Virtual Reality for Responsible Tourism: A Case Study of Jordan's Coral Reef

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Abstract: The present study examines the potential of immersive virtual reality (VR) experiences to shape more conscious and sustainable tourism attitudes, considering the dynamic challenges posed by mass tourism's negative environmental impact. VR enables the exploration of sensitive ecosystems, such as coral reefs, without the risk of damaging them, and this is the focus of the present study, which examines the potential of VR to shape more conscious and sustainable tourism attitudes. The study focuses on a coral reef in Aqaba, Jordan, a key marine ecosystem threatened by mass tourism. The experiment involved 527 participants who took a virtual tour of Jordan combined with education about coral reefs. A mixed-methods approach was used, and data were collected through surveys and interviews after the VR experience. The results indicate participants' strong emotional response to environmental issues and their willingness to adopt greener tourism practices, such as sustainable transportation and support for local initiatives. Many respondents considered virtual tourism a viable alternative to travel to sensitive destinations. The results may be useful for tourism organisations, policymakers and researchers working on sustainable tourism development and environmental education.

Keywords: Virtual reality (VR), Responsible tourism, Sustainable tourism, Coral reefs Jordan, Mass tourism

1. Introduction

The statistical data indicates that 790 million tourists travelled during the initial six-month period of 2024. This represents an increase of 11% relative to 2023 (UNWTO, 2024). The phenomenon of mass tourism is having an ever-increasing impact on the environment and the resources of planet Earth. In its 2020 report, the World Tourism Organization (UNWTO) specifically notes that the overuse of natural resources by mass tourism can lead to irreversible changes in ecosystems. It is evident that government intervention is a fundamental aspect in the resolution of this issue. As Smith and Richards (2019) observe, the dynamic growth of the global tourism industry may lead to the loss of natural and cultural values. The author identifies the greatest threat to destinations that attract the largest number of tourists. In their study, Lee and Syah (2018) provide an illustrative example of the impact of mass tourism on a specific destination: the island of Bali in Indonesia. It has been demonstrated that an excess of tourism infrastructure results in an ecological imbalance. This results in a violation of environmental stability. As Dudek and Kuziak (2017) and Gössling (2002) have observed, there is a risk that intensive tourism may lead to the destruction of cultural heritage. The available evidence indicates that an excessive level of tourism places considerable strain on the natural resources of an area. The impact is particularly evident in fragile coral reefs, delicate archipelagos and subarctic areas, as well as in national parks and areas under special protection (Buckley, 2012; Weaver & Lawton, 2017; Ólafsdóttir and Runnström, 2013; G, 2013). As Goodwin (2021) observes, the concept of responsible tourism is gaining ground, evidenced by increased interest in research and tourism policy. The views of Lee & Syah (2018) and Egresi (2016) are that residents of popular destinations often derive little benefit from increased tourism development. This has the effect of reinforcing the need for sustainable solutions that would benefit local communities more. The application of modern technologies, such as virtual reality (VR), offers innovative and environmentally friendly approaches to tourism.

They make it possible to have immersive and realistic travel experiences without having to physically visit places that are exposed to environmental degradation (Kask, 2018; Geng, 2022). There is evidence that VR enables consumers to explore places that are difficult to access or threatened. Such experiences can positively influence visitors' environmental attitudes and, most importantly, increase awareness of the need to protect these areas (Guttentag, 2010; Stainton, 2020; Beck et al., 2019). Furthermore, Fatma and Bhat (2023) posit that VR has the potential to increase tourists' tendency to engage in responsible behavior. The researchers emphasize that it can support the development of responsible tourism. The objective of this paper is to provide insight into the role of VR in promoting responsible tourism behavior. It is crucial to investigate the potential of VR as a tool to support the protection of sensitive ecosystems and cultural heritage areas. The paper discusses the applications of VR as an alternative to mass tourism, focusing on research on the impact of immersive technologies on tourists' attitudes towards sustainability using the example of the Red Sea Coral Reef in Jordan.

2. Literature Review

This chapter provides a comprehensive review of existing literature on responsible tourism, the environmental impact of mass tourism, and the role of virtual reality (VR) in promoting sustainable tourism. The literature is critically analysed to identify key themes, gaps, and areas requiring further exploration.

