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A Bibliometric Expedition through Augmented Reality and Web3's Impact on Ecotourism Destinations

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ABSTRACT

This paper explores the matchmaking between augmented reality (AR) and Web3 technologies within the context of ecotourism, providing a bibliometric analysis of the research landscape to understand how these digital innovations are empowering sustainable tourism practices. Using data from the Web of Science Core Collection, we conducted a targeted search that provided the key themes and clusters for the research. The findings reveal four primary clusters: AR and Metaverse in immersive tourism experiences, decentralization and security in community-driven tourism management, AI-enhanced AR for ecotourists' engagement, and blockchain outcomes for ecotourism initiatives. This study contributes to the literature by clarifying the roles of AR and Web3 in promoting responsible tourism, fostering trust, and empowering local communities through decentralized models.

1. Introduction

The development of emerging technologies such as augmented reality (AR) and Web3 has brought transformative potential to the tourism industry, particularly within ecotourism. These advancements have reshaped the ways tourists interact with destinations, allowing for immersive and interactive experiences that emphasize sustainability and environmental awareness. While AR offers unique possibilities for enhancing engagement with natural settings, Web3 technologies, encompassing blockchain, decentralized platforms, and cryptocurrency, provide new strategic frameworks for community-driven tourism. Together, AR and Web3 lead to a paradigm shift toward more responsible, participatory ecotourism that emphasizes sustainable resource management.

Despite these developments, there is still a lack of comprehensive analysis on how AR and Web3 collectively impact ecotourism. Existing research has often explored these technologies in isolation or within the broader tourism context, leaving a research gap in understanding their combined effects specifically in ecotourism, where sustainability and community involvement are the main strategic determinants. This study addresses this gap by conducting a bibliometric analysis to map the research landscape, identify key themes, and assess emerging trends in the integration of AR and Web3 within ecotourism.

The primary research questions in this study are as follows:

1. What are the dominant themes and research clusters in the literature examining AR and Web3 in ecotourism?
2. How do AR and Web3 technologies contribute to sustainable practices and community engagement within ecotourism?
3. What are the future directions for integrating AR and Web3 to further enhance responsible and sustainable ecotourism?

By addressing these questions, this paper contributes to the tourism literature by offering a consolidated view of the interdisciplinary connections between AR, Web3, and ecotourism. This analysis highlights the opportunities for ecotourism, from reducing ecological footprints through virtual experiences to enabling decentralized, transparent funding models for conservation. The study also identifies potential areas for further research and practical implications for tourism stakeholders seeking to adopt these technologies.

The structure of this paper is as it follows: Section 2 describes the methodology, including data collection and analysis procedures. Section 3 presents the findings from the bibliometric analysis, organized

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by identified thematic clusters. Section 4 discusses the implications of these findings for sustainable ecotourism practices, while Section 5 concludes with recommendations for future research and practical applications in tourism management.

2. Methodology

Our bibliometric study aims to explore the intersections of ecotourism, augmented reality (AR), and Web3 technologies as reflected in scholarly research. To achieve this goal, we conducted a comprehensive analysis using the Web of Science Core Collection, focusing on relevant publications indexed within this database. Our search parameters were defined to capture publications related to "tourism OR ecotourism AND augmented reality OR Web3" within the topic fields, leading a total of 84,679 results. These results provided an overview for understanding how AR and Web3 are impacting tourism, with a particular focus on ecotourism.

The data was collected from the Web of Science Core Collection, an extensive academic database renowned for its coverage of high-impact journals. We utilized the search query based on "tourism OR ecotourism AND augmented reality OR Web3" within the topic fields, which includes titles, abstracts, keywords, and keywords plus. This targeted approach allowed us to gather a comprehensive dataset that reflects the current state of the art at the convergence of digital technologies and ecotourism.

Following data collection, we processed the dataset using VOSviewer, a widely-used tool for bibliometric analysis and visual mapping. VOSviewer facilitated the clustering and network visualization of keywords, enabling us to identify four distinct thematic areas within the field (Figure 1).

