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A Framework for the Implementation of Extended Reality in Tourism From the Perspective of Human-Centered Experiences

Abstract

This research explores the deployment of immersive technologies in the tourism sector to identify specific, cost-effective, and replicable alternatives and strategies to enrich the field of human-centred experiences. This article studies the current landscape of these studies to establish a spectrum of methodologies and resources associated with this phenomenon by using bibliographic information and network analysis to identify and categorize key topics in this field. The study draws on 664 peer-reviewed articles indexed in the Scopus database, covering the period 2000–2024, which were analysed to capture trends and clusters in XR-tourism research. We highlight six dimensions: technologies, devices, approaches, strategies, experiences, and data for designing the proposed framework. This articulation underscores that XR in tourism should be approached as an interconnected ecosystem, where theoretical and managerial advances depend on aligning these layers to create inclusive, sustainable, and human-centered experiences.

Keywords: extended reality, immersive technologies, human centricity, network analysis, tourism

1. Introduction

Tourism is a vital driver for economies in emerging countries (Khan et al., 2020; Sharma & Thapar, 2016), and tourism-related capital flows are often the most important source of foreign exchange in many developing nations (Fang, 2020). Additionally, the expected growth of tourism destinations in emerging nations is twice that of advanced economies by 2030 (Inchausti-Sintes, 2020). Exploring opportunities created by adopting new technologies can aid in developing innovative strategies and generating human-centric experiences with valuable propositions for the industry. The widespread availability of digital technologies enables their implementation and production in tourism initiatives of any scale. These factors highlight the importance of examining research related to these issues. In this context, scientific publications offer a platform to review interests and developments in this field.

Although tourism is among the first sectors to adopt the development and implementation of new technologies (Trček, 2022), it is also the largest category of products and services sold online (Navío-Marco et al., 2018). A challenge for extended reality (XR) is that many devices require controlled test environments, which can be difficult to achieve in outdoor settings. However, tourism companies face the challenge of attracting new

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visitors by making them feel central to the experience, such as by encouraging them to share it. Furthermore, in the context of advancing tourism and immersive technologies, collecting and analyzing comprehensive data has become increasingly important, as it can offer valuable insights (Paredes et al., 2021). Consequently, tourism research depends on large amounts of robust, current, timely, and relevant data to support and guide decision-making processes (Egger et al., 2020; Hannam et al., 2014; Pearce & Gretzel, 2012).

This paper investigates the use of immersive technologies—augmented reality (AR), virtual reality (VR), and mixed reality (MR)—to enhance human-centred tourism experiences. It describes these technologies as essential elements of the Fourth Industrial Revolution and emphasises their potential to enable more personalised and meaningful interactions within tourism. Building on an extensive review of the literature, the paper proposes a framework that defines the key dimensions needed to implement immersive technologies in tourism from a human-centred perspective. While many studies have examined individual applications of AR, VR, and MR, there remains a notable gap in integrating these insights into a single conceptual model. This framework tackles that gap by using bibliometric and network analyses to identify dominant themes and their interconnections, ultimately guiding the development of more comprehensive and human-centric immersive tourism experiences. This leads to our research question: How can extended reality (XR) technologies be utilised in tourism through an integrated human-centred framework that aligns devices, technologies, approaches, strategies, experiences, and data to craft tourist experiences?

1.1. Immersive technologies

Immersive technologies are defined as those that dissolve the boundaries between the physical and virtual worlds, allowing users to experience a sense of immersion. These technologies enable the creation of synthetic environments where users can fully interact with artificial or hybrid real-world elements through rich sensory stimuli. They support applications such as space design validation before construction by assessing functionality (Prabhakaran et al., 2022). The use of immersive technologies varies widely, including industrial training that reduces risks and safeguards operator health (Garcia Fracaro et al., 2022), as well as innovations in medical practice by creating realistic training environments (Tang et al., 2022; Diaz et al., 2014). VR has become a strategic priority in the national policies of countries like the United States, South Korea, Japan, and China (Dincelli & Yayla, 2022).

Immersive worlds aim to remove the interface between user and content, allowing users to feel immersed in the content by engaging each sensory channel (Scolari, 2009). Key elements such as first-person perspective, multimodal interaction design, content-driven empathy, and user-controlled spatial navigation become more significant in this medium (Jerald, 2016). Building on Milgram and Kishino's (1994) concept of virtuality continuum, they examine the relationship between reality and immersive worlds through different combinations of real and virtual components. This continuum distinguishes concepts like augmented reality (AR), virtual reality (VR), and mixed reality (MR) based on the extent of reality-virtuality integration. Often called Extended Reality (XR), these modes include all environments and human-machine interactions that combine real and virtual elements, created by computer technology and wearable devices. XR thus broadens opportunities for sensory engagement and experimentation, applying design principles and applications that enhance user experiences across various platforms.

