and challenges of NFTs and blockchain-based tourism solutions. Particularly, Acikgoz and Stylas [14] as well as Dogru and colleagues [10] explore the potential of blockchain technology in the sector, stressing the role of this technology in transparency, security and efficiency. The paper also discusses the importance of the blockchain for smart contract and secure payments, allowing for the improvement of operational performance as well as customer satisfaction. Moreover, the authors address main challenges related to the blockchain, such as energy consumption, regulatory compliance and technical complexity. Regarding NFTs, some works [13,15] analyze the possibility offered by NFTs in hotel bookings, arguing that this technology can reduce intermediaries also providing a secure platform for transactions. Following their investigation, NFTs potentials are also related to enhancement of customer loyalty and could be used to create additional revenue streams through secondary markets, such as digital souvenirs, providing a unique and personalized experience for tourists whilst supporting sustainability efforts [13]. However, despite the conceptual discussions around these opportunities, there is a lack of empirical studies assessing the real-world impact of NFTs in tourism. This paper proposes a methodological framework to fill this gap by providing a structured approach to evaluating NFT implementations in the tourism sector.

Despite the evident advantages of NFTs and the blockchain, they have struggled to gain widespread adoption. This is partly due to the technological challenges associated with their implementation, primarily caused by the lack of expertise outside technology specialists. Other issues—such as sustainability concerns, which will be discussed later—create further obstacles, making it difficult to determine the appropriate metrics to assess their positive or negative impact across various sectors. This paper aims to provide a practical framework, supported by technological and econometric methodologies, to correctly adopt NFTs and the blockchain in the tourism sector, ensuring an objective and accurate evaluation of cost-benefit and overall advantage.

This study addresses the research question of how NFTs and the blockchain can be effectively adopted in the tourism industry by proposing a methodological framework to evaluate their applications, benefits, and challenges. The primary objective is to establish foundational groundwork for ongoing research, hypothesizing that these technologies can enhance tourism experiences, loyalty programs, and digital asset management. The novelty of the approach lies in its structured methodology, which systematically bridges the gap between theoretical exploration and practical implementation. This framework is essential for validating the impact of NFTs and the blockchain through future proof-of-concept case studies, providing a clear and replicable methodology for researchers and industry practitioners.

The paper is organized as follows: Section 2 presents the literature review related to the application of NFTs and the blockchain in tourism; Section 3 illustrates materials and methods of the proposed framework; Section 4 introduces a critical discussion about the benefits of the adoption of the framework, discussing challenges and limitations, followed by a conclusion paragraph.

2. Literature Review

The literature review was conducted to provide an overview of the applications of NFTs and the blockchain across various fields, with less emphasis on specific areas of application and greater focus on the technological aspects discussed in subsequent sections. This approach aims to define the methodological framework within the context of the tourism sector. The selected papers were sourced from Web of Science (WOS) and Scopus, covering publications up to the year 2024.

The literature review follows a systematic approach to ensure a comprehensive and unbiased selection of relevant studies. The search was conducted using Scopus, Web of Science, and Google Scholar, focusing on peer-reviewed articles published between 2018 and 2024. The following keywords were used: “NFTs in tourism”, “blockchain applications in hospitality”, “digital assets for travel”, and “decentralized technologies in tourism”. Boolean operators (AND/OR) were applied to refine the search.

Inclusion criteria consisted of (1) relevance to tourism and NFTs, (2) empirical or conceptual contributions, and (3) publication in high-impact journals or conferences. Exclusion criteria included (1) articles unrelated to tourism applications, (2) non-peer-reviewed sources, and (3) duplicate studies.

The selected literature was categorized based on thematic areas such as NFT-based ticketing, virtual experiences, and blockchain-driven tourism services. This structured approach ensures the literature review aligns with the research objectives.

New technologies like the blockchain and NFTs, as well as other innovative technologies such as artificial intelligence (AI), machine learning (ML), and virtual reality (VR) [16], are influencing the development of tourism. Particularly, NFT technology can reform the tourism industry since it enables the decentralization of activities, eliminates mediators, and provides a trustworthy platform that connects tourists and companies [17]. There are several possibilities for applying the blockchain in tourism, ranging from a customer perspective to infrastructure management and the financial sector. On the customer side, exchanges among peers, smart contracts, and product and services, including primary and secondary values, can be introduced, whilst infrastructure management includes infrastructure, physical and human resources. The financial side includes mining and earning national and international revenues. Also, costs have to be considered, considering those related to the platform set up on a blockchain system, specialized development, and purchasing a minor [18].

Following the literature, blockchain technology could significantly benefit the tourism sector. In fact, it can introduce competitive advantages as well as providing improvements in customer satisfaction and enhancements in performance [19]. The application of the blockchain could improve tourism in several ways: (i) the traveler experience could be improved by support through the platform; (ii) cross-border payments could become faster and trouble-free; (iii) diversification offered by the use of the blockchain could safeguard the currency and make the banking system stronger; (iv) the blockchain can contribute to lowering total operating costs. The blockchain replaces intermediaries, reduces costs and has the potential to become a record-keeping system for all the processes.

NFTs' advantages to the tourism industry include improved marketing, a more engaging travel experience, higher engagement rates, repeat business, streamlined booking, customer loyalty, and brand building.

NFTs, virtual reality [20], and augmented reality allow for the presentation of tourist destinations before an actual visit, influencing potential tourists in a modern and engaging way. The NFT can be utilized for check-ins, transactions, and loyalty point redemption at hospitality destinations or more. The further value of NFTs is related to how tourism industry brands could engage with partners and customers (b2b and b2c markets), expanding awareness as well as introducing new forms of revenue.

For example, Flybondi, a low-cost Argentine airline, recently announced that it is planning to introduce blockchain technology with the purpose of issuing tickets as NFTs, expanding the possibilities of what customers could use them for. In fact, users could sell or transfer them to other travelers up to three days before the chosen flight.

The application of the blockchain in tourism emerging from the tourism and hospitality industry has been classified as follows [21]: (1) inventory management, (2) tracking and maintenance, (3) booking, (4) payments (including tax compliance), (5) loyalty programs and customized marketing, (6) tokenization, (7) identity and privacy, (8) baggage tracking, (9) smart contracts, (10) smart tourism through decentralized applications (Dapps), (11) avoidance of intermediation, and (12) action coordination and competition. Specific use cases refer to managing hotel booking and tracking and tracing food supply.

Gretzel [22] outlines possible ways blockchain technology, tourism, and hospitality will shape each other in the future and projects a thriving symbiosis. Aysan and Tunali [15] highlight that the real potential of NFTs lies in linking tangible assets and services with sole ownership rights, which the NFTs are actually for. Since an NFT can be easily exchanged on the blockchain, the owner of the NFT could sell its hotel reservation to another person, earning profits from each trade considering that the early-bird costs are usually less expensive than the later calls. The customers of hotel NFTs could have several purposes in mind in handling their hotel reservations through NFTs. A particularly significant aspect is related to the decrease in intermediation, usually causing an increase in costs and mentioned as a major issue since the early 2000s with the increase in the popularity of online travel agencies (OTAs) [23].

Tham and Sigala [24] point out further cryptocurrencies' benefits. Specifically, they argue that cryptocurrencies can contribute to sustainable tourism by democratizing involvement in economic systems and redistributing economic power.

NFT tokens should contribute to building tourists' trust in the providers of the destination's tourism offerings [25]. As a result, NFTs, through blockchain technology, can outsource the principle of faith to technology, although not entirely. These include establishing systems addressing concerns about transparency and traceability as well as blockchain security. They also enhance transaction efficiency and trustworthiness, contemporarily promoting innovation through knowledge management (KM) systems. Furthermore,

Ratna et al. [26] suggest that applying the blockchain, fintech, and KM can trigger new opportunities in the tourism and hospitality sector.

However, all the considered studies primarily focus on theoretical aspects, with limited empirical evidence on the real-world implementation and effect of NFTs in tourism. This review identifies a critical need for a comprehensive methodological framework that combines quantitative and qualitative approaches to assess the multifaceted effects of NFTs in the tourism industry. Starting from previous works [27,28], the framework proposed in the next paragraph could be adopted to verify the actual effectiveness of the introduction of NFTs in a specific tourist initiative. Overall, the Internet of Value involves the instant transfer of assets that can be expressed in monetary terms over the internet between peers without intermediaries [29]. The Internet of Value (IoV) and its underlying technological (e.g., the blockchain) and application-related (i.e., tokens) topics have not yet been exploited in marketing research. Related features, (such as value transfer and community building) as well as their practical implications for customer satisfaction, are still on a higher protocol stack level. In fact, they are currently easier to include into existing frameworks and theories [30]. This paradigm shift in asset transfer underscores the potential for enhanced efficiency and reduced transactional friction in economic exchanges [31].

Patel [32] states that companies should consider the opportunities given by these specific features using them to leverage unique brand experiences and awareness, facilitating interaction with customers and stimulating general interest in their products and brand. New customer relationships could then be explored by marketing managers and researchers, to understand how to apply them to arouse emotions and create a closer link. In this light, NFTs can be used as follows:

- Create unique experiences related to the brand;
- Increase awareness;
- Encourage interaction with customers and business partners;
- Create interest in products and brands.

That said, NFTs, associated with metaverses, could also monetize a country's heritage beyond its physical assets, consequently promoting research and human resource education [33], as an example from Dalmatia [34]. The author demonstrates one new technology that is generating significant interest in blockchain technology based on a specific algorithm that uses a decentralized network of unknown computers.

3. Materials and Methods

This research follows a structured methodological framework to assess the role of NFTs in tourism. This study is conducted in three key phases: (1) data collection, (2) data analysis, and (3) validation. In the first phase, relevant data sources, including academic literature, industry reports, and case studies, were identified. We focused on real-world implementations of NFTs in tourism, such as ticketing systems, virtual experiences, and blockchain-based loyalty programs. In the second phase, qualitative and quantitative methods were analyzed with the aim of selecting those to be included in the methodological framework. Qualitative content analysis was selected for the ability to examine industry reports, while econometric modeling was included because it is useful to assess NFT adoption trends. In the final phase, all the components were checked and harmonized.

Key questions include how to use NFTs to bring hotel and tourism products closer to new digital-world generations and achieve synergy between the invisible tourist service and the digital world amidst the increasingly turbulent challenges of the tourism market.

Despite evident advantages and criticisms (the latter are discussed further in this paper), engaging in an NFT project should be accompanied by a methodological framework allowing for the pre- or post-evaluation of the initiative's effectiveness. In the following

sub-paragraphs, a practical methodology to face this challenge is proposed, giving practical indications about the framework composed of three main parts:

- Data collection to ensure enough helpful information for evaluating the initiative;
- Analytical techniques to perform on the collected data;
- Technological framework, allowing for monitoring and evaluation.

3.1. Data Collection

Gathering comprehensive and diverse data is essential to effectively evaluating the impact of NFTs in the tourism industry. This section outlines the data types that should be collected, encompassing financial, visitor, user feedback, operational, and ethical/legal dimensions.

1. Financial Data

Collecting financial data is crucial for assessing NFT initiatives' economic viability and profitability in the tourism sector. The key financial data points include the following:

- Revenue from NFT sales indicates the total revenue generated from the sale of NFTs, including initial sales and any secondary market transactions;
- Implementation costs indicate all costs associated with implementing the NFT initiative, including development, marketing, and operational expenses;
- Pricing strategies involve analyzing the pricing models used for NFTs, including fixed prices, auction formats, and dynamic pricing mechanisms.

2. Visitor Data

Visitor data provide insights into the demographics and behaviors of tourists engaging with NFT initiatives. The following data points should be collected:

Demographics:

- Age: age groups of visitors engaging with NFTs;
- Gender: gender distribution of NFT users;
- Location/country of residence: geographic distribution of visitors;
- Education level: educational background of visitors;
- Income level: income brackets of visitors.

Visit Details:

- Purpose of visit: the primary reason for the visit, such as leisure, business, or other purposes;
- Duration of stay: length of the visitors' stay;
- Type of accommodation: types of accommodation used, such as hotels, vacation rentals, etc.;
- Number of people in travel group: size of the travel party;
- Activities participated in: types of activities, including museums, tours, outdoor adventures, etc.;
- Spending patterns: expenditure on accommodation, dining, activities, shopping, and other categories.

Familiarity with NFTs:

- Prior knowledge/experience with NFTs and the blockchain: understanding and previous interaction with NFTs;
- Motivations for purchasing/interest in tourism NFTs: reasons for engaging with tourism NFTs;
- Preferred digital platform/marketplace for NFTs: platforms or marketplaces used for purchasing NFTs.

3. User Feedback

Collecting user feedback is essential for understanding the user experience and identifying areas for improvement. A mixed approach incorporating both quantitative and qualitative elements is recommended:

Quantitative Feedback:

- Surveys/questionnaires use numerical scales (e.g., 1–5) to rate various aspects of the NFT experience;
- Net Promoter Score (NPS): measures customer loyalty and satisfaction through questions asking how likely users would recommend tourism NFTs to others;
- Structured ratings/reviews collect structured feedback on digital platforms regarding specific NFT features and overall experience.

Qualitative Feedback:

- Open-ended questions allow visitors to share detailed thoughts and experiences;
- Sentiment analysis analyzes social media and tourism website comments and reviews to gauge public perception and sentiment;
- Focus group discussions or interviews conduct in-depth discussions to gather deeper insights into user experiences and attitudes.

4. Operational Data

Operational data provide insights into the efficiency and integration of NFT initiatives within existing systems. Critical operational data points include:

- Process efficiency: metrics on the time and resources required to implement and maintain NFT initiatives;
- System integration: how well NFTs are integrated with existing tourism systems and platforms;
- Operational challenges: any issues or obstacles encountered during implementation and operation;

5. Ethical and Legal Considerations

Ensuring ethical and legal compliance is crucial for the responsible adoption of NFTs. This includes the following:

- Data privacy: measures taken to ensure data and privacy protection;
- Regulatory compliance: adherence to relevant laws and regulations, including those related to the blockchain and digital assets.

By collecting a comprehensive mix of financial, visitor, user feedback, operational, and ethical/legal data, researchers and analysts can better understand the impact of NFTs and the blockchain on the tourism sector. Structured data (such as visitor numbers, transactions, and revenue) and unstructured data (such as open feedback and focus group discussions) are essential for a thorough analysis. This multifaceted approach will enable a nuanced assessment of the challenges and opportunities deriving from NFT adoption in tourism. All the data should be collected in a database used for the following steps of the evaluation process.

The following Figure 1 shows a proposed database schema designed to collect and organize data for evaluating the adoption and impact of NFTs in the tourism industry following a structured and systematic approach to collecting and analyzing data. The database is structured to capture various types of data, each linked to specific NFTs, enabling a comprehensive analysis of their implementation. Below is a description of the key components:

- NFTs Table:
  Fields: 'id' (primary key), 'name', 'description', 'creation_date'.
  Purpose: stores core information about each NFT, such as its name, description, and creation date.
- Financial Data Table:
  Fields: 'id' (primary key), 'revenue', 'implementation_costs', 'pricing_strategy', 'nft_id' (foreign key).
  Purpose: tracks financial metrics related to NFTs, including revenue generated, implementation costs, and pricing strategies.
- Visitor Data Table:
  Fields: 'id' (primary key), 'age', 'gender', 'location', 'education_level', 'income_level', 'purpose_of_visit', 'duration_of_stay', 'type_of_accommodation', 'number_of_people', 'activities_participated', 'spending_patterns', 'prior_knowledge', 'motivations', 'preferred_platform', 'nft_id' (foreign key).
  Purpose: collects detailed demographic and behavioral data about visitors interacting with NFTs, helping to analyze their preferences and engagement.
- Operational Data Table:
  Fields: 'id' (primary key), 'nft_id' (foreign key), 'process_efficiency', 'system_integration', 'operational_challenges'.
  Purpose: records operational aspects of NFT implementation, such as process efficiency, system integration, and challenges faced.
- User Feedback Table:
  Fields: 'id' (primary key), 'nft_id' (foreign key), 'survey_score', 'nps' (Net Promoter Score), 'structured_ratings', 'open_ended_feedback', 'sentiment_analysis', 'focus_group_discussions'.
  Purpose: gathers user feedback through surveys, ratings, open-ended responses, sentiment analysis, and focus group discussions to evaluate user satisfaction and experiences.
- Ethical and Legal Data Table:
  Fields: 'id' (primary key), 'nft_id' (foreign key), 'data_privacy_measures', 'regulatory_compliance'.
  Purpose: tracks ethical and legal considerations, such as data privacy measures and compliance with regulations, ensuring responsible NFT implementation.

The database uses a relational model, linking all data tables to the 'NFTs' table via the 'nft_id' foreign key. It captures financial, operational, visitor, feedback, and ethical/legal data, enabling a holistic evaluation of NFT adoption in tourism. Furthermore, the schema is designed to accommodate additional fields or tables as new data requirements emerge.

Figure 1. The proposed database reference structure to collect data for the evaluation process.

3.2. Analytical Techniques

The data collection has been designed considering the analytical techniques to evaluate the effectiveness of NFT/blockchain initiatives in tourism and to be further discussed in the technological workbench. Part of the latter includes the analysis methodologies to be applied. Analytical techniques should be used to analyze the collected data for an effective workbench. Based on the authors' previous studies and the presented literature [35], the following methods have been individuated, including econometric and statistical methodologies and investigation models from information technology and artificial intelligence (AI):

- Econometric modeling: Techniques such as regression analysis, time series analysis, and structural equation modeling can be used to identify trends and relationships between variables. Econometric modeling helps quantify the impact of NFTs on financial performance and visitor behavior.
- Sentiment analysis: This involves using artificial intelligence methods such as natural language processing (NLP) and machine learning (ML) algorithms to analyze user feedback from online reviews and social media. It provides information about public perception and user satisfaction.
- Qualitative analysis: Content analysis and thematic coding will help interpret qualitative feedback and identify common themes. Qualitative analysis complements quantitative data by providing deeper insights into user experiences and operational challenges.

- Comparative analysis: Comparing the performance of NFT initiatives across different sectors, use cases, and target audiences to identify best practices helps generalize findings and identify successful strategies for NFT implementation in tourism.

The analytical techniques employed in assessing the impact of NFTs in the tourism industry should encompass a range of quantitative and qualitative approaches. The following outlines advanced methods for sentiment analysis, comparative analysis, and qualitative analysis to highlight the multifaceted nature of NFT adoption in tourism. For each technique, a short description and a list of possible methodologies to apply are given to provide a comprehensive picture and practical indications of the modules that should compose the final workbench.

Sentiment analysis can be performed using different approaches, such as NLP techniques, aspect-based sentiment analysis (ABSA), and multimodal sentiment analysis. Natural language processing (NLP) techniques include lexicon-based approaches, where sentiment lexicons such as VADER (Valence Aware Dictionary for Sentiment Reasoning) [36] are used to analyze social media data, online reviews, and user comments related to tourism NFTs. VADER is particularly effective for understanding sentiment in short, informal texts typical of social media.

Machine learning models like naive Bayes, support vector machines (SVMs), and BERT (Bidirectional Encoder Representations from Transformers) can be applied to develop domain-specific sentiment analysis models tailored to the tourism and NFT context. These models can be trained on a corpus of tourism-related text to improve accuracy in detecting sentiments specific to NFT experiences.

ABSA can be used to pinpoint specific aspects/features of NFT tourism applications, such as "ease of use", "value proposition", and "environmental impact". Using ABSA models, sentiment scoring should then be applied to analyze sentiment for each identified aspect. This approach helps understand user sentiments towards different components of NFT tourism initiatives, providing granular insights.

Multimodal sentiment analysis represents the integration of multiple modalities, combining text, images, and videos to provide a holistic sentiment analysis. For instance, analyzing comments alongside images or videos of NFT-based tourism experiences can reveal more profound insights into user sentiment. To perform a multimodal analysis, experts should develop models that can process and integrate data from various modalities, leveraging deep learning techniques such as convolutional neural networks (CNNs) to perform image analysis and recurrent neural networks (RNNs) for text analysis.

Qualitative analysis includes content analysis (including coding and categorization), thematic analysis, frameworks and models, and the adoption of qualitative data analysis software.

Content analysis should be conducted on tourism organizations' websites, promotional materials, and social media platforms to identify recurring themes, sentiments and topic clusters related to NFT adoption and, generally, NFT and blockchain impacts. This operation can be performed using commercial software or coding and categorization, which involves developing a coding scheme to categorize the content into themes such as user engagement, operational challenges, and perceived benefits of NFTs.

Thematic analysis consists of six phases, as proposed by Braun and Clarke [37]: data familiarity, coding, generating themes, reviewing themes, defining themes, and writing up. This rigorous approach ensures depth and accuracy in analyzing qualitative data. The analysis should then be applied to open-ended survey responses, focus group transcripts, and interview data to identify patterns and themes in user experiences with NFT initiatives.

In the presented model, frameworks and model design refer to the adoption of the Unified Theory of Acceptance and Use of Technology (UTAUT) to guide qualitative analysis, which aims to identify factors that could influence the adoption of NFTs in cultural

tourism, such as performance expectancy, effort expectancy, social influence, and facilitating conditions. The UTAUT model must be adapted to fit the context of NFT-based cultural tourism experiences, ensuring relevance and applicability.

Qualitative data analysis software: This can be performed with open-source platforms such as R for organizing, coding, and analyzing qualitative data. These platforms facilitate the efficient management of large datasets and enhance the rigor of qualitative analysis. Data should be triangulated from multiple sources (interviews, documents, and observations) to ensure a comprehensive analysis. This approach helps cross-validate findings and uncover deeper insights.

Comparative analysis mainly consists of case study comparison using benchmarking and comparative analysis tools.

A cross-case synthesis to compare different case studies of NFT applications in tourism is suggested. Identifying commonalities, differences, and recurring themes across various contexts, such as digital art exhibitions, virtual tours, and loyalty programs, helps to evaluate any initiative. Pattern-matching techniques [38] can be used to compare predicted patterns with observed data, enhancing the validity of the findings.

Benchmarking and comparative analysis tools should be used to benchmark NFT initiatives against industry standards and best practices. In addition, comparative analysis tools can be used to evaluate performance metrics such as financial returns, user engagement, and operational efficiency. For example, employing scenario-planning and forecasting tools to predict future trends and outcomes of NFT adoption in tourism would be relevant. This approach helps in strategic planning and decision-making.

A research team can comprehensively assess visitor feedback and experiences related to NFT cultural tourism initiatives by incorporating these advanced analytical techniques and qualitative frameworks. This approach will provide a nuanced understanding of the factors influencing adoption and the overall impact of NFTs in the tourism industry.

3.3. NFT Tourism Workbench

The NFT Tourism Workbench will serve as a comprehensive platform for monitoring and evaluating NFT initiatives through key performance indicators (KPIs), data integration and visualization, benchmarking, and comparative analysis tools, and for exploring different scenarios and forecasting future performance.

Different KPIs should be considered, with specific details on how they will be measured and validated:

- Financial KPIs:
  - Return on investment (ROI): measured by comparing the net profit generated from NFT initiatives to the total investment costs;
  - Revenue growth: tracked through periodic financial reports, comparing revenue before and after NFT implementation;
  - Profitability: calculated as the ratio of net profit to total revenue, validated through financial audits.
- Visitor KPIs:
  - Visitor numbers: measured using ticket sales, NFT purchases, or digital engagement logs;
  - Repeat visitor rate: calculated by analyzing the percentage of visitors who return, using loyalty program data or NFT transaction histories;
  - Engagement metrics: tracked through digital interactions, such as time spent on NFT platforms or participation in NFT-based activities.
- User Experience KPIs:

- Net Promoter Score (NPS) [39]: collected via post-visit surveys, asking visitors how likely they are to recommend the NFT experience;
- Sentiment scores: analyzed using natural language processing (NLP) on open-ended feedback or social media comments;
- Ratings/rankings: gathered through structured surveys or platform reviews, validated by cross-referencing with user feedback.

- Operational KPIs:
  - Process efficiency: measured by tracking the time and resources required to implement NFT initiatives, validated through operational audits;
  - System integration: evaluated by assessing the compatibility and performance of NFT systems with existing infrastructure, using technical diagnostics;
  - Compliance metrics: monitored through regular checks to ensure adherence to legal and ethical standards, validated by third-party audits.

Data integration and visualization tools are essential for integrating data from multiple sources and visualizing performance metrics. This feature enhances data accessibility and facilitates real-time monitoring. Several platforms allowing for data visualization, including commercial or open-source platforms such as D3.js, an open-source JavaScript library for producing dynamic, interactive data visualizations in web browsers, can be used.

Benchmarking and comparative analysis tools help identify areas for improvement and set performance targets, whilst scenario-planning and forecasting tools aid in strategic decision-making and preparing for potential challenges. Phyton libraries can apply these methodologies (e.g., sci-kit-learn, XGBoost). Leveraging machine learning capabilities with Python v-3.31, the workbench can develop predictive models to forecast future performance metrics, visitor trends and potential adoption rates based on historical data and market variables.

To provide comprehensive decision support, the workbench should include several key areas for scenario planning and forecasting: adoption, financial performance, visitor experience and engagement, and environmental impact forecasting.

Adoption forecasting can be performed through projections of NFT adoption rates, forecasting adoption rates across different tourism sectors (e.g., hospitality, aviation, attractions) and geographical regions over time. Then, a scenario analysis will help explore the impact of factors like regulatory changes, technological advancements (e.g., metaverse integration), and consumer awareness campaigns on adoption rates.

Financial performance forecasting should consider revenue and profitability projections, that is, modeling revenue and profitability for NFT tourism offerings under varying market conditions, pricing strategies, and competitive landscapes. In this case, scenario modeling will help understand the impact of factors such as energy costs, environmental taxes, and market saturation on the financial viability of NFT initiatives.

Visitor experience and engagement forecasting provides predictive modeling of visitor metrics, forecasting visitor numbers, engagement metrics (e.g., social media interactions, repeat visits), and user sentiment based on historical data and potential influencing factors. Also, the scenario analysis helps explore the impact of generational shifts, technological adoption rates, and changes in consumer preferences on visitor experiences with NFT tourism offerings.

Last but not least, environmental impact forecasting is significant, especially in light of the criticisms of NFTs and the blockchain. First, carbon footprint modeling should be considered to model the carbon footprint and energy consumption associated with NFT minting, trading, and storage operations under different adoption scenarios and technological advancements (e.g., more energy-efficient blockchain protocols). In this case, a scenario analysis will help to explore the impact of potential regulations, carbon pricing

mechanisms, and sustainability initiatives on the environmental sustainability of NFT tourism operations [29].

The NFT Tourism Workbench aims to be a versatile and customizable platform, integrating various data sources and analytical tools to meet the specific needs of different tourism organizations. By combining advanced data visualization, benchmarking, and scenario-planning capabilities, the workbench will provide a comprehensive decision-support tool, enabling organizations to anticipate potential challenges, identify opportunities, and proactively develop strategies to maximize the benefits and mitigate the risks associated with adopting NFTs within their respective contexts and target markets.

Overall, this integrated approach ensures that the workbench facilitates the monitoring and evaluation of NFT initiatives and supports strategic planning and evidence-based decision-making in the tourism industry.

3.4. Key Factors for Practical Implementation

The NFT Tourism Workbench is designed to provide a structured and systematic approach for evaluating the adoption and impact of NFTs in the tourism industry. Its practical implementation necessitates the integration of advanced analytical tools, robust computational resources, and rigorous validation methodologies to ensure effective monitoring, analysis, and decision-making. Below, the key aspects of its practical implementation are outlined:

1. Analytical tools and methodologies to process and interpret data.

- Data integration and visualization: Open-source libraries for data visualization will be utilized to integrate heterogeneous data sources and generate interactive visual representations. These tools facilitate real-time monitoring and enhance the accessibility of performance metrics.
- Econometric modeling: Statistical software packages will be employed to conduct regression analysis, time series analysis, and structural equation modeling. These techniques enable the quantification of relationships between variables, such as the impact of NFTs on financial performance and visitor behaviors.
- Sentiment analysis: Natural language processing (NLP) techniques, including lexicon-based approaches and machine learning models, will be applied to analyze user feedback from social media, surveys, and online reviews. These methods provide insights into public perception and user satisfaction.
- Qualitative analysis: Content analysis and thematic coding will be conducted using qualitative data analysis software to interpret open-ended feedback and identify recurring themes. This approach complements quantitative data by offering deeper insights into user experiences and operational challenges.
- Scenario planning and forecasting: Predictive modeling techniques, including machine learning algorithms, will be employed to forecast adoption rates, financial performance, and environmental impact. Scenario analysis is conducted to evaluate the potential effects of external factors, such as regulatory changes and market trends.

2. Computational resources, to manage large datasets and perform complex analyses.

- Cloud-based infrastructure: Scalable cloud computing platforms should be utilized to provide the necessary storage and processing power for data integration, analysis, and visualization. These platforms ensure flexibility and adaptability to varying data volumes and computational demands.
- Blockchain integration: Access to blockchain networks is essential for tracking NFT transactions and ensuring data transparency. The integration of blockchain technology enables the verification of transaction records and enhances the reliability of financial and operational data.

- High-performance computing: Advanced computational resources are required to train and deploy machine learning models for sentiment analysis, predictive modeling, and scenario forecasting. These resources support the efficient processing of large datasets and the execution of complex algorithms.

3. Validation and benchmarking, to ensure the robustness and reliability of the workbench, rigorous validation, and benchmarking practices.

- Cross-validation: Data from multiple sources, including surveys, blockchain records, and social media, are triangulated to validate findings and ensure consistency. This approach enhances the credibility of the results and mitigates potential biases.
- Benchmarking: NFT initiatives should be compared against industry standards and best practices using benchmarking tools. This process enables the identification of performance gaps and the formulation of strategies for improvement.
- Scenario testing: Hypothetical scenarios need to be modeled to assess the impact of external factors, such as regulatory changes and technological advancements, on NFT adoption and performance. This approach supports strategic planning and risk management.

4. User training and adoption, through the active engagement of stakeholders and the provision of training programs.

- Training programs: Workshops and tutorials should be conducted to familiarize stakeholders with the functionalities and capabilities of the workbench. These programs ensure that users can effectively utilize the platform for monitoring and decision-making.
- User-friendly interfaces: The workbench should be designed with intuitive dashboards and visualizations to facilitate ease of use for non-technical stakeholders. This design enhances user adoption and ensures the accessibility of analytical insights.

4. Benefits, Challenges, and Limitations of the Proposed Framework

The proposed framework for assessing the impact of NFTs in the tourism industry is designed to provide a comprehensive and robust analysis of how NFTs can enhance visitor engagement, generate additional revenue, and promote destinations as tech-savvy tourism hotspots. However, potential limitations and challenges still need to be acknowledged, as well as opportunities for contextual adaptations that can strengthen the framework's applicability across different tourism contexts. Potential limitations are related to data availability and quality, technology, cross-context comparability, subjectivity, and resources, as detailed in the following.

Obtaining complete, reliable, and consistent data from tourism organizations implementing NFT initiatives can be challenging, particularly in the early stages of adoption. Concerns around data privacy, competitive advantages, and a lack of standardized reporting practices can limit the availability and quality of data necessary for robust analysis.

The NFT ecosystem and underlying blockchain technologies are rapidly evolving, with new platforms, protocols, and use cases emerging frequently. This dynamism could limit the framework's long-term applicability, necessitating regular updates or adaptations to accommodate technological advancements and paradigm shifts.

The diverse nature of tourism experiences and the varied applications of NFTs across different contexts (e.g., digital souvenirs, ticketing, loyalty programs) pose challenges in establishing standardized metrics and benchmarks for direct comparisons. This variability may complicate efforts to draw broad conclusions or conduct comparative analyses.

Despite using theoretical frameworks and rigorous coding techniques, qualitative data analysis—such as interpreting open-ended feedback and expert opinions—can be influ-

enced by researcher bias or subjective interpretations, potentially affecting the reliability and generalizability of the findings.

Implementing the proposed framework, which includes data collection, advanced analytics, and developing a comprehensive workbench, requires significant financial and human resources. This may limit its feasibility for smaller tourism organizations or research initiatives with limited budgets.

Some particular challenges in implementation need to be addressed:

- Organizational buy-in and collaboration: Securing buy-in from tourism organizations to participate in research and share relevant data can be challenging, particularly if they perceive the initiative as a threat to their competitive advantages or have concerns about data privacy and intellectual property rights.
- Interdisciplinary expertise: The framework necessitates a diverse range of expertise, including tourism management, econometrics, data science, sentiment analysis, qualitative research methods, and emerging technologies like the blockchain and NFTs. Assembling a team with the requisite interdisciplinary expertise can be challenging.
- Integration with existing systems: Seamlessly integrating the proposed workbench with tourism organizations' existing data infrastructure, analytics platforms, and operational systems may pose technical challenges, especially where legacy systems or proprietary solutions are in use.
- User adoption and training: Ensuring effective adoption and utilization of the workbench by tourism stakeholders may require extensive user training and change management efforts, as the framework introduces novel concepts and analytical techniques that may be unfamiliar to some users.

A further aspect to consider is the extension and adaptation of the framework to different tourism contexts. Specifically, various approaches to tourism should be considered, such as eco-tourism, cultural tourism, and adventure tourism. The presented model already includes comprehensive environmental impact assessments, such as carbon footprint calculations, energy consumption analysis, and scenario modeling for sustainable NFT implementations aligned with eco-tourism principles, whilst, within cultural tourism, the qualitative analysis component could be enhanced by incorporating techniques like semiotics and discourse analysis to gain deeper insights into the cultural significance, symbolism, and representation of heritage assets through NFTs. Additionally, the framework could explore NFTs' potential to facilitate ethical and sustainable cultural exchange, preservation, and education. For adventure tourism, the framework could incorporate risk assessment, safety analysis, and scenario modeling for potential emergencies or logistical challenges associated with tokenizing and commercializing adventure experiences through NFTs.

The framework could also be extended to assess the accessibility and inclusivity aspects of NFT tourism initiatives, particularly for individuals with disabilities, diverse socioeconomic backgrounds, or varying levels of technological literacy. This ensures that the benefits of NFTs are equitably distributed and do not exacerbate existing disparities within the tourism industry. Adopting NFTs in tourism may inadvertently create barriers for individuals with limited access to digital technologies, financial resources, or technological literacy, leading to potential exclusion and widening the digital divide. Initiatives should be inclusive and provide accessible entry points for diverse audiences, ensuring that the benefits of NFT tourism are not confined to a privileged few. Best practices could include offering educational resources, providing alternative access methods, and exploring affordable pricing models or subsidies for underserved communities.

In evaluating the environmental impact, guidelines and best practices should be developed to promote using energy-efficient blockchain protocols, renewable energy sources, and carbon-offsetting strategies for NFT operations. Furthermore, another ethical aspect

to consider is ethical monetization and commercialization. The introduction of NFTs in tourism raises questions about the moral boundaries of monetizing cultural heritage, natural wonders, and shared experiences that may hold deep significance for communities and societies. Guidelines should be established to ensure that the commercialization of tourism experiences through NFTs does not exploit or commodify cultural or natural resources in an unethical manner. Collaborative approaches involving local communities, indigenous groups, and stakeholders should be encouraged to ensure equitable benefit-sharing and respectful representation.

Fair and transparent business practices should also be considered because the decentralized nature of NFTs and blockchain technology raises concerns about regulatory oversight, consumer protection, and fair business practices within the tourism industry. Guidelines should be developed to ensure transparency in pricing, clear terms and conditions, and mechanisms for dispute resolution and redress in the context of NFT tourism offerings. Best practices could include adhering to industry standards and self-regulatory frameworks and collaborating with relevant authorities to establish appropriate governance structures.

Furthermore, responsible marketing and representation must be addressed. The marketing and representation of NFT tourism offerings should be accurate and truthful, and misleading or deceptive claims about their value, exclusivity, or associated benefits should be avoided. Guidelines should be established to ensure responsible marketing practices, including disclosing the risks, limitations, and potential environmental impacts of NFTs. Best practices could involve collaborating with consumer advocacy groups, industry associations, and regulatory bodies to develop ethical marketing standards for NFT tourism initiatives.

To ensure responsible NFT adoption in the tourism industry, a collaborative effort involving tourism organizations, technology providers, regulatory bodies, and community stakeholders is essential. By developing comprehensive guidelines and best practices that address these ethical considerations, the tourism industry can unlock the potential of NFTs while prioritizing sustainability, privacy, inclusion, and ethical business practices.

Some final observations are related to data privacy and security. NFT tourism initiatives may involve collecting and storing personal data, including visitor information, transaction records, and potentially sensitive information about travel preferences and behaviors. Robust data privacy and security measures must be implemented to protect visitor privacy, prevent unauthorized access, and comply with data protection regulations, such as GDPR and CCPA. Best practices should include transparent data collection and usage policies, secure data storage and encryption protocols, and mechanisms for visitors to control and manage their data.

By the aforementioned potential limitations, challenges, and opportunities, the proposed framework can be further refined, strengthened, and tailored to address the specific needs and considerations of different tourism sectors and stakeholders, enhancing its robustness and applicability in assessing the impact of NFTs across a diverse range of tourism contexts.

The framework's comprehensive approach, incorporating quantitative and qualitative data collection, advanced analytical techniques, and scenario-planning capabilities, offers valuable insights into NFT initiatives' economic, operational, and experiential impacts on the tourism industry. Through continuous refinement and adaptation, this framework can serve as a vital tool for tourism organizations seeking to leverage NFTs to enhance visitor engagement, drive innovation, and stay competitive in an increasingly digital world.

Despite all the advantages of adopting NFTs and the blockchain in tourism, it is necessary to consider limitations and criticisms. The blockchain requires broad technological, regulatory, and social coordination for implementation. Blockchain management is coded into protocols

and processes as an integral part of the network architecture. The strength of blockchain technology resides in its ability to algorithmically enforce private agreements and social principles globally, transferring the cost of trust and coordination onto the network [40].