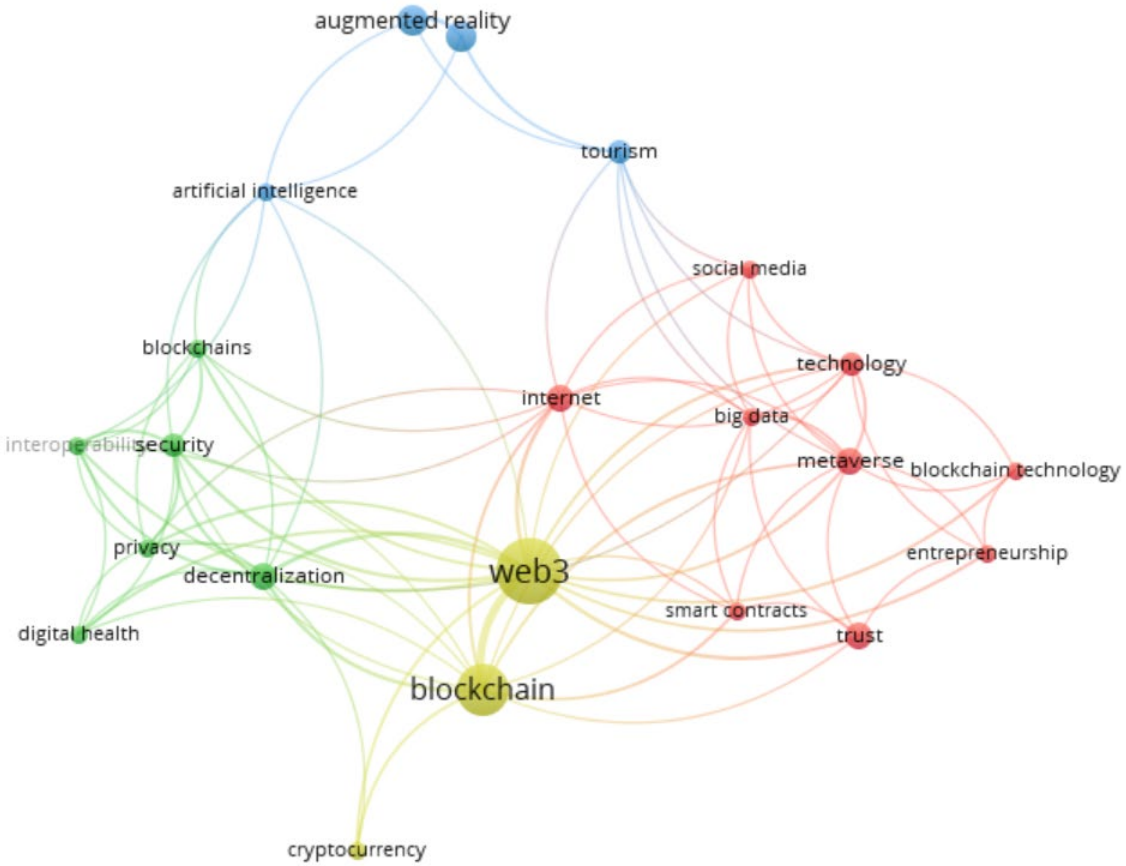

Figure 1. Clusters of research topics on digital technologies and ecotourism
Source: VOSviewer software

Our analysis aims at examining keyword co-occurrence, identifying clusters of related research topics, and understanding the strength of connections among these keywords.

3. Findings

Table 1 highlights the convergence of Web3 technologies, Metaverse, Augmented Reality (AR), and big data within the ecotourism landscape. The integration of metaverse platforms with AR capabilities empowers interactive, virtual experiences for tourists, creating a new dimension for ecotourism that reduces physical impact on natural environments. Big data, social media, and smart contracts enhance personalization, environmental education, and transaction transparency, supporting sustainable tourism while enabling innovative entrepreneurship within this industry.