2.1 Responsible Tourism Research

Research on responsible tourism has predominantly focused on two main areas: sustainability and environmental protection (37%) and the impact of tourism on local communities (23%) (Ruhanen et al., 2015). Other significant themes include responsible tourism management, ethics, and social responsibility. According to Bramwell et al. (2008), responsible tourism emerged as a recognized research area in the 1980s alongside the growing discourse on sustainable tourism. More recent studies (Prasetyo, 2022) highlight the growing emphasis on practical applications of responsible tourism, particularly in fragile ecosystems, with the latest data revealing 176 publications from 2020 to 2021 focused on sustainable tourism applications.

Table 1: Distribution of research topics in responsible tourism. Source: Autor`s work

Variable	(n) %
Responsible Tourism Management	100 (19)
Tourism's Impact on Communities	121 (23)
Ethics & Social Responsibility	69 (13)
Socially Responsible Tourism	42(8)
Sustainability & Env. Protection	195 (37)

Mass tourism is damaging the environment and local communities, so it is important to practice responsible tourism to minimize these negative impacts and protect the natural world (Goodwin, 2021). As Leslie (2012) highlights, the environmental education of tourists is of paramount importance for the economic benefits of local communities. Research findings indicate that residents are more likely to support tourism when they perceive economic benefits (Nunkoo & So, 2016). Furthermore, social benefits are identified when tourism serves to reinforce local identity (Stylidis et al., 2014). Rasoolimanesh et al. (2017) demonstrate that support for tourism increases in conjunction with the level of community involvement and the perception of benefits. This phenomenon is particularly evident in tourist destinations and traditional villages.

Sharpley (2014) posits that a beneficial perception of tourism is fundamental to sustainable development in developing countries. Kurek (2013) argues that developing countries are resistant to the idea of giving up mass tourism, as it represents their primary source of income.

However, Mihalic (2016) and Mohamadi et al. (2022) highlight that, despite a wealth of research, the practical implementation of sustainability initiatives continues to face significant challenges, particularly in developing regions where the necessary tools and strategies are lacking. Goodwin (2021) presents a discussion of the evolution of responsible tourism from a niche initiative to a global environmental strategy. Smith and Richards (2019) and Dodds and Butler (2010) investigated the significance of tourist involvement and consistent regulation in mitigating the adverse effects of mass tourism on the vulnerable environment.

2.1.1 Research gaps and contribution of this study

Despite extensive research on mass tourism's impact and VR's potential, gaps remain in long-term behavioural studies and applications beyond Western contexts.

This study contributes by:

- Evaluating VR's influence on responsible tourism behaviour.
- Examining its role in reducing visits to sensitive ecosystems.
- Expanding research to Jordan's Coral Reef.

By addressing these gaps, this study enhances understanding of VR as a sustainable tourism alternative, particularly in ecologically fragile areas

2.1.2 Environmental impact of mass tourism

In his work, Kurek (2013) identifies the transformation of tourism into a mass phenomenon in the period following the Second World War. The author posits that this was due to an increase in technology, income and the convenience of air transport. The topic of mass tourism is a source of concern for many academics and authorities. An increase in tourism has been identified as a contributing factor to the degradation of all ecosystems (Buckley, 2012). The researcher underscores that the overexploitation of natural resources by humans poses a significant threat to biodiversity and the overall health of the ecological system. Weaver and Lawton (2017) argue that coral reef ecosystems are susceptible to adverse effects.

Of particular concern are the effects of pollution, erosion and ecological disturbance. This results in an over-intensive tourist presence and the expansion of tourist infrastructure. It has been demonstrated that large-scale tourism represents a significant contributing factor to environmental change in popular tourist destinations. Bali and the Great Barrier Reef are illustrative examples of natural resource destruction (D'Hauteserre, 2015; Hughes, Kerry and Simpson, 2017; UNWTO, 2020).