In their paper, Abubakar et al. [41] focus on the most significant obstacles to using NFT technology from the points of view of security, confidentiality, ownership, administration, and property ownership. Remarkably, they point out that cryptocurrencies and NFTs are not tied to a regulated central bank or sovereign institutions, making them impossible to regulate, and as such, they are susceptible to economic shocks from the global banking system and markets.

Moreover, despite NFTs and the blockchain offering significant security advantages (such as tamper-proof ownership records and immutable ledgers), consequently enhancing data integrity and reducing fraud risks, and the blockchain's decentralized nature promoting transparency and trust, both technologies face security challenges. In fact, NFTs are vulnerable to hacking, fraud, and intellectual property theft if not properly secured, and blockchain systems can be compromised by smart contract vulnerabilities, attacks, or weak consensus mechanisms. Robust security measures, such as encryption, secure wallets, and regular protocol updates, are essential to mitigate these risks.

The following Table 1 summarizes the advantages and disadvantages of NFTs and the blockchain, highlighting that NFTs focus on enhancing visitor experiences, generating revenue, and preserving culture, but face challenges like ethical concerns and exclusion risks, whilst the blockchain offers transparency, security, and decentralization, but struggles with energy consumption, regulatory gaps, and high implementation costs.

Table 1. Summary of NFTs' and blockchain's advantages and disadvantages.

NFTs	
Advantages	**Disadvantages**
Enhanced Visitor Engagement: unique, interactive experiences (e.g., digital souvenirs).	Ethical Monetization: risk of exploiting cultural or natural resources unethically.
Additional Revenue Streams: NFTs generate income through digital assets.	Exclusion Risks: may exclude individuals with limited access to technology or financial resources.
Cultural Preservation: NFTs can ethically preserve and promote cultural heritage.	User Adoption: requires extensive training and change management for stakeholders.
Educational Opportunities: NFTs can be used for cultural education and awareness.	Subjectivity in Analysis: qualitative data analysis may be influenced by researcher bias.
Promotes Tech-Savvy Image: adopting NFTs positions destinations as innovative and modern.	Cross-Context Comparability: varied tourism experiences make standardized metrics challenging.
Blockchain	
Advantages	**Disadvantages**
Transparency and Fair Practices: ensures transparent and fair business practices.	Technological Complexity: rapidly evolving technology requires constant updates and adaptations.
Environmental Impact Assessments: supports carbon footprint calculations for sustainability.	Environmental Concerns: energy-intensive protocols may conflict with eco-tourism principles.
Data Security: provides secure and tamper-proof data storage.	Data Privacy Concerns: collecting and storing personal data raises privacy risks.
Decentralization: reduces reliance on central authorities, promoting trust and transparency.	Regulatory Challenges: lack of central regulation makes the blockchain susceptible to economic shocks.
Integration with Existing Systems: potential for seamless integration with modern data systems.	Resource Intensive: implementation requires significant financial and human resources.
Community Involvement: encourages equitable benefit-sharing with local communities.	Organizational Buy-In: securing participation from tourism organizations can be difficult.

5. Conclusions

NFTs are blockchain-based cryptographic assets characterized by unique identification codes and metadata. They cannot be traded or exchanged at equivalency. The advantage of NFTs is that they eliminate transaction intermediaries, store data in multiple locations, have unlimited duration, and fully enable intellectual property ownership [42].

This paper presents a methodological framework for conducting empirical research on the impact of NFTs in the tourism industry. By establishing standardized protocols and metrics, the framework aims to facilitate cross-study comparisons and contribute to developing best practices for leveraging NFTs and the blockchain in tourism. Future research directions include validating the framework through real-world case studies and exploring additional applications of NFTs in tourism.

Tokens having the purpose of rewarding travelers and building customer relationships must be designed differently from those that guarantee bookings or solutions accelerating data flows between travelers and agents [43]. The major concerns around NFTs are the uncertainties related to the legal rights, financial benefits provided by NFTs, and the environmental impact of the blockchain [44]. Collaboration, standardization, and privacy-enhancing technologies will shape the future of the blockchain in tourism and hospitality. To prepare for the blockchain revolution, stakeholders should invest in education and training, foster collaboration, engage with policymakers, conduct pilot projects, and develop long-term strategies [14].

Given the current reports of scientific inquiry, NFTs are expected to have significant effects on the financial and economic sectors. To cite one, NFTs enlarge the potential use cases of the blockchain [45].

The proposed methodological framework for assessing the impact of NFTs in the tourism industry has been designed with the aim of offering a comprehensive and robust approach to understanding how NFTs can enhance visitor engagement, generate additional revenue, and promote destinations as tech-savvy tourism hotspots. However, several potential limitations and challenges must be acknowledged. Data availability and quality may pose significant issues, particularly in the early stages of NFT adoption, where privacy concerns, competitive advantages, and a lack of standardized reporting practices can impede robust analysis. Furthermore, the rapidly evolving NFT ecosystem, characterized by frequent technological advancements and emerging use cases, may limit the framework's long-term applicability, necessitating regular updates to remain relevant.

Due to the diverse tourism experiences and the varied applications of NFTs across different contexts, cross-context comparability presents another challenge, complicating the establishment of standardized metrics and benchmarks. Despite rigorous coding techniques and theoretical frameworks, qualitative data analysis is susceptible to researcher bias and subjective interpretations, potentially affecting the reliability and generalizability of findings. Moreover, the significant financial and human resources required for implementing the framework, including data collection, advanced analytics, and developing a comprehensive workbench, may limit its feasibility for smaller tourism organizations or research initiatives with constrained budgets.

In terms of implementation, securing organizational buy-in and collaboration can be difficult, particularly if tourism organizations perceive the initiative as a threat to their competitive advantages or have concerns about data privacy and intellectual property rights. The necessity for interdisciplinary expertise, encompassing tourism management, econometrics, data science, sentiment analysis, qualitative research methods, and emerging technologies like the blockchain and NFTs, adds another layer of complexity in assembling a competent team. Technical challenges may also arise in integrating the proposed workbench with existing data infrastructures, analytics platforms, and operational systems,

especially those relying on legacy systems or proprietary solutions. Ensuring effective adoption and utilization of the workbench by tourism stakeholders may require extensive user training and change management efforts, given the novel concepts and analytical techniques involved.

Despite these challenges, there are significant opportunities for contextual adaptations of the framework across different tourism contexts. The framework could incorporate comprehensive environmental impact assessments for eco-tourism, including carbon footprint calculations, energy consumption analysis, and scenario modeling for sustainable NFTs implementations. Qualitative analysis could be enhanced in cultural tourism by incorporating semiotics and discourse analysis techniques to gain deeper insights into the cultural significance, symbolism, and representation of heritage assets through NFTs. Additionally, the framework could explore NFTs' potential to facilitate ethical and sustainable cultural exchange, preservation, and education. For adventure tourism, the framework could include risk assessment, safety analysis, and scenario modeling for potential emergencies or logistical challenges associated with tokenizing and commercializing adventure experiences through NFTs. Assessing the accessibility and inclusivity aspects of NFT tourism initiatives is also crucial to ensure that the benefits of NFTs are equitably distributed and do not exacerbate existing disparities within the tourism industry.

Ethical considerations are paramount when adopting NFTs in tourism. The environmental impact of NFTs, particularly their energy-intensive mining, trading, and storage processes, raises significant concerns about sustainability [12]. Robust data privacy and security measures must be implemented to protect visitor information and comply with data protection regulations. Ethical monetization and commercialization practices should be established to ensure that NFTs do not exploit or commodify cultural or natural resources unethically. Ensuring accessibility and inclusion is critical to prevent widening the digital divide and to make NFT tourism initiatives accessible to diverse audiences. Transparency, fair business practices, and responsible marketing are essential to maintain consumer trust and regulatory compliance.

By recognizing the potential limitations, challenges, and opportunities for contextual adaptation, the proposed methodological framework can be refined and optimized to address better the specific requirements of different tourism sectors and stakeholders. This process strengthens the framework's robustness and enhances its applicability in evaluating the impact of NFTs across diverse tourism contexts. Continuous refinement and customization will ensure that this framework is essential for tourism organizations aiming to leverage NFTs to enhance visitor engagement, foster innovation, and maintain competitiveness in an increasingly digital landscape while adhering to ethical and sustainable practices.

The methodological framework presented in this study serves as a foundation ground for the evaluation of the impact of NFTs and the blockchain within the tourism industry. By combining both quantitative and qualitative approaches, the framework allows for a thorough assessment of NFT initiatives, focusing on KPIs such as financial performance, visitor engagement, user experience, and operational efficiency. This multifaceted approach is vital in addressing the unique challenges posed by the rapidly evolving landscape of NFTs in tourism. The analysis underscores the potential for NFTs to enhance visitor experiences, improve operational processes, and generate new revenue streams, especially in the post-pandemic context where the tourism sector seeks innovation and aims to attract a diverse clientele. However, the framework also recognizes significant challenges, including issues related to data availability, technological integration, and the necessity for interdisciplinary expertise.

Overcoming these challenges demands ongoing collaboration among tourism stakeholders, technology providers, and policymakers to establish standardized protocols and

promote ethical practices. As the tourism industry continues to confront sustainability issues and the effects of climate change [31], the framework stresses the importance of ethical considerations in the adoption of NFTs. This involves assessing the environmental impact of blockchain transactions, safeguarding data privacy, and fostering inclusive practices to prevent exacerbating existing disparities within the sector.

In addition to these considerations, the practical implementation of the framework must address the inherent complexities of blockchain technology, such as scalability, interoperability, and the energy consumption associated with NFT transactions. These technical challenges, coupled with the need for regulatory clarity and stakeholder education, underscore the importance of a phased and collaborative approach to adoption. By addressing these barriers, the tourism industry can better position itself to harness the transformative potential of NFTs while mitigating associated risks.

The proposed framework contributes to the field by providing a structured and comprehensive methodology for evaluating the adoption and impact of NFTs in the tourism industry. It addresses the need for standardized protocols and metrics, enabling cross-study comparisons and the development of best practices. The framework offers a holistic assessment of NFT initiatives, focusing on key performance indicators (KPIs) such as financial performance, visitor engagement, user experience, and operational efficiency.

The framework also highlights the potential of NFTs to enhance tourism experiences, generate new revenue streams, and promote destinations as tech-savvy hubs, while addressing ethical and sustainability concerns. It provides a foundation for future empirical research, including real-world case studies, and encourages contextual adaptations across diverse tourism sectors, such as eco-tourism, cultural tourism, and adventure tourism. By fostering collaboration among stakeholders, promoting ethical practices, and addressing technical and regulatory challenges, the framework serves as a vital tool for tourism organizations seeking to innovate and remain competitive in an increasingly digital landscape.

While NFTs offer promising opportunities for tourism, several challenges must be addressed. Scalability remains a major issue, as blockchain networks such as Ethereum experience high transaction costs and processing delays during peak usage. Additionally, as already stressed, regulatory uncertainties create barriers to widespread adoption, with different countries imposing varied compliance requirements for digital assets.

Another key concern is environmental sustainability. Many NFT transactions rely on energy-intensive proof-of-work (PoW) blockchains, contributing to significant carbon emissions. However, the shift toward proof-of-stake (PoS) models, as seen with Ethereum 2.0, offers potential solutions for reducing environmental impact. Furthermore, adoption barriers persist, including a lack of technical literacy among tourism stakeholders and skepticism about the long-term viability of NFT applications.

To advance the understanding and implementation of NFTs in tourism, future research should focus on several areas. First, empirical studies are needed to assess the real-world impact of NFT adoption, analyzing customer engagement and economic feasibility. Second, innovative use cases beyond ticketing and digital collectibles should be explored, such as smart contracts for hotel bookings and decentralized travel insurance models.

Another key area is sustainability-driven research, investigating the viability of eco-friendly blockchain solutions and carbon-offsetting mechanisms for NFT-based tourism applications. Additionally, integrating AI and machine learning could enhance NFT-based personalization in tourism, offering tailored travel experiences based on blockchain-verified preferences. Addressing these research gaps will be critical in maximizing the potential of NFTs while mitigating their risks.

Author Contributions: Conceptualization, R.F. and T.B.; methodology, R.F., T.B. and S.G.; investigation, R.F. and T.B.; resources, R.F. and T.B.; writing—original draft preparation S.G.; writing—review and editing, S.G., R.F. and T.B.; visualization, S.G.; supervision, T.B.; project administration, R.F., T.B. and S.G.; funding acquisition, T.B. and S.G. All authors have read and agreed to the published version of the manuscript.

Funding: The University of Rijeka, Faculty of Tourism and Hospitality Management, funded this research with grant number ZIP-UNIRI-116-1-23, and the APC was also funded by the University of Rijeka, Faculty of Tourism and Hospitality Management. Certain sections of this article were written using tools funded by the Slovenian Research and Innovation Agency, the Ministry of the Environment, Climate and Energy, and the Ministry of Cohesion and Regional Development, under grant number CRP2023 V5-2331. This research was funded by the Department of Philosophy "Piero Martinetti" of the University of Milan under the Project "Departments of Excellence 2018–2022" awarded by the Ministry of Education, University and Research (MIUR).

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Novo Mesto (protocol code UNM 49/2024), and the date of approval was 24 April 2024.

Informed Consent Statement: Informed consent was deemed unnecessary given the lack of direct participant involvement in this research.

Data Availability Statement: The data is available upon request from the first author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Base de Données FAOLEX. Available online: https://faolex.fao.org/docs/pdf/cro211259.pdf (accessed on 23 October 2024).
2. How NFTs Became a $40bn Market in 2021. Available online: https://www.ft.com/content/e95f5ac2-0476-41f4-abd4-8a99faa7737d (accessed on 23 October 2024).
3. Nadini, M.; Alessandretti, L.; Di Giacinto, F.; Martino, M.; Aiello, L.M.; Baronchelli, A. Mapping the NFT revolution: Market trends, trade networks, and visual features. *Sci. Rep.* **2021**, *11*, 20902. [CrossRef] [PubMed]
4. He, Y.; Li, W.; Liu, L.; He, W. NFTs—A game changer or a bubble in the digital market? *J. Glob. Inf. Technol. Manag.* **2023**, *26*, 1–8. [CrossRef]
5. Mofokeng, N.; Fatima, T. Future tourism trends: Utilizing non-fungible tokens to aid wildlife conservation. *Afr. J. Hosp. Tour. Leis.* **2018**, *7*, 1–20.
6. Bakan, U.; Atabey, Z. Symbolizing Creativity: Investigating the Impact of Pixel Art on the NFT Phenomenon. In *Impact of Contemporary Technology on Art and Design*; IGI Global: Hershey, PA, USA, 2025; pp. 261–286.
7. Beckman, M. *The Comprehensive Guide to NFTs, Digital Artwork, and Blockchain Technology*; Skyhorse: New York, NY, USA, 2021.
8. Swan, M. *Blockchain: Blueprint for a New Economy*; O'Reilly Media, Inc.: Sebastopol, CA, USA, 2015.
9. Inasiti, M.; Lakhani, K.R. Istina o Blochkchainu, Blockchain. In *Harvard Business Review, Boston*; Mate Zagreb: Zagreb, Croatia, 2022; pp. 3–27.
10. Dogru, T.; Mody, M.; Leonardi, C. *Blockchain Technology & Its Implications for the Hospitality Industry*; Boston University: Boston, MA, USA, 2018; pp. 1–12.
11. Önder, I.; Gunter, U. Blockchain: Is it the future for the tourism and hospitality industry? *Tour. Econ.* **2022**, *28*, 291–299. [CrossRef]
12. Crosby, M.; Pattanayak, P.; Verma, S.; Kalyanaraman, V. Blockchain technology: Beyond bitcoin. *Appl. Innov.* **2016**, *2*, 71.
13. Folgieri, R.; Gricar, S.; Baldigara, T. NFTs: What opportunities and challenges in tourism? In Proceedings of the Tourism & Hospitality Industry 2022, Congress Proceedings, Lima, Peru, 27–28 October 2022; pp. 83–96. [CrossRef]
14. Acikgoz, F.; Stylas, N. Blockchain Technology in Tourism and Hospitality Industry. In *Blockchain for Tourism and Hospitality Industries*; Onder, I., Acikgoz, F., Eds.; Routledge: London, UK, 2022; ISBN 9781003351917.
15. Aysan, A.F.; Tunali, A.S.; Gozgor, G. Non-fungible token potentials for hotel bookings. *Ann. Tour. Res. Empir. Insights* **2023**, *4*, 1. [CrossRef]
16. Gričar, S.; Šugar, V.; Baldigara, T.; Folgieri, R. Potential integration of metaverse, non-fungible tokens and sentiment analysis in quantitative tourism economic analysis. *J. Risk Financ. Manag.* **2023**, *17*, 15. [CrossRef]