Table 1. Cluster 1 (red)

Keyword	Cluster	Occurrences	Links	Link strength
Metaverse	1	4	11	15
Internet		4	11	14
Technology		3	10	12
Big data		2	8	9
Social media		2	6	6
Entrepreneurship		2	5	6
Trust		4	6	8
Smart contracts		2	6	7

Source: VOS Viewer 1.6.19 output

In recent years, the intersection of Web3 technologies, augmented reality (AR), and ecotourism has emerged as a prolific area of study within digital innovation and sustainable tourism management.

Metaverse, a virtual environment shaped by 3D spaces and stakeholders' interactivity, enables the integration of Web3 technologies within ecotourism. As an immersive platform, Metaverse facilitates virtual tours, AR-powered enhancements, and digital transactions, offering an innovative way for ecotourists to interact with destinations even before visiting them on-site. Metaverse enhances AR immersive digital trips on real-world settings, enabling users to engage deeply with different sites without affecting ecological balance (Buhalis et al., 2023). Studies outline that virtual or AR-based experiences influence destination choice and increase environmental awareness among tourists (Singh et al., 2024).

Web3 aims at creating a decentralized internet infrastructure, which contrasts with the traditional internet's centralized system. Web3's blockchain technology enables transparent transactions, data ownership, and decentralized applications, which lead to a more sustainable management of ecotourism resources. Ecotourism destinations are confronted with challenges in balancing visitor numbers and environmental preservation; in this context, technology advancements contribute to effective deployment of AR experiences that provide ecological education, reducing the necessity for physical interaction with fragile ecosystems (Jayasinghe et al., 2024).

Big data analytics represent a real support for ecotourism operators in better understanding visitor preferences, environmental impact, and resource allocation. Analyzing big data enables ecotourism stakeholders to tailor AR content to visitor profiles, enhancing marketing outcomes (Spalding et al., 2023). Additionally, data gathered on tourist behaviors and environmental footprints are pillars of the AR experiences' strategic design in line with tourism ecosystems' conservation goals. For instance, big data analytics are valuable in developing virtual ecosystems or AR simulations that allow tourists to experience virtual landscapes without impacting real ones (Fan et al., 2022).

Social media promotes ecotourism destinations offering tailored digital experiences. Through social media platforms, ecotourism destinations are able to share AR-enhanced content, inviting potential visitors to engage with the destinations' environmental features (Chi, 2021). The virtual engagement positively affects a visitor's perception and increase destination desirability while maintaining ecological sensitivity. Social media's global reach empowers ecotourism destinations to increase their reputation as sustainable travel locations, supported by Web3's transparent systems that check claims and commitments (Uşaklı et al., 2017).

Entrepreneurship within Web3 and AR creates new opportunities in the ecotourism industry. Small and medium-sized enterprises (SMEs) in tourism technology are discovering ways to use AR for interactive educational tools, while Web3 facilitates decentralized finance options for ecotourism project funding (Sze et al., 2024). The entrepreneurial activity enhances the availability of AR applications that promote site conservation and community benefits, by convincing tourists to seek sustainable travel experiences. By creating decentralized economic models within ecotourism, Web3 offers a self-sustaining, community-driven approach that benefits both the environment and local communities (Aggarwal and Mittal, 2024).

In the ecotourism context, both tourists and destination managers are looking for trustworthy experiences. Smart contracts, a feature of blockchain technology, facilitate transparent transactions. In ecotourism, smart contracts are drivers for sustainable practices by ensuring that funds contribute directly to conservation efforts or community initiatives (Fiorentino and Bartolucci, 2021). Trust, a vital component in ecotourism, is enhanced while tourists feel confident that their experiences are authentic and that their financial investments are effectively allocated. The transparency positively influences visitors' perceptions of ecotourism destinations, reinforcing commitment to sustainable practices.