Some countries are implementing precautionary measures, such as the temporary closure of Maya Bay in Thailand for the purpose of environmental regeneration. Australia has implemented a restriction on the number of divers permitted on the Great Barrier Reef (Great Barrier Reef Marine Park Authority, 2021). Similarly, tourist fees have been introduced in Venice (Seraphin, Sheeran & Pilato, 2018). The Philippine Island of Boracay has been closed by the government to address critical issues and protect nature (Reyes et al., 2018). Despite the number of tourists in summer reaching 5,000 per day, which exceeds the UNESCO limit by half (Philips, 2019), Peru has introduced changes to morning and afternoon visits.

As indicated by the Ministry of Business, Innovation & Employment (2019), since 1 July 2019, most international visitors to New Zealand have been subject to a $100 International Visitor Conservation and Tourism Levy (IVL). In their research, Rinzin, Vermeulen & Glasbergen (2007) posit that Bhutan employs a quota system to regulate tourist numbers, levying high fees to this end. To safeguard the local flora, Iceland has temporarily closed the Fjaðrárgljúfur canyon to the public (Iceland Insider, 2023). The Spanish city of Barcelona is renowned for its numerous restrictions on tourism. The neologism 'Touristophobia', which denotes a negative perception of visitors by the local community, is frequently referenced in academic literature (Romangnoli, 2020; Martins, 2018; Tesfahuney, 2024).

2.1.3 Virtual reality in tourism: Supporting the sustainability of coral reefs

Loss of coral reefs endangers the well-being of millions of people and the stability of marine ecosystems. The Red Sea Reef is one of the most ecologically vulnerable in the world (Kleinhause et al., 2020).

The utilization of innovative virtual reality (VR) technology presents a promising avenue for the safeguarding of vulnerable natural ecosystems and corals. The use of immersive technologies enables tourists to experience the beauty of nature without the need for physical presence in these locations, thereby reducing the potential for degradation (Zhang et al., 2022; Tussyadiah et al., 2018).

Virtual reality (VR) has the potential to be a powerful tool for education, fostering positive environmental attitudes and raising awareness about the importance of environmental protection. To illustrate, virtual reality simulations permit individuals to virtually 'visit' coral reefs, thereby mitigating the adverse effects of mass tourism (Stainton, 2020). Furthermore, research indicates that such technologies influence tourists' responsible attitudes towards the environment (Beck et al., 2019). The efficacy of environmental education utilizing VR technology for wetland ecosystems has been validated (Ou, Chu and Tarng, 2021).

Furthermore, the use of VR has been demonstrated to facilitate CO_2 reduction (Liu et al., 2021), the simulation of environmental (Scurati, 2021) and humanitarian risks (International Committee of the Red Cross, 2024).

The use of VR technology in the case of the Jordan coral reef provides an innovative tool for the ecological promotion of sustainable development. Digital simulations not only motivate conservation but also offer a modern alternative to traditional tourism by reducing the physical impact on fragile ecosystems. This approach promotes global environmental awareness while protecting the fragile natural resources of coral reefs.

"The problem of negative environmental impact, on the other hand, stems from the fact that the most attractive areas for tourism are also the most valuable in terms of nature (Kurek, 2013)." The use of virtual reality helps to better understand the importance of coral reefs and the threats they face. Table 2 shows the main applications of VR in coral reef conservation.

Table 2: VR technology has potential for coral reef conservation. Source: Author's work

Application of VR Technology	Explanation
Ecological education for tourists	VR enables virtual diving, educating tourists about reefs without physical visits.
Simulation of reef threats	VR illustrates the impact of pollution and overfishing, raising awareness of human actions.
Virtual tours of protected areas	Allows tourists to explore protected reefs virtually, reducing direct environmental impact.
Training for divers and researchers	Enables controlled practice, reducing accidental reef damage during real dives.
Monitoring reef health	VR visualizes reef changes in real time, aiding in faster response to threats.
Promoting reef conservation	Creates emotional connections with reefs, encouraging sustainable practices.

2.1.4 Research methodology

This study presents the methodological framework, which integrates both qualitative and quantitative approaches (Table 3).

Table 3: Methodology Overview.Source: Author's work

Element	Description
Research approach	**Mixed-methods approach**: combination of qualitative and quantