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## CONCEPTUAL FRAMEWORK AND FUTURE RESEARCH DIRECTIONS FOR A WEB-BASED AUGMENTED REALITY FOR SUSTAINABLE TOURISM

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### Abstract:

This paper is a systematic review of the new role of Web-Based Augmented Reality (WebAR) in the promotion of sustainable tourism with particular focus on the educational and environmental value that it adds. The review is conducted using a scoping methodology in line with the PRISMA-ScR guidelines to make the review transparent and methodologically rigorous. The search was conducted in academic databases (Scopus, Web of Science, and Google Scholar) on the keywords WebAR, augmented reality, sustainable tourism, heritage management, and digital learning. It screened 52 articles published since 2012, 26 of which passed through the inclusion criteria in thematic synthesis. The review presents three clusters of dominant research, namely: (i) WebAR as a cultural heritage preservation and environmental protection, (ii) educational and behavioural effects of immersive technologies, and (iii) governance and policy mechanisms to facilitate sustainable adoption. Although the adoption of digital data is fast in Southeast Asian studies, comparative data in Europe and the Middle East shows that there are advanced integration with cloud learning, artificial intelligence, and open-access education platforms. Based on the synthesis, it is proposed to create a conceptual framework that would connect WebAR applications to sustainability results in the

environmental, social, and economic aspects. The paper ends by offering recommendations on how the study can be empirically tested, work with other parts of the global community, and more closely aligned with the United Nations Sustainable Development Goals (SDGs), specifically SDG 4 on quality education and SDG 11 on sustainable cities and communities.

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## Introduction

The tourism sector has become one of the most powerful socio-economic sectors in the world, applied to preservation of heritage, creating job opportunities, and intercultural communication. Nevertheless, the fast development of the sector has increased demands on natural resources and urban facilities as well. The transition to sustainable tourism is thus meant to focus on harmonizing economic development and the environment and cultural stability (UNWTO, 2024). Over the past few years, digital technologies like Augmented Reality (AR) and Virtual Reality (VR) have become strategic enablers of this balance and have generated experience-based interactions, involved tourists and minimized physical effects on sensitive locations.

Of those inventions, WebAR is the technology that has the most distinct benefits to sustainable tourism as it is utilized directly in the browsers without the necessity to install an application. This has made WebAR a democratizing tool to cultural education, inclusive learning and responsible visitation models. Researchers have been investigating the possibility of AR to transform visitor experience more and more (Chung, Han, and Joun, 2015; Lin and Zhang, 2020), though a significant portion of such studies have dedicated to mobile apps development and not to websites. This current research thus analyses the potential of WebAR as a low-impact and scalable and educationally enriched tool that can be used in sustainable urban tourism.

This investigation is not only relevant to tourism management. Recent research shows that immersive and cloud-based technologies have the potential to improve the learning experience and awareness of sustainability (Papadakis et al., 2023; Lampropoulos and Papadakis, 2025). Combining AR and cloud infrastructure and artificial intelligence will allow it to provide adaptive, real-time content delivery, which will be in line with the objectives of lifelong learning and universal access. Such advancements prove the thesis that WebAR can promote

the Sustainable Development Goals (SDG 4 on quality education and SDG 11 on sustainable cities and communities) at the same time, thus extending the concept of tourism innovation to the society at large.

Even with the increased interest, there have been major gaps in knowledge. The existing research does not provide any systematic overview of the role of WebAR in supporting sustainability, especially in its capacity to incorporate the environmental, cultural, and educational aspects. Most of the existing research is usually descriptive or technology-oriented and little theoretical or policy focused studies are available. Moreover, studies are more inclined to study individual regional situations, which restrict the extrapolation of knowledge on different tourism systems. To overcome these constraints, this paper will use a scoping review to follow PRISMA-ScR principles and discover and systematize evidence on WebAR applications in sustainable tourism across the world. By doing this, it will (i) combine thematic patterns in the application of WebAR to sustainability, (ii) assess its implications on a global and regional scale, and (iii) introduce a conceptual framework to inform future studies and empirical implementation.