Table 2 provides insights on decentralization, security, blockchain, and privacy as pivotal elements of Web3 in ecotourism. Decentralization empowers local stakeholders to manage resources and policies, fostering a transparent ecosystem aligned with sustainable practices. Privacy-enhancing technologies protect personal data and cultural heritage, while blockchain ensures secure, verifiable transactions, building trust among ecotourists concerned with ethical, environmentally responsible travel.

Table 2. Cluster 2 (green)

Keyword	Cluster	Occurrences	Links	Link strength
Decentralization	**2**	4	10	17
Security		3	9	15
Blockchains		2	7	9
Privacy		2	8	10
Interoperability		2	8	11

Source: VOS Viewer 1.6.19 output

Decentralization, a main principle of Web3, shifts control from centralized systems to a distributed network, promoting transparency and accountability across the entire tourism ecosystem. It is particularly relevant to ecotourism, where local communities often seek greater autonomy in managing their natural resources. In a decentralized system, ecotourism stakeholders, including local communities, tour operators, and NGOs, interactively participate in the decision-making process. Decentralization enables these groups to collectively manage resources, funding, and policies through blockchain-based managerial models (Vongvisitsin and Tung, 2024). The empowerment of local stakeholders is in line with ecotourism's sustainability principles, allowing communities to set their sites' restoration priorities and promote local culture and heritage with reduced external interference.

In ecotourism activities, trust between tourists, local operators, and environmental custodians is highly important. Web3 enhances security through protections that ensure the integrity of digital transactions, records, and experiences. For instance, VR and AR applications used in ecotourism, which offer virtual representations of sensitive ecosystems, require secure management to prevent misuse of ecological data (Chung et al., 2015). Blockchain-based AR platforms secure data sharing and maintain the authenticity of digital experiences, offering tourists the opportunity to experiment an accurate representation of ecotourism sites (Bamakan and Far, 2024). Secure, decentralized networks also help prevent fraudulent activities, a main factor in gaining the trust of environmentally conscious tourists who are increasingly concerned about the ethical dimensions of their travel choices.

Blockchains, the underlying technology of Web3, are facilitators of sustainable practices within the ecotourism sector. For instance, blockchain records track the impact of funds collected from ecotourists, verifying that these funds directly support sites' restoration projects. Smart contracts, self-executing agreements built on blockchain, automate these transactions, guaranteeing that contributions are assigned as promised, thereby building trust with ecotourists. Blockchain's ability to securely record and audit transactions also provides ecotourism operators with an accountable tool to demonstrate environmental importance, fostering stronger relationships with ecotourists committed to sustainability (Rashideh, 2020).

In the context of ecotourism, privacy is highly appreciated by both tourists and local communities. Web3 introduces advanced privacy features that safeguard personal data while ecotourists to interact with AR and other digital experiences. Privacy-enabled technologies within Web3 enable tourists to verify identity or make transactions without exposing sensitive information (Gong and Schroeder, 2022). This capability reassures ecotourists that their personal data is protected, reducing concerns related to data misuse and unauthorized tracking. Additionally, for local communities, privacy features help them to protect cultural knowledge and practices when engaging with digital platforms, ensuring that such information is not exploited or modified without consent.

Interoperability is a strategic determinant of seamless digital experiences in Web3-based ecotourism. In the context of ecotourism, interoperability allows various digital platforms, AR applications, and blockchain systems to interact, enhancing the cohesiveness of virtual experiences. For example, ecotourists could seamlessly transition between AR experiences offered by different ecotourism sites, maintaining continuity while exploring different regions (Balasubramanian et al., 2022). Web3 also supports decentralized digital identity, allowing tourists to maintain one digital profile across multiple platforms. This opportunity enhances the ecotourist's experience, making it easier to access sustainable, digital ecotourism services across different regions and platforms.