VR offers users an immersive experience through physical and psychological engagement within an entirely virtual environment. In contrast, AR and VR have distinct applications within the tourism sector. AR enhances interactions between tourists and destinations, providing supplementary information that enriches the travel experience in the place. Conversely, VR allows customers to experience a realistic preview of a destination or hotel, reducing perceived risks and aiding decision-making processes. These immersive technologies contribute to an enhanced sense of presence and telepresence by delivering (1) additional contextual information, (2) vivid and interactive experiences, and (3) mental imagery of destinations (Fan et al., 2022).

Technological advancements have enabled such interactions to enhance user understanding and improve consumer experience, highlighting the persuasive integration of virtual and physical elements and providing unique value beyond traditional methods (Shen et al., 2022). Some applications of AR and VR aim to attract younger audiences, showcasing locations in ways that appeal to children and maintain their interest. Moreover, researchers have increasingly incorporated these technologies into educational settings to promote interactive learning for children (Kysela & Štorková, 2015; Zhou et al., 2022).

AR and VR also become relevant (Bec et al., 2021) when compared to traditional and carbon-intensive tourism (Akhtar et al., 2021; Barker & Rodway-Dyer, 2023; Lu et al., 2022). However, it is emphasised that reducing tourism in certain types of spaces, where the economy is directly dependent on it, can cause harm to the community (Nautiyal & Polus, 2022).

1.2. Immersive technologies and human-centric tourism

The intersection of technology and tourism is rapidly evolving, with innovative approaches transforming how travellers engage with destinations. The study by Lee et al. (2024) adopts a unique perspective on the expanding role of the metaverse in the hospitality and tourism sector. They employ the 5W1H framework to examine users' behaviours and motivations within metaverse tourism. By investigating the key questions of what, when, where, why, who, and how users interact with metaverse platforms, the research highlights important motivating factors such as the opportunity to preview future travel destinations, access valuable planning information, and explore otherwise inaccessible locations. The flexibility offered by the metaverse—particularly its capacity to remove geographical barriers while delivering immersive experiences—emerges as a significant attraction for users. The study concludes that the metaverse complements traditional tourism, with virtual experiences enhancing real-world travel plans.

Lee et al. (2024) emphasise the importance of information and communication technology (ICT) in their study. They highlight integrating ICT with hospitality practices to improve user experience. Technologies such as AR, VR, and Artificial Intelligence (AI) play a key role in developing personalized, immersive, and user-friendly metaverse platforms that address users' diverse preferences.

Similarly, Ramos et al. (2024) demonstrate a practical application of human-centricity in tourism, using the Analytic Hierarchy Process (AHP) to evaluate tourist destination choices based on human-related factors such as cultural differences, simplicity, and human relations. Both studies highlight the ongoing significance of human connections in tourism, whether through digital platforms or traditional experiences. This emphasis on fostering emotional and social bonds in creating meaningful tourist experiences reminds the industry of its core principles.

AR applications benefit tourists by offering insights into geological and cultural heritage origins, providing valuable experience and localised knowledge without the need for a tour guide. Similarly, many AR advancements have supported tourists' decision-making when selecting a travel destination and enhancing their understanding of the local environment and attractions once they arrive (Ahmad et al., 2023; Do et al., 2020; S. Jiang et al., 2023). Due to this innovative technology, there have been developments in museums that create didactic moments, which may also contribute to a richer learning experience (Serravalle et al., 2019). Meanwhile, VR technologies can evoke the sensation of being in a specific destination, increasing the desire to visit—especially during restrictive times such as the pandemic—and assist those who, due to certain conditions, cannot access tourist locations (Schiopu et al., 2022). Restrictions on the use of some tourist spaces often aim to protect the environment, as illustrated by the case of the Notre Dame Cathedral, which, after the fire in 2019, is under repair and not accessible to visitors despite being the most visited monument in the world—more so than the Eiffel Tower (Allal-Chérif, 2022).

Not only do tourists benefit from immersive technologies, but tourism companies also gain valuable insights through these tools, enabling them to collect user interaction data and use them to improve customer experience and business outcomes (Pranoto et al., 2023). Experience providers can generate predictive insights to attract users with personalized proposals by utilizing data gathered through immersive, AI-supported technologies. This approach boosts customer engagement by delivering experiences that closely match users' profiles, including their preferences, needs, and behaviours within these spaces (Park & Stangl, 2020).

Tourism plays a major role in the economies of many regions; however, excessive tourism can cause irreversible environmental and cultural damage. The rapid growth in tourism often results in large numbers of visitors, vehicles, and waste, which can harm natural landscapes, architectural landmarks, and cultural heritage (Rosalina et al., 2021). This increase in human activity also impacts biodiversity, leading to behavioural changes in certain animal species and disrupting entire ecosystems (Yuxi et al., 2022). Implementing proper regulatory measures can help sustainably protect these environments. XR technologies provide innovative solutions for reducing tourists' physical contact with sensitive environments. For example, creating virtual avatars enables tourists to explore restricted areas remotely, fostering connections to unique experiences without environmental damage. Ecotourism operators, especially those limiting physical interactions with wildlife, can utilise AR to engage tourists while safeguarding natural habitats (Huang, 2021).

VR and AR are not new to the tourism industry. Their application in theme parks is well established, with simulators and immersive experiences serving as key attractions. However, with the widespread adoption of mobile technology, developing applications based on these technologies is now accessible to all types of businesses (Schiopu et al., 2021). In the tourism field, particularly in countries like Greece and Italy, which possess extensive cultural and architectural heritage, these nations have led the way in adopting immersive technologies for their promotion, management, and revival (Hincapie et al., 2016). Recently, digitalisation has facilitated the revitalisation of cultural heritage. The utilisation of AR in these contexts has shown that users can rediscover lost heritage, which influences the process of gaining knowledge and learning about cultural and architectural legacies as part of the reactivation of cities and sites.

The application of technologies in the tourism sector serves various purposes, from essential business operations to improving customer experience and fostering brand loyalty. Technology can fulfil educational, informational, recreational, or logistical roles within this sector, each supporting specific business goals. A key advantage of digitalising the tourism experience is the ability to collect user data, which then enhances service strategies. This data-driven approach allows organisations to make well-informed strategic choices (Cranmer et al., 2021). Additionally, these technologies help make nature tourism more accessible to individuals facing barriers such as health issues or financial constraints that prevent them from visiting destinations physically.

Alongside the technologies of the fourth industrial revolution, the tourism sector has developed marketing strategies for the digital ecosystem (Cranmer et al., 2020). Establishing a presence and position within the digital ecosystem has become a key business goal. To achieve this, they have devised strategies that, in addition to content on social media and channels where social interaction and content creation are dominant, include positioning on travel and accommodation booking platforms. Furthermore, maintaining a prominent position in search engines and georeferenced maps is also a significant aspect.

One of the main strategies in the digital and human-centric experience fields is encouraging customers and users to generate content. The content they share with their contacts demonstrates loyalty to the service provider (Javed & Awan, 2022). Using applications that connect users with experiences via AR or VR, through a story linked to the key factors or unique elements of the business, serves as an important tool to achieve

this. In theory, such content drives traffic to the brand's media and links potential customers with the business' services. The more traffic a page receives, the higher the chance of establishing a business relationship with interested individuals.

The integration of XR technologies into tourism offers multifaceted benefits that change how destinations are experienced, promoted, and preserved. These technologies improve travelers' journeys by providing immersive previews of destinations, enabling access to remote or restricted sites, and enhancing cultural and educational engagement through interactive storytelling. XR tools also support inclusive and sustainable tourism by allowing individuals with mobility, health, or financial limitations to participate in virtual experiences while decreasing the environmental impact on fragile ecosystems (Giampiccoli et al., 2020). From a business perspective, immersive platforms give tourism operators valuable data on user behaviours and preferences, allowing for more personalised services and targeted marketing strategies. Furthermore, as tourism evolves within the digital ecosystem, user-generated content via XR becomes a powerful driver of brand loyalty and visibility (Chamboko-Mpotaringa & Tichaawa, 2025). However, to make these innovations effective, developing engaging, audience-centred content is essential—well-designed XR experiences are more likely to capture users' attention and deliver meaningful results (Han et al., 2019). Only by connecting emotionally and cognitively with users can XR achieve its full potential in making tourism a more human-centred, inclusive, and sustainable experience (tom Dieck et al., 2016). Equally crucial is employing a robust methodological framework that ensures all vital elements—such as user needs, interaction design, development processes, and testing—are coherently addressed throughout the application's lifecycle. Frameworks like the one proposed by Hincapie et al. (2016) for revitalising cultural heritage serve as valuable models for guiding the structured and effective integration of XR into tourism contexts.

2. Review methodology

This review methodology follows the stages of a scientific bibliographic analysis. We extracted relevant information for the research question and examined previous scientific publications on the topic. We then filtered the most pertinent works and analysed the resulting set of articles using various techniques. In this case, we analysed articles with more than 300 citations to identify the main lines of research with significant impact. Additionally, we built a network to visualise relationships within the entire set.

An effective presentation of the issue, central idea, or study topic will analyse the keywords that form the basis of an information search equation, as demonstrated by Utkarsh & Sigala (2021). In this context, network analysis examines the relationships between keywords to identify connections among them and establish potential semantic fields (Xu & Chang, 2020).

We established the data collection method using the tool provided by the Scopus platform, a bibliographic database that enables specific literature searches based on user-defined characteristics and easily groups the results into downloadable files. Scopus is widely recognised as a versatile source of bibliographic information and has established itself as a comprehensive and dependable database, and in certain respects, has even been regarded as outperforming WoS (Pranckutė, 2021). To obtain information on publications related to the topic, we implemented the search using the following equation ((augmented AND reality) AND (tourism)) OR ((extended AND reality) AND (tourism)) OR ((virtual AND reality) AND (tourism)) OR ((immersive AND technology) AND (tourism)) OR ((mixed AND reality) AND (tourism)), which yielded 664 related articles. From this database, we considered and extracted the necessary information from the articles identified.

Figure 1
Information search methodology

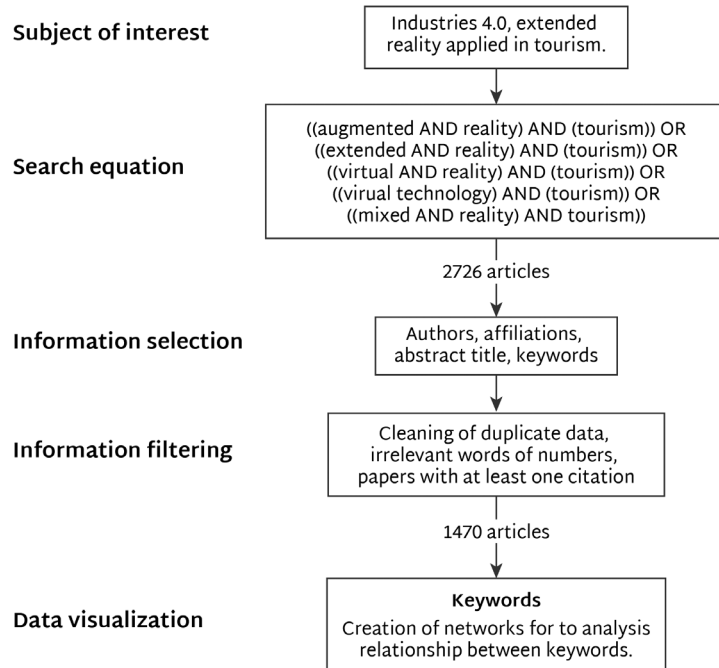
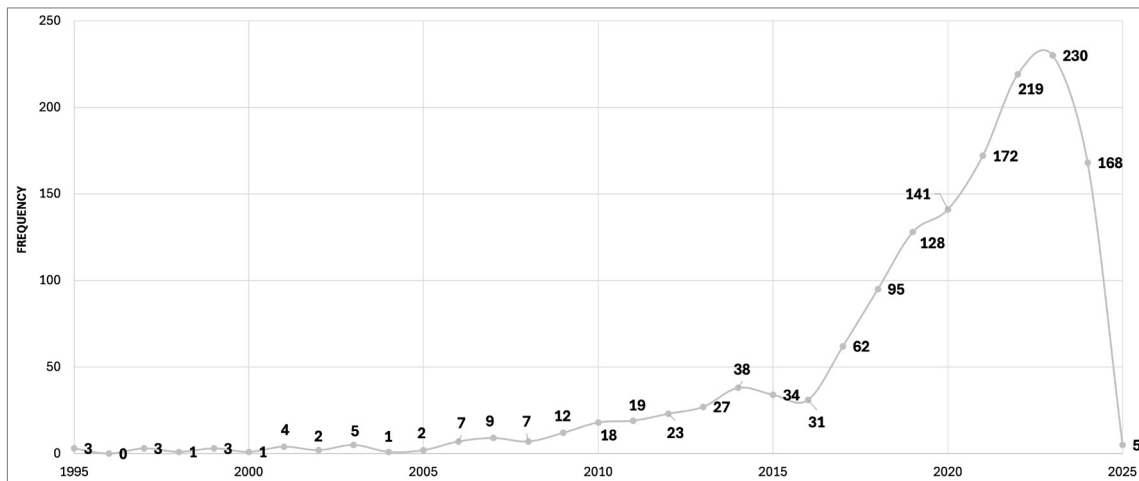


Figure 1 illustrates the search methodology used to identify relevant articles. Of 2,726 available articles, 1,470 have at least one citation, constituting reference material. Finally, we worked with the keywords for data visualization analysis.

2.1. Management and description of the data

Figure 2 shows the number of articles published each year. Since tourism focused on XR has been increasing over time, it makes sense to see a similar rise in the need to study this type of tourism. There has been a notable growth in article publications, especially between 2017 and 2023, with a total of 1,047 publications, or 71% of the overall. The decline in 2024 is due to the data being incomplete at the time of collection.

Figure 2
Number of articles published per year



One of the most cited articles, with 1,079 citations, is titled *Virtual reality: Applications and implications for tourism*, published in 2010. There are 15 articles with more than 300 citations. The list of the most cited articles shows the interest in exploring the trends related to applying this technology in tourism and how its implementation can improve the experience or offer benefits to urban, heritage, and cultural tourism. The articles reveal an interest in all types of extended reality technologies, including augmented, virtual, and metaverse. They also focus on the relationship between these technologies and tourists' behaviour in terms of their motivations, stimuli, intentions, and sense of presence. How this is also linked to management and marketing strategies is another area of concern.

Table 1
Articles with more than 300 citations

Authors	Title	Source title	Year	Cited by
Guttentag D.A.	Virtual reality: Applications and implications for tourism	Tourism Management	2010	1079
Kim M.J.; Lee C.-K.; Jung T.	Exploring Consumer Behaviour in Virtual Reality Tourism Using an Extended Stimulus-Organism-Response Model	Journal of Travel Research	2020	769
Tussyadiah I.P.; Wang D.; Jung T. H.; tom Dieck M.C.	Virtual reality, presence, and attitude change: Empirical evidence from tourism	Tourism Management	2018	757
Yung R.; Khoo-Lattimore C.	New realities: a systematic literature review on virtual reality and augmented reality in tourism research	Current Issues in Tourism	2019	606
Buhalis D.; Harwood T.; Bogicevic V.; Viglia G.; Beldona S.; Hofacker C.	Technological disruptions in services: lessons from tourism and hospitality	Journal of Service Management	2019	603
Martín-Gutiérrez J.; Mora C.E.; Añorbe-Díaz B.; González-Marrero A.	Virtual technologies trends in education	Eurasia Journal of Mathematics, Science and Technology Education	2017	514
Huang Y.C.; Backman K.F.; Backman S.J.; Chang L.L.	Exploring the Implications of Virtual Reality Technology in Tourism Marketing: An Integrated Research Framework	International Journal of Tourism Research	2016	439
Chung N.; Han H.; Joun Y.	Tourists' intention to visit a destination: The role of augmented reality (AR) application for a heritage site	Computers in Human Behavior	2015	432
Loureiro S.M.C.; Guerreiro J.; Ali F.	20 years of research on virtual reality and augmented reality in tourism context: A text-mining approach	Tourism Management	2020	409
Jung T.; Chung N.; Leue M.C.	The determinants of recommendations to use augmented reality technologies: The case of a Korean theme park	Tourism Management	2015	385
Buhalis D.; Leung D.; Lin M.	Metaverse as a disruptive technology revolutionizing tourism management and marketing	Tourism Management	2023	381
Kim M.J.; Hall C.M.	A hedonic motivation model in virtual reality tourism: Comparing visitors and non-visitors	International Journal of Information Management	2019	331
Bogicevic V.; Seo S.; Kandampully J.A.; Liu S.Q.; Rudd N.A.	Virtual reality presence as a preamble of tourism experience: The role of mental imagery.	Tourism Management	2019	329
tom Dieck M.C.; Jung T.	A theoretical model of mobile augmented reality acceptance in urban heritage tourism	Current Issues in Tourism	2018	328
Kounavis C.D.; Kasimati A.E.; Zamani E.D.	Enhancing the tourism experience through mobile augmented reality: Challenges and prospects	International Journal of Engineering Business Management	2012	317

2.2. Network keywords

The analysis presented will concentrate on keyword graph analysis. We demonstrate the graph based on the keywords in Figure 3 for more than three relationships. This keyword graph depicts a vast number of interactions between keywords, with tourism emerging as the central axis, being the most representative and anticipated behaviour when focusing the bibliographical search based on the concept (Biggs et al., 1986).

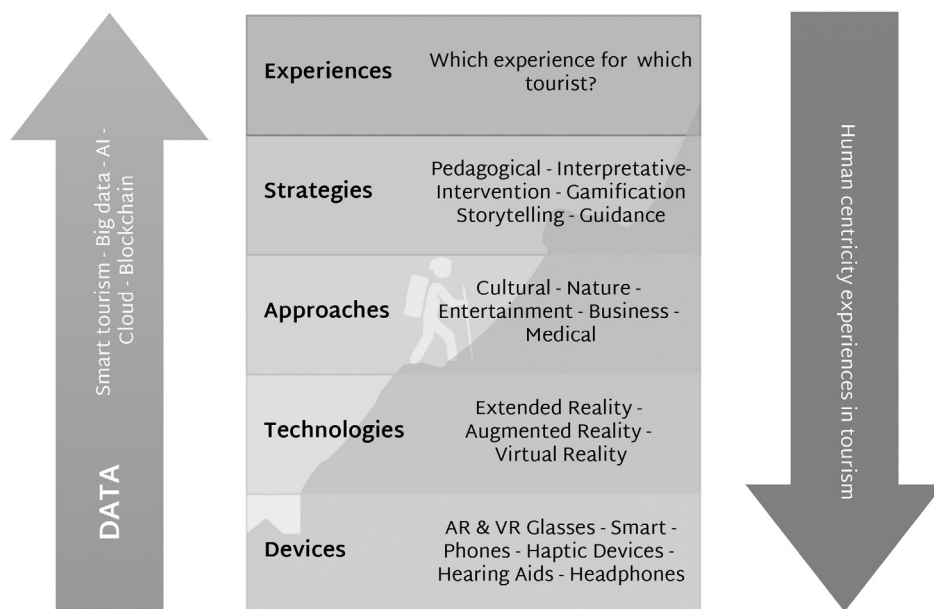
of interest in global research. The focus shifts from the type of tourism to the aspects related to implementing and deploying AR and VR technologies. Keywords such as mobile, information, systems, technology, along with applications, computers, computing, and software, indicate the motivation concerning infrastructure and engineering needed to strengthen the connection between these technologies and cultural and heritage tourism – heritage, cultural, heritages – which appear 225 times.

2.3. Discussions with a framework for a human-centric experience for extended reality in tourism

Figure 4 synthesises the findings from the literature review to propose a framework that places the tourist at its centre, around which a set of identified dimensions should revolve. Currently, it is evident that development concentrates on enhancing tools across six key dimensions.

- First, devices such as glasses, hearing aids, cell phones, and haptics.
- Secondly, technologies such as immersive XR, AR, and VR.
- Thirdly, approaches such as those deriving from culture: heritage, museums, architecture, archeology or nature: species of fauna, flora, natural phenomena.
- Fourthly, strategies such as orientation or guidance, pedagogy, preservation, gamification, and storytelling.
- Fifth, experiences focusing on strategies for tourists. Resolving the question of what role the tourist plays in the experience becomes fundamental.
- Sixth, data is needed to empower the user and facilitate the digital experience itself: smart tourism, big data, AI and cloud infrastructure are key in the analysis of these.

Figure 4
Framework for a human-centric experience for augmented reality in tourism



Applying each of these dimensions to support tourists in every stage of experiencing is only possible when viewed from a human-centred perspective.

In other words, to promote human-centered tourism, it is important to consider the relationship between the multiple layers involved, from the tourist to the experience. Therefore, tourists use various technological

devices, applying different approaches based on a strategy that aligns with the experience's objectives. Data traverses all these layers, and researchers collect, manage, and process them. In this context, each location adopts one or more tourism approaches, providing diverse experiences where XR, AR, and VR enhance engagement for specific tourist segments.

From the layers proposed in the framework in Figure 4, questions arise regarding how to make a human-centred tourism experience truly efficient and favourable.

- **Devices:** Who provides the devices? This question is critical because transportation conditions, updates, and support can impact device usability. When tourists provide their own devices, versatility increases, but control decreases. In contrast, users gain control over devices provided within the experience itself. However, versatility is lost, much more so if we consider that devices such as glasses or haptic sensors require direct contact with users without considering the economic factor.
- **Technologies XR, AR, VR:** Which technology? Each of the immersive technologies requires different skills; their adoption also requires the ability to decide which one is the most relevant. In tourism, if the place deserves it, it is pertinent not to allow a complete immersive experience since the tourist needs the experience itself to be expanded and not a denial of it. A virtual reality experience can work in cases such as those subscribed to the disappearance of the place and the possibility that this technology will give the tourist the experience as it was.
- **Approaches:** Which one? Each approach differs from the others and raises specific questions from its perspective. For the nature approach, for instance, questions are posed regarding the relevance of simulating species and to what extent this impacts and respects the virtualisation of the species. Similarly, regarding the cultural approach, how is it relevant to show a work or an artist without exceeding the aesthetic experience it offers, or how can it be expanded without restricting or nullifying it?
- **Strategies.** Which strategy? Like the approach, each strategy must serve a specific purpose, affecting the type of tourist targeted. Tourists will engage with preservation strategies, while others will participate in gamification strategies. Likewise, some experiences will be better suited to one strategy over the other, and this must be confirmed.
- **Experiences:** How to design the experience? There will be tourists who favor and recommend different experiences and are more inclined to one or the other. Facilities will be available for stakeholders to tailor their experience in terms of technological development and design. However, one aspect of this framework is that the experience must be centered on the human being rather than solely on the capabilities of the place or a limited tourist proposition.
- **Data:** What is the purpose of the data? The flow of data between each layer must be consistent without compromising or limiting the user's privacy. In this regard, obtaining or sharing data should be based on informed consent and transparent rules. It is essential to recognise that without this, there is no experience centered on the tourists and their specific characteristics. Without them, the experience remains generic and lacks distinction.

3. Conclusions

Scholars view AI, big data, and blockchain supporting infrastructures that enable adaptive and personalised immersive experiences, rather than as standalone main technologies.

The six dimensions identified in our framework—technologies, devices, strategies, experiences, data, and approaches—reflect the main clusters observed in the keyword co-occurrence network. For example, clusters around ‘cultural tourism,’ ‘user experience,’ and ‘AR/VR devices’ directly inform our categorisation.

Research and development in tourism and immersive technologies benefit the cultural sector, which encompasses fields such as heritage, archaeology, architecture, and museums. Trends include educating tourists, gamifying experiences, and collecting valuable data for decision-making. The digital experiences provided by augmented, extended, and mixed reality improve people's ability to connect with hotels, routes, museums, and other attractions, and to share experiences on social networks via mobile devices. Mobile devices are the most common platform for using extended reality technologies. Research highlights the use of virtual reality glasses and other tools to stimulate additional senses, such as headphones and haptic devices.

Since the cultural sector most commonly adopts this technology, researchers recognise its capacity to expand physical space as a platform for development and temporal experience. Most studies aim to help travellers recognise the cultural heritage of a place as it once was, appealing to their memory. Augmented reality systems, covering visual, auditory, and tactile elements, are identified as areas of interest. Similarly, organisations combine the potential to collect data from travellers with the development of innovative tourism and sustainable experiences. Although tourist encounters are closely connected to individuals, it remains difficult to offer unique experiences, a challenge that is becoming more urgent with globalisation. Using technologies like AR or VR enhances a journey through cultural evolution; architectural, archaeological, and artistic heritage are incorporated into tourism to showcase different eras to visitors. These technologies also help make the tourist feel central, as personalising this type of element—through data and feedback—enables ongoing improvements.

From a broad perspective, this work identified a weak connection between research on tourism and the use of immersive technologies aimed at conservation. This is noteworthy because conservation is not solely regarded in terms of wildlife and ecology, but also in relation to heritage and memory. We demonstrate that this is one of the key issues for researchers, specifically in analysing how this technology fosters appropriation whilst preventing deterioration, disappearance, or oblivion. Furthermore, we emphasise concerns regarding design, experience, and interaction from an investigative standpoint. There is also an emphasis on studying the user as the primary beneficiary of this type of experience.

Researching the impact of technology at all levels, including the tourism sector, involves understanding the dynamics among tourism operators and software developers who provide such solutions to their customers and users (Pratisto et al., 2022; Ronaghi & Ronaghi, 2022). A key question in scientific research is whether there is a direct link between the adoption of these technologies and the benefits they bring at economic, social, or ecological levels. These are the types of answers that beneficiaries of these technologies seek, and only through diligent scientific work can they be discovered.