## **Literature review**

### ***Overview of Augmented Reality in Tourism***

The use of Augmented Reality (AR) technologies has changed the way tourists view, engage, and experience tourism destinations. AR allows immersive interaction with the real world to add to stories and improve the knowledge of visitors about heritage, culture, and environment by blending virtual and real worlds (Chung, Han, and Joun, 2015; Lin and Zhang, 2020). Uses have spanned museum interpretation to the eco-trail navigation systems and historical recreations, so AR has been the catalyst to experiential learning. Nonetheless, the conventional AR systems typically involve downloads of the app, which creates issues of access, compatibility, and service (Kounavis, Kasimati, and Zamani, 2012).

### ***The Emergence of Web-Based Augmented Reality (WebAR)***

WebAR has become one of the browser-based options that do not require the installation of application that reduces the technological barrier and allows a wide range of participation (Nguyen, Le, Chen, and Smith, 2021). Interactive experiences are made available to the users through a single URL link or through QR code and can be accessed on the device directly. The technology has good potential regarding sustainable tourism since it reduces the consumption of resources, does not require the intensive updating of the apps, and offers light-weight data-driven experiences. Researchers have pointed out that WebAR can facilitate responsible tourism, by redirecting physical traffic around vulnerable locations, which has an indirect effect on environmental conservation (Ali, Wong, Tan, and Kumar, 2022). Although these are the benefits, there are limited systematic assessments of the long-term sustainability effect of WebAR, particularly in policy-related and social inclusion.

### ***AR and Sustainability: Linking Environmental and Educational Goals***

The convergence between AR and sustainable studies has risen over the past years and the focus has been on environmental concern and education. Rehman, Awan, and Rather (2024) discovered that the ecotourism apps supported with AR reinforce the pro-environmental

attitudes and behavior of stewardship. These observations can be seen in the educational settings worldwide where AR is employed to simulate the complex environmental systems to unite learning and sustainability (Papadakis et al., 2023). Integration of cloud computing and AR has also promoted open learning in the environment by promoting access and interactive learning (Papadakis et al., 2023; Lampropoulos and Papadakis, 2025). These practices indicate the dual role of AR both as an environmental communication tool and as a digital medium of education in accordance with the Sustainable Development Goals.

### ***Thematic Developments in Global Research***

Current reviews also emphasize that the research on AR related tourism falls into three main themes: (i) technological design and user experience; (ii) behavioural and educational effects; and (iii) sustainability and policy frameworks (Yung and Khoo-Lattimore, 2019; Hanaa and Abdul, 2024). In the West, research has been conducted on technological architecture and cross-platform usability (Rauschnabel, Tom Dieck, and Hinsch, 2023), whereas the Asian research is usually oriented towards user acceptance and cultural immersion (Alam et al., 2024). However, both of the streams lead to the same conclusion that immersive technologies have a potential to promote more profound emotional and cognitive involvement in the tourist, thus supporting the sustainable behaviour change.

### ***Regional Studies and Limitations***

AR-based tourism projects have expanded quickly in Southeast Asia, especially in Malaysia, through high levels of governmental support and the increase in digital literacy (Tan and Lim, 2023). Nevertheless, the majority of the implemented ones are still pilots and do not have standardized sustainability assessment measures. According to comparative experience in Europe and the North America, more organized cooperation between universities and tourism boards and technology companies in integrating AR into heritage and smart city programs is observed (Wang et al., 2024; Choi, 2023). These cross regional differences point to the necessity of common structures and performance metrics that can evaluate the economic, environmental and cultural effects of AR on a similar level.

### ***Identified Gaps***

Despite the fact that the literature of the world supports the use of AR in tourism, there are still three gaps that stick around:

1. Methodological Rigour: There is a paucity of studies that implement a systematic or a scoping review process to enhance transparency and reproducibility.