Table 3 focuses on the application of augmented reality (AR), artificial intelligence (AI), and ecotourism principles. AR enriches ecotourism by offering immersive experiences that educate visitors about ecological conservation, while AI-driven analytics optimize resource management and personalize visitor experiences. Together, AR and AI create a dynamic, interactive environment, allowing tourists to engage responsibly with natural settings without physically impacting them.

Table 3. Cluster 3 (blue)

Keyword	Cluster	Occurrences	Links	Link strength
Ecotourism	3	3	5	7
Augmented Reality		3	5	6
Tourism		3	7	8
Artificial Intelligence		2	7	7

Source: VOS Viewer 1.6.19 output

Ecotourism focuses on fostering responsible travel that supports the conservation of natural environments and the well-being of local communities. Integrating AR into ecotourism aligns with this mission by offering immersive, interactive experiences that educate tourists on environmental issues while reducing the ecological footprint of tourism activities (Das and Chatterjee, 2015). Through AR, ecotourists can visualize endangered species in their natural habitats, explore protected ecosystems virtually, and access real-time information about flora and fauna. AR, therefore, enhances the ecotourism experience by providing meaningful educational content that deepens tourists' understanding of conservation challenges without requiring physical interaction with fragile environments. The interconnected AR activities align with the principles of sustainability, as it minimizes disturbances to ecosystems while fostering a greater appreciation for environmental appreciation.

Within the broader tourism industry, AR has become a pivotal tool for enhancing visitor engagement by adding layers of digital information to real-world settings. In the context of ecotourism, AR enables operators to offer guided tours that overlay historical, cultural, and ecological insights onto natural landscapes, providing tourists with a comprehensive understanding of the destination. AR also allows ecotourism destinations to create virtual tours, giving tourists the opportunity to "visit" locations remotely, an especially valuable feature for ecologically sensitive areas that can only sustain limited visitation (Cranmer et al., 2020). These virtual tours extend the reach of ecotourism while preserving local environments, offering a responsible alternative for destinations facing high visitor numbers and environmental pressures.

AI contributes to ecotourism by analyzing data that informs sustainable practices and personalizes visitor experiences. AI-driven algorithms can predict visitor behavior, assess environmental impact, and optimize resource management within ecotourism destinations. For instance, machine learning models are able to monitor foot traffic in popular areas, allowing operators to manage crowds and reduce human impact on delicate ecosystems. Additionally, AI enhances personalization within AR applications, offering tailored content that aligns with individual tourist interests and conservation values (Gupta et al., 2023). Through data analytics, AI is valuable for ecotourism operators in making informed decisions that balance visitor satisfaction with environmental conservation, addressing one of the core challenges in the ecotourism sector.

The combination of AI and AR creates an intelligent ecosystem within ecotourism destinations, where real-time data informs dynamic and interactive experiences. AI computes the information from AR interactions to deliver relevant content to tourists based on their behavior and preferences, thus enhancing engagement and other outcomes. For example, as tourists explore an AR-enhanced trail, AI algorithms could analyze user interactions and provide personalized recommendations on other trails, conservation projects, or cultural insights based on the tourist's interests. The synergy between AI and AR not only enriches the tourist experience but also offers operators valuable reccomendations into visitor patterns, enabling data-driven improvements in service delivery and environmental protection.

In a Web3-enabled ecosystem, AR and AI technologies can work synergistically to support sustainable tourism within ecotourism destinations. Web3 introduces a decentralized structure that allows communities and stakeholders to directly participate in the governance and decision-making of ecotourism projects. For instance, local communities can leverage blockchain-based platforms to directly receive funding from eco-conscious tourists, verified through smart contracts. This direct support model encourages sustainable practices and fosters transparency, as tourists can see the impact of their contributions in real-time through AR and AI-driven updates. Additionally, the decentralized nature of Web3 aligns with the values of ecotourism by empowering local stakeholders and promoting community-driven conservation efforts (Jiang et al., 2023).

The interconnection of ecotourism, tourism, AR, and AI reveals a significant trend within the tourism sector towards sustainable and technology-driven experiences. Bibliometric analysis of recent studies shows a growing interest in the integration of AR and AI within ecotourism, driven by the need to provide engaging, educational experiences while preserving natural habitats. AR and AI are pivotal tools for achieving the goals of enhancing tourist experiences and supporting environmental respect (tom Dieck et al., 2024). Through AR, tourists immerse themselves in natural settings with minimal environmental impact, while AI ensures that these interactions are optimized to balance tourist satisfaction with ecological responsibility.

Table 4 covers the concepts of Web3, blockchain, and cryptocurrency within ecotourism. Decentralized platforms empower local communities by distributing control and profits, while blockchain enhances transparency, allowing ecotourists to track their financial contributions to destinations. Cryptocurrency facilitates direct, fee-minimized transactions, supporting sustainable tourism initiatives. This

digital finance structure aligns with ecotourism's goals by promoting equitable revenue distribution and incentivizing environmentally responsible behavior through tokenized rewards.

Table 4. Cluster 4 (yellow)

Keyword	Cluster	Occurrences	Links	Link strength
Web3	**4**	17	24	48
Blockchain		13	15	32
Cryptocurrency		2	3	5

Source: VOS Viewer 1.6.19 output

At the core of Web3 is the shift towards decentralization, which contrasts with the centralized frameworks of Web 2.0. In the context of ecotourism, decentralization provides local communities with greater control on tourism activities, allowing them to directly benefit from visitor spending and make decisions that support environmental sustainability. Web3 platforms operate without intermediaries, enabling tourism stakeholders to participate in a peer-to-peer ecosystem where control and profit-sharing are distributed. For ecotourism destinations, it leads to adoption of decentralized models for decision-making and funding, giving local communities a power in managing natural resources and tourism policies. The decentralized nature of Web3 leads to the achievement of ecotourism's goal of empowering local communities by promoting transparency and equitable revenue distribution (Vongvisitsin and Tung, 2024).

Blockchain is responsible for building transparent, accountable systems within ecotourism. Blockchains securely record transactions and data entries, providing an unalterable record that can be verified by anyone in the network. The transparency is particularly valuable in ecotourism, where tourists are increasingly seeking assurances that their travel expenditures genuinely support local communities. Blockchain systems check the ethical and sustainable practices of tourism operators by documenting the flow of funds and resources, allowing ecotourists to see how their payments contribute to local projects, conservation initiatives, or community support (Tan and Salo, 2023).

Moreover, blockchain's transparency enhances trust among stakeholders, addressing the problem of making false claims about environmental practices. Blockchain systems manage certifications, conservation efforts, and sustainability milestones, providing an auditable history of ecotourism operators' contributions to environmental preservation.

Cryptocurrency is a component of the Web3 ecosystem, enabling peer-to-peer financial transactions, without the need for traditional banking intermediaries. For ecotourism, cryptocurrency offers a new way to facilitate transactions that benefit local communities directly. Tourists are incentivized to use cryptocurrencies to pay for ecotourism services, make donations, or contribute to conservation projects. Cryptocurrencies enable direct payments that reduce transaction fees, increasing the funds that reach local communities and conservation organizations (Quan et al., 2023).

Additionally, cryptocurrencies can be programmed with smart contracts, which are self-executing agreements on the blockchain. Smart contracts automate donations to conservation funds or trigger payments upon the completion of specific milestones in local tourism projects. For example, tourists could make cryptocurrency payments that are held in escrow until an ecotourism operator meets predefined conservation targets, ensuring that contributions are used as intended (Luo et al., 2024). This mechanism promotes financial accountability and incentivizes sustainable practices, creating a financial model that aligns with ecotourism's objectives.