There is indeed a research ecosystem oriented towards creating applications and establishing work methodologies from the tourism sector mediated by immersive technology components, whether AR, VR, or MR. It is worth noting the role that developing countries play in establishing research questions to provide answers to this matter. The initiatives undertaken by developed countries may still be cautious. However, they will likely play a crucial role in advancing research on human-centricity tourism and harnessing technologies from the Fourth Industrial Revolution. Developing countries have a latent concern about strengthening their approaches to tourism. Per (Goffi et al., 2019), businesses in developing countries often perceive sustainability as a cost rather than an investment. Structural constraints challenge sustainability, including a lack of access to planning experts, weak community development, a lack of budget, education, mistrust, power disparities, and unequal distribution of costs and benefits (Reindrawati, 2023).

This research shows that the implementation of AR and VR in heritage tourism is considerably higher than in nature-based tourism. However, it indicates a growing interest in their use within the latter sector (Clark & Nyaupane, 2023). The fact that emerging countries regard tourist attractions as an option through adopting these technologies will soon encourage research to develop applications for nature tourism. This connection could bring conservation and sustainability trends closer together.

As the tourism sector adopts new technologies, it will raise many questions about their implementation and their effects on users and businesses. These questions include which regulatory frameworks should prevent misuse of extracted data, the environmental impacts caused by their use, the challenges involved in adopting each tool, how they can be naturally integrated into experiences and services, and the importance of ethical and value-based technology design methodologies (Giampiccoli et al., 2020).

3.1. Theoretical implications

This research contributes to the discussion on the use of immersive technologies like XR in tourism, shaping how visitors view both physical and digital environments (Sorcaru et al., 2025). This broad perspective draws on theories related to technology use in services, highlighting XR's role in enhancing authenticity and supporting meaning-making, rather than just offering a new feature.

Our findings also expand research on inclusivity and accessibility in technology-driven tourism. Salazar-Martinez et al. (2025) demonstrate that ICT adoption can both empower and exclude communities depending on design and governance. Building on this, our results suggest that XR scholarship should incorporate equity-oriented frameworks that address digital divides in skills, access, and cultural interpretation.

Furthermore, this study aligns with Del Vecchio et al. (2025), who emphasize the importance of assessing immersive experiences for their contribution to perceived value and sustainable competitiveness. By considering XR within service design, we contribute to how technology reshapes value in tourism for all stakeholders.

Finally, our study complements Giraldo et al. (2024), who see augmented reality in SMEs as both facilitated and hampered by resource constraints. Our findings support the idea that XR should be integrated within organizational capabilities and contextual limitations, rather than as a universally applied innovation, like X. Jiang et al. (2023), who also acknowledge digital technologies as varying across environments.

Beyond highlighting individual applications of XR in tourism, the framework in our study shows how immersive technologies function as part of a layered ecosystem. The arrangement of devices, technologies, approaches, strategies, experiences, and data emphasises that both theoretical and practical progress rely on their systemic interaction rather than isolated innovations. This ecosystem perspective encourages researchers to examine cross-layer relationships—such as how device accessibility influences strategy effectiveness or how data governance impacts experience design—and guides managers to develop collaborative, inclusive, and sustainable XR initiatives that align technological capacities with human-centred outcomes, enhancing adoption and satisfaction (Chamboko-Mpotaringa & Tichaawa, 2025).

3.2. Managerial implications

The findings of our study highlight several practical recommendations for destination stakeholders considering the adoption of extended reality (XR) solutions. Management must balance XR applications with the overall tourism experience to prevent overreliance on technology and to preserve authenticity with visitors (Onyemelukwe et al., 2024).

Furthermore, future investments in immersive technology must prioritize accessibility and inclusivity, as XR-mediated experiences can unintentionally reinforce digital divides by favoring digitally skilled visitors. To prevent this, managers should implement training, user-friendly interfaces, and inclusive design features to increase adoption (Salazar-Martinez et al., 2025).

Finally, adopting XR requires a careful balance between humans and technology, as it can be taxing for both employees and tourists in terms of cognitive load, emotional effort, and adapting to new formats. This calls for staff training and other measures to prevent visitor fatigue, which is vital for maintaining positive experiences (Del Vecchio et al., 2025; Sorcaru et al., 2025). Effective evaluation metrics must support XR initiatives, and

managers need to assess outcomes related to value creation, learning, sustainability, and destination resilience (Giraldo et al., 2024; Skandali & Tsourvakas, 2025).

Declaration of Competing Interests

The authors declare that they have no known competing interests that could have appeared to influence the work reported in this paper.

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