**Table 1: Highlights Of the Review**

| Aspect                     | Findings  |
|----------------------------|---|
| <b>Technology Focus</b>    | WebAR Web-Based Augmented Reality.                                  |
| <b>Application Context</b> | Sustainable urban tourism in Kuala Lumpur.                          |
| <b>WebAR advantages</b>    | No app is required to use, wide accessibility, immersive narration. |

|                                      |   |
|--------------------------------------|---|
| <b>Weaknesses of Recent Research</b> | Research on user interface and experience, not sustainability.        |
| <b>Gaps found</b>                    | There are no empirical data, policy integration, no standard metrics. |

**Table 2: Research Gap Vs Research Opportunities**

| Identified Research Gap                                  | Suggested Research Opportunity  |
|--|---|
| Limited focus on sustainability outcomes of WebAR        | Carry out long-term studies of effects on the ecological and cultural fronts. |
| Absence of accessibility strategies for all demographics | Develop inclusive, multilingual, low-bandwidth WebAR interfaces               |
| Weak policy and institutional integration                | Establish governance and cooperation structures.                              |
| No standard metrics for evaluating impact                | Design indicators for social, environmental, and economic impact              |

2. Cross-Regional Integration: The research is regionally focused, which decreases the generalizability and theoretical building.

3. Sustainability Assessment: Missing any regular frameworks and metrics that would connect the application of WebAR to the environmental, educational, and socio-economic performance. The sole solution to these gaps is an integrative approach, which will bring together technological innovation, educational design, and sustainability science. In turn, the current paper constructs a conceptual framework according to which WebAR becomes a meeting point of digital heritage, sustainability policy, and inclusive education.

The review literature synthesis indicated some strengths and limitations of the current WebAR research in terms of sustainable tourism. The technology is highly accessible and can be used to tell stories in an immersive manner (as illustrated in Table 1), however, it is still poor in terms of sustainability assessment and policy integration. In order to connect these results to the trends in the future, Table 2 represents a summary of the key gaps in the research and the opportunities they introduce to future studies. This cross-comparison explains why the work of the future that should shift to the interface design will enable the work to focus on inclusivity, political frameworks, and quantifiable sustainability results.

## Methodology

### *Review Design*

To ensure that the paper has a consistent, transparent, and reproducible methodology, the PRISMA-ScR framework (Tricco et al., 2018) is taken into account to design a scoping review.

I have chosen this approach since the area of Web-Based Augmented Reality (WebAR) in sustainable tourism remains a nascent area and is highly diverse in the goals, contexts, and criteria of assessment.

A scoping method therefore enables mapping of existing evidence, identifying conceptual linkages, and outlining directions for future empirical work rather than testing predefined hypotheses.

### ***Data Sources and Search Strategy***

The literature search was conducted between January 2025 and May 2025 using the databases Scopus, Web of Science, ScienceDirect, and Google Scholar. Additional relevant papers were located through backward and forward citation tracking.

The following Boolean search string was applied and adapted for each database:

> (Web-based augmented reality OR WebAR OR browser-based AR) AND (tourism OR heritage OR destination management OR visitor experience) AND (sustainability OR environmental impact OR education)

Only peer-reviewed journal articles, conference proceedings, and book chapters published in English between 2012 and 2025 were included to capture both early and current developments.

### ***Inclusion and Exclusion Criteria***

The criterial of choosing the best journals for the study adopted the inclusion and exclsion norms as stated in Table 3

**Table 3 Criteria Adopted in The Study**

| Inclusion Criteria  | Exclusion Criteria   |
|---|--|
| Studies that explicitly examined AR or WebAR applications in tourism, heritage, or sustainability contexts          | Articles not involving tourism or sustainability (e.g., industrial or medical AR)      |
| Papers reporting conceptual, empirical, or review findings related to sustainability outcomes, education, or policy | Non-English publications or grey literature without peer review                        |
| Research that discussed environmental, cultural, or educational implications of AR use                              | Studies focusing solely on hardware development without user or sustainability context |

### ***Data Extraction and Synthesis***

The most important bibliographic and analytical information, including the purpose of the study, the methodology, the geographical focus, and the AR type, or aspects of sustainability

were noted in a table structured format. Thematic analysis was then used to define recurring patterns and conceptual connections between the studies. Such a procedure produced six key categories:

1. Environmental impact and resource efficiency
2. Cultural heritage preservation
3. User experience and inclusivity
4. Educational and behavioural change
5. Policy and governance integration
6. Technological scalability and collaboration

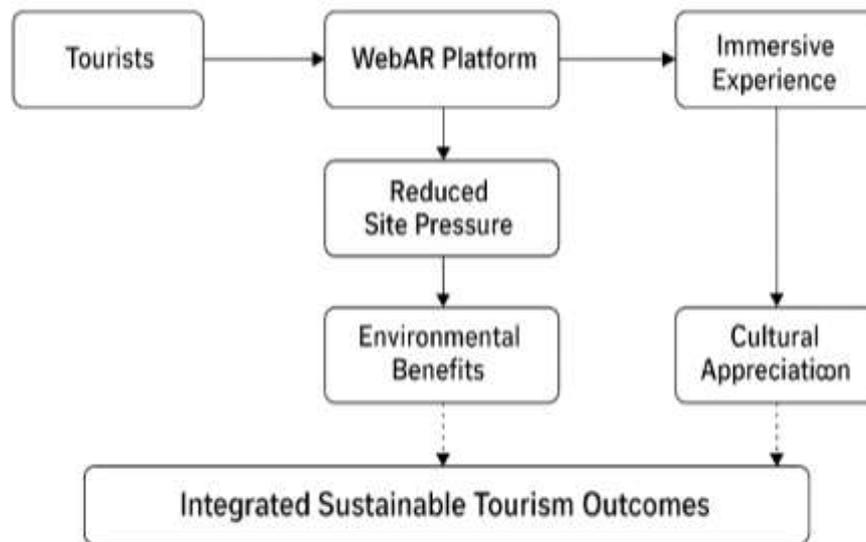
The synthesis emphasized cross-regional comparisons to ensure balanced global representation and avoid over-reliance on any single context.

### ***Ethical and Quality Considerations***

Since the review is made on the basis of secondary data accessible to everyone, the approval of the ethical issues was not necessary. However, the reporting took place in the PRISMA-ScR checklist to promote the transparency in the selection and synthesis. All the studies included were evaluated on criteria of clarity of the methodology used, relevance and contribution to the discourse of sustainable tourism; however, there was no quantitative quality-scoring tool implemented on this conceptual review.

### **Conceptual Framework: WebAR for Sustainable Tourism**

The theoretical framework that was formed during the current review makes Web-Based Augmented Reality (WebAR) a mediator between technological innovation and sustainable urban tourism. Based on the knowledge formulated in the previous chapters, the model acknowledges that WebAR is able to meet both environmental, social, and economic goals along with promoting learning and culture.



**Figure 1: Webar for Sustainable Tourism – The Conceptual Framework**

In order to represent the relationships of actors in a sustainable tourism in the context of integrative relationships, Figure 1 illustrates the conceptual framework that can be adopted in the implementation of Web-Based Augmented Reality (WebAR). As shown in the figure, four stakeholder groups, namely, government agencies, tourists, local communities, and developers' interface with each other based on a central WebAR platform and promotes environmental, social, and economic deliverables. The framework (Figure 1) highlights cross-sector partnership and shows how digital participation has the potential to alleviate sites pressure, propagate cultural appreciation and support livelihoods of community. WebAR platform is an online platform allowing to provide an experience in 3D, without downloading any applications. These experiences may involve virtual heritage tours, interactive story telling or live interpretation of ecological sites. All these factors combine to create three sustainability pillars as in the following sections.

***Environmental Dimension:***

WebAR will help reduce or eliminate reliance on paper, decrease carbon emissions caused by travelling, and decrease overcrowding in vulnerable cultural or ecological locations through virtual alternatives. The patient is adequately clothed and experiencing good health.

***Social and Cultural Dimension:***

Digital narratives should be co-created by local communities as they reflect their heritage in an authentic way and encourage inclusiveness and intercultural discussion. This type of participatory storytelling contributes to cultural diversity respect and corresponds to the SDG targets of sustainable development related to education.

### ***Economic Dimension:***

The technology creates novel possibilities of micro-entrepreneurship, which include AR-based walking tours, digital souvenirs, and joint marketing by tourism boards and small businesses. These programs will enhance resilience of the communities in accordance with SDG 11 on sustainable cities and communities.

The framework insists that sustainability outcomes will be realized once these interactions between the stakeholders are synchronized using enabling policy and governance frameworks. It highlights the idea that effective collaboration and ethical data management are also essential to be used not only with the help of technologies. As an example, the municipal authorities would be required to incorporate WebAR in the tourism master plans, and developers would have to comply with the privacy and accessibility guidelines to promote fair participation.

The ways these interconnections take place dynamically are shown in figure 1. This interaction between tourism and WebAR interfaces creates immersive experience and relieves physical pressure on the site which consequently leads to environmental conservation. At the same time, the culture and community involvement with the help of mutual stories, and a feedback loop is built, which supports sustainable behaviour. Finally, the framework postulates that digitally mediated tourism experiences may be used as a complement, but not as a replacement of traditional visitation by facilitating education, conservation awareness, and inclusivity.

### **WebAR (SDG 4) Quality Education.**

Education is central to the attainment of sustainable development since it provides local people and tourists with education and values to preserve cultural and natural heritage. In the suggested WebAR model (Figure 1), education is not only the binding chain between technological innovation, community engagement, and environmental care but also the connecting part between the former two. Online augmented experiences have the potential to make tourism not a passive activity, but an active learning experience, therefore, supporting Sustainable Development Goal 4 (SDG 4) -ensure inclusive and equitable quality education, and provide lifelong learning opportunities to all.

### ***WebAR as a Pedagogic Lifelong and Experiential Learning.***

Constitution of these interconnections is dynamic as seen in figure 1. Tourists use WebAR interfaces and obtain immersive experiences, creating a reduction in site pressure and making a contribution to the preservation of the environment. At the same time, cultural awareness and community involvement amplify, with unity of stories, establishing a feedback system that supports sustainable behaviour. Finally, the framework hypothesizes that digital mediated tourism experiences are not necessarily substitutive of traditional visitation because they provide educational, awareness of conservation, and inclusiveness boosts.

### ***Advocacy of Inclusive and Equitable Access.***

Traditional educational tourism is usually based on physical mobility and monetary ability. WebAR, in contrast, minimizes these obstacles by providing lightweight and browser-based access and works on the conventional mobile devices. It is important to the remote learners, individuals with disabilities, and those with low income who might not be able to have the

traditional travel experience. The strategy aligns with the SDG Target 4.5 that focuses on ensuring equal access to education to all learners irrespective of background or circumstance.

***Knowledge Contributors Local Communities Can Be Empowered to contribute.***

Local communities are not just beneficiaries that are satisfied, but also active participants in the WebAR ecosystem. Through digitization of oral histories, cultural performances and traditional ecological knowledge, residents are also given the chance to be teachers to themselves. The participatory method will help build the pride of a community and develop skills in digital storytelling, as well as promote the knowledge transfer between generations. It supports SDG Targets 4.3 and 4.4, which are concerned with access to relevant technical and vocational skills to work and preserve cultural values as well.

**Table 4. Presentation Of How Tourism Supported by Webar Advances SDG 4**

| <b>WebAR-Enabled Educational Function</b>   | <b>SDG 4 Target Aligned</b>                       |
|---|---|
| <b>Offers self-directed learning and lifelong learning based on interactive heritage and environmental.</b> | Target 4.7 (Sustainability Education)             |
| <b>Facilitates low cost and inclusive education to remote or under-resourced users.</b>                     | Target 4.5 (Equity in Access)                     |
| <b>The fostering of intercultural knowledge and respect by using digital storytelling.</b>                  | Target 4.7 (Cultural Appreciation)                |
| <b>Empowers the local communities in creating content and acquiring digital skills.</b>                     | Targets 4.3 & 4.4 (Skills and Technical Training) |

***Educational Outcomes Are Connected to The Effect On Sustainability.***

The incorporation of WebAR in sustainable tourism does not just move education to the level of thinking but makes a change in behaviours. Tourists who follow interactive and contextualized stories have a higher chance of adopting responsible travel practices, have an impact on conservation efforts and observe the local culture. In that way, the educational role of the WebAR supports the environmental and social aspects mentioned in Figure 1 and changes the learning outcomes into quantifiable sustainability effects. Table 4 overviews the key areas of how the WebAR tourism promotes SDG 4 and the UN targets.

**Future Research Directions**

As the basis of the conceptual model shown in Figure 1, future research on Web-Based Augmented Reality (WebAR) as a sustainable tourism methodology must step forward to increasingly integrated and empirical research. Figure 2 conceptualizes the six major themes found with the help of this review as policy integration, sustainability metrics, stakeholder collaboration, environmental impact, inclusivity design, and technological scalability.

Collectively, these aspects constitute a research agenda in enhancing the theoretical and practical backgrounds of WebAR.

The policy should be integrated and governed by the company in accordance with the principles of leadership and integrity.

### ***Policy Integration and Governance.***

The company should be able to integrate the policy and govern it according to the principles of leadership and integrity. This approach to implementation is usually project-specific and fragmented, although it has potential. The research question that needs to be investigated in future studies is how the strategies of WebAR can be integrated into national and municipal tourism policies, such as smart city and digital heritage policies. The comparative analysis of policies in different areas may offer superior international practices in regulatory framework, data use ethics, and digital inclusion. Another aspect of this research theme is that cooperation among tourism authorities, cultural organizations, and learning institutions is necessary so that digital projects can cement the development strategies of the locals.

### ***Sustainability Metrics and Evaluation Models.***

Most of the current WebAR initiatives do not involve standardized means of quantifying what they are contributing to sustainability. To this end, the researchers ought to establish multi-criteria evaluation models that would integrate environmental indicators (i.e. carbon minimization through virtual visitation), social inclusivity indicators, and cultural engagement outcomes. The use of a combination of qualitative and quantitative approaches including user analytics, content impact studies, and lifecycle assessments would increase the comparability and accountability of future interventions.

### ***Stakeholder Co-operation and Co-Creation of Knowledge.***

Sustainable tourism requires interdisciplinary cooperation to be successful when it comes to WebAR. Future studies ought to explore participatory design models in which co-producers of digital content are local communities, technology developers, tourism boards and academic institutions. Comparative case studies of other governance arrangements may also help in identifying which partnership arrangements are the ones that promote long-term sustainability and the equitable distribution of benefits.

### ***Environmental Impact and Digital Ethics.***

Although WebAR has the potential to decrease the amount of physical travel and the number of emissions, the digital infrastructure does not present a zero environmental footprint. Research would be needed to assess the power usage, information storage and the dependence on devices associated with deploying WebAR. Besides, there are ethical aspects of digital pollution, misinformation, and privacy that should be addressed systematically. Ethical design guidelines of low impact digital tourism is an emerging research priority.

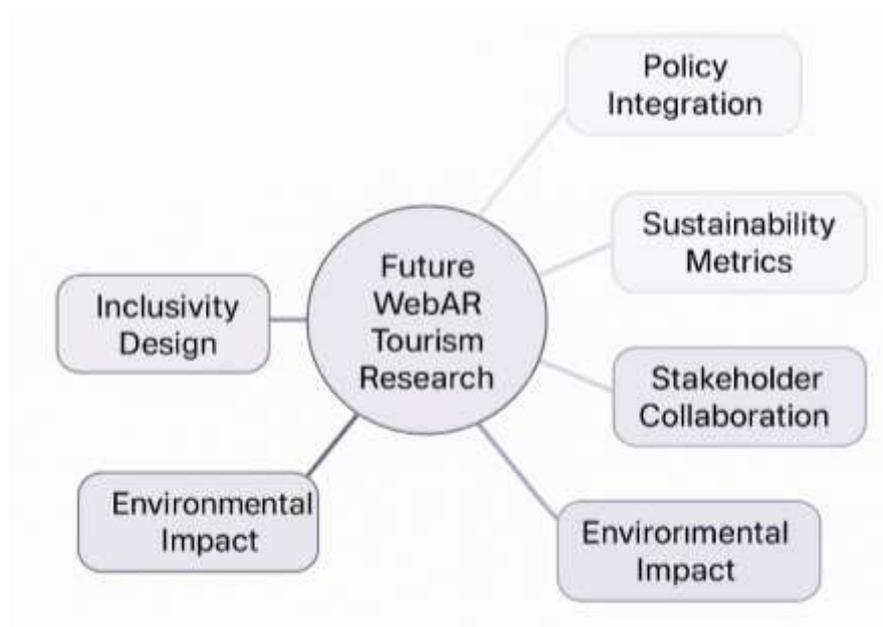
Inclusiveness/Universal Design: All stakeholders must receive equally fair treatment without discrimination because of diversity differences.

***Inclusivity and Universal Design:***

Stakeholders must be treated equally without discrimination due to differences in diversity. Sustainable digital transformation has to continue being inclusive. Future research can look into accessibility criteria of various user communities such as older individuals, individuals with disabilities, and low-bandwidth communities. This comprises of multilingual interfaces, simplified navigation and adaptive content. By incorporating the principles of inclusive design, it will be possible to make WebAR applications similar to SDG 4 and overall sustainability tourism objectives of equity.

***Scalability and integration with New Tools Technologically.***

Lastly, WebAR is supposed to be researched in connection with other technologies that are under development, including artificial intelligence, Internet of Things (IoT), and cloud learning systems.



**Figure 2 Elements of Future WebAR Tourism Research**

Interdisciplinary initiatives may measure the improvements of personalization, data analytics, and dynamic storytelling on the basis of such integrations. The studies in this field would also add to the international standards of interoperability of sustainable tourism technologies

These thematic directions are not independent, but in fact, they are linked to each other as shown in Figure 2. They all champion the concept of multidimensional approach of technology, policy, education and environmental science coming together in order to define the next generation of responsible tourism systems. Furthering research in this direction will see WebAR surmount novelty applications and become a powerful evidence-based sustainability tool.

The effectiveness of such integrations in terms of personalization, data analytics, and dynamically told stories could be tested on cross-disciplinary projects. The studies on this topic would also play a role in creating standards of global interoperability of sustainable tourism technologies.

## Conclusion

This review points out the disruptive nature of Web-Based Augmented Reality (WebAR) as a driver of sustainable tourism. The systematic mapping of the current body of literature with the help of a PRISMA-ScR guided methodology, the study becomes the first systematic review to summarize the available evidence on the idea of WebAR, which can be utilized to improve visitor experiences and assist in conserving the environment, preserving its culture, and providing inclusive education. This research and the proposed conceptual framework can be described as positioning WebAR as an integrative platform which connects four key stakeholder groups governments, communities, tourists, and developers to a collective digital ecosystem which develops the social, environmental and economic pillars of sustainability.

These results reveal that due to the browser-based access of WebAR, the latter allows more people to participate in it, decreases the environmental footprint of physical travel, and immerses people in the cultural experience. All these attributes are directly in line with SDGs 4 (Quality Education) and 11 (Sustainable Cities and Communities), which shows how digital innovation can support the educational and ecological roles of tourism. Notably, WebAR is not only entertainment, but also can be used as a lifelong learning, responsible visitation, and community empowerment model.

However, the review also reveals the ongoing issues, such as poor integration of the policies, inconsistency in sustainability indicators, and absence of cross-regional cooperation. Further studies should hence be based on the empirical verification of the framework in diverse cultural and geographical settings, the construction of standardized evaluation instruments and the discussion of the governance systems that will make the implementation of WebAR technologies ethical, inclusive, and with minimal impact.

To sum up, WebAR is not just a technological trend, but it is a paradigm shift in the way destinations present heritage, the manner in which communities convey knowledge, and ways in which visitors learn about the world in a responsible manner. With an evidence-based policy implemented, WebAR can be a part of creating resilient, equitable, and sustainable tourism futures in the world when carefully embedded into tourism planning.

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