17. Năstase, C.E.; Niță, A.C.; Vrânceanu, M.; Petrovan, C.I. The Decentralization of Romanian tourism through blockchain and non-fungible tokens: A case study on Stramosi NFTs. In *International Conference on Modern Trends in Business Hospitality and Tourism*; Springer Nature: Cham, Switzerland, 2022; pp. 225–245.
18. Aghaei, H.; Naderibeni, N.; Karimi, A. Designing a tourism business model on block chain platform. *Tour. Manag. Perspect.* **2021**, *39*, 100845. [CrossRef]
19. Erceg, A.; Sekuloska, J.D.; Kelić, I. Blockchain in the tourism industry—A review of the situation in Croatia and Macedonia. *Informatics* **2020**, *7*, 5. [CrossRef]
20. Stublić, H.; Bilogrivić, M.; Zlodi, G. Blockchain and NFTs in the cultural heritage domain: A review of current research topics. *Heritage* **2023**, *6*, 3801–3819. [CrossRef]
21. Treiblmaier, H.; Leung, D.; Kwok, A.O.; Tham, A. Cryptocurrency adoption in travel and tourism—An exploratory study of Asia Pacific travellers. *Curr. Issues Tour.* **2021**, *24*, 3165–3181. [CrossRef]
22. Gretzel, U. The future of blockchain technology for tourism and hospitality. In *Blockchain for Tourism and Hospitality Industries*; Routledge: Oxfordshire, UK, 2023; pp. 139–150.
23. Onder, I.; Treiblmaier, H. Transforming tourism and hospitality: The innovative potential of non-fungible tokens (NFTs). In *Blockchain for Tourism and Hospitality Industries*; Routledge: Oxfordshire, UK, 2023; pp. 51–65.
24. Tham, A.; Sigala, M. Road block (chain): Bit (coin) s for tourism sustainable development goals? *J. Hosp. Tour. Technol.* **2020**, *11*, 203–222. [CrossRef]
25. Picinini, R.; Baptista, M.L.C. Deterritorialized technologies and trust: NFTs and blockchain as clues to tourism's mutation. *Mark. Tour. Rev.* **2022**, *8*, 2.
26. Ratna, S.; Saide, S.; Putri, A.M.; Indrajit, R.E.; Muwardi, D. Digital transformation in tourism and hospitality industry: A literature review of blockchain, financial technology, and knowledge management. *EuroMed J. Bus.* **2024**, *19*, 84–112.
27. Avram, D. Changes in Rural Tourism: What's New? In *New Trends and Opportunities for Central and Eastern European Tourism*; IGI Global: Hershey, PA, USA, 2020; pp. 191–206.
28. Fernandes, C.E.; Morais, R. November—Do NFTs sound good? An exploratory study on audio NFTs and possible avenues. *Informatics* **2022**, *9*, 94.
29. Lohmer, J.; Birkel, H.; Müller, J.M. The internet of value: Towards a definition, framework, and understanding of its sustainability implications. *Technol. Forecast. Soc. Chang.* **2024**, *206*, 123466.
30. Treiblmaier, H. Beyond blockchain: How tokens trigger the internet of value and what marketing researchers need to know about them. *J. Mark. Commun.* **2023**, *29*, 238–250. [CrossRef]
31. Peeters, P.; Çakmak, E.; Guiver, J. Current issues in tourism: Mitigating climate change in sustainable tourism research. *Tour. Manag.* **2024**, *100*, 104820.
32. How Brands Are Using NFTs. Available online: https://neilpatel.com/blog/non-fungible-tokens/ (accessed on 14 October 2024).
33. Arafat, S. SoK: Can NFTs Solve the Economic Problems of Countries with Ancient Heritage? Egypt as a Case Study. In *International Conference on Blockchain Technology and Emerging Applications*; Springer Nature: Cham, Switzerland, 2022; pp. 155–175.
34. Carev, D. Vrijednost Nezamjenjivih Tokena (NFT-ova) u Promociji Turističke Destinacije. In Proceedings of the 4. Međunarodna Znanstveno-Stručna Konferencija RRT 2023, Zagreb, Croatia, 23–24 November 2024; pp. 241–257.
35. Wu, Q.; Li, M.-Q.; Wang, J.-H. Behavioral intentions in metaverse tourism: An extended technology acceptance model with flow theory. *Information* **2024**, *15*, 632. [CrossRef]
36. Hutto, C.; Gilbert, E. Vader: A parsimonious rule-based model for sentiment analysis of social media text. In Proceedings of the International AAAI Conference on Web and Social Media, Ann Arbor, MI, USA, 1–4 June 2014; Volume 8, pp. 216–225.
37. Braun, V.; Clarke, V. *Thematic Analysis*; American Psychological Association: Washington, DC, USA, 2012.
38. Li, J.; Xu, L.; Tang, L.; Wang, S.; Li, L. Big data in tourism research: A literature review. *Tour. Manag.* **2018**, *68*, 301–323. [CrossRef]
39. Baquero, A. Net promoter score (NPS) and customer satisfaction: Relationship and efficient management. *Sustainability* **2022**, *14*, 2011. [CrossRef]
40. Murck, P. Who Controls the Blockchain? Harvard Business Review, Boston. 2017. Available online: https://hbr.org/2017/04/who-controls-the-blockchain (accessed on 14 October 2024).
41. Abubakar, M.; Gunathilake, N.A.; Buchanan, W.J.; O'Reilly, B. A Review of the Non-Fungible Tokens (NFT): Challenges and Opportunities. In *International Conference on Big Data Technologies and Applications*; Springer Nature: Cham, Switzerland, 2023; pp. 171–190.
42. Collins, C. *NFT World: The Worldwide Explosion of NFTs, Cryptoart, and the Metaverse, and How You Can Profit from This New and Exciting Investment*; Publishing Forte: New York, NY, USA, 2022.
43. Treiblmaier, H. The token economy as a key driver for tourism: Entering the next phase of blockchain research. *Ann. Tour. Res.* **2021**, *91*, 3. [CrossRef]

44. Taherdoost, H. Non-Fungible Tokens (NFT): A Systematic Review. *Information* **2023**, *14*, 1.
45. Franceschet, M. HITS Hits art. *Blockchain Res. Appl.* **2021**, *2*, 100038.