One of the unique traits of cryptocurrency within Web3 is its capacity to tokenize assets and create unique digital currencies or tokens that represent real-world assets or reward systems. In ecotourism, tokens are used to incentivize sustainable practices among tourists and operators. For instance, visitors to ecotourism sites could earn eco-tokens by participating in sustainable activities, such as waste cleanup or using eco-friendly transportation options. The tokens could be redeemed for discounts, souvenirs, or donations to local conservation projects, encouraging a culture of responsible travel (Tham and Sigala, 2020).

Tokenization also allows ecotourism operators to raise funds through Initial Coin Offerings (ICOs) or similar models, where they offer tokens in exchange for investment in eco-friendly tourism infrastructure efforts. The tokens are often perceived as proof of commitment to specific conservation goals, giving tourists an investment stake in the environmental success of the destinations. ecotourism is a builder of a community-driven ecosystem that rewards environmental interest by engaging tourists and stakeholders through tokenized incentives (Erol et al., 2022).

While Web3 technologies hold significant potential, their implementation within ecotourism requires careful consideration. Cryptocurrency volatility presents financial risk, as the value of contributions could fluctuate, impacting both tourists and operators. Additionally, the technical complexities of blockchain and cryptocurrencies could be inhibitors for accessibility in the case of reluctant tourists (Manahov and Li, 2024). The partnerships with organizations that offer technological support and education ensure that Web3 implementations are beneficial for all stakeholders equitably.

4. Conclusions

The bibliometric analysis conducted in this study reveals significant insights into the intersection of augmented reality (AR), Web3 technologies, and ecotourism. The four thematic clusters identified are focusing on the Metaverse and digital engagement, decentralization and security, the role of AI and AR in enhancing ecotourism experiences, and the implications of blockchain and cryptocurrency. Notably, the integration of AR and Web3 technologies is strategically empowered to transform the ecotourism landscape by providing immersive experiences that enhance visitor engagement while promoting sustainability and ethical practices.

The findings indicate a growing recognition of the importance of digital technologies in facilitating responsible tourism practices. The findings suggests that AR significantly enrich ecotourism by allowing tourists to engage with protected environments without physical interference, thus reducing their ecological footprint. Simultaneously, Web3 technologies empower local communities by decentralizing control over tourism operations, fostering greater transparency, and ensuring that financial contributions from tourists directly benefit conservation and restoration efforts.

This study contributes to the growing body of knowledge on the role of digital technologies in tourism by providing a comprehensive bibliometric analysis of AR and Web3 in ecotourism. The research highlights sustainable tourism practices, enabling a more immersive and responsible travel experience. By identifying key themes and trends in the literature, this paper underscores the potential for AR and Web3 to address some of the pressing challenges that ecotourism is facing nowadays.

The findings of this study have several theoretical implications. First, they expand the conceptual framework of ecotourism by integrating digital innovation as a central theme, positioning AR and Web3 not merely as technological tools but as essential pillars of sustainable tourism strategy. This research also opens new avenues for interdisciplinary studies that connect tourism management, environmental studies, and digital technology, encouraging further exploration of how these fields can synergistically enhance ecological conservation and community well-being.

For practitioners in the tourism sector, the insights gained from this study provide multiple recommendations. Stakeholders, including ecotourism operators, local communities, and policymakers, should consider leveraging AR and Web3 technologies to develop engaging and sustainable tourism experiences. This may involve creating virtual tours using VR, AR and AI, to educate tourists about conservation efforts or utilizing blockchain for transparent financial transactions that ensure contributions are effectively allocated to local projects.

Despite the contributions of this study, we assume its limitations. The bibliometric approach, while comprehensive, may not capture all dimensions of the qualitative aspects of AR and Web3 technologies in ecotourism. Furthermore, the analysis is limited to publications indexed in the Web of Science Core Collection, potentially overlooking relevant research in other databases.

Future research should focus on case analyses of successful ecotourism initiatives that integrate these technologies, assessing their impact on both environmental outcomes and tourist experiences. Moreover, investigating user perspectives on AR and Web3 applications could enhance understanding of their effectiveness and acceptance among tourists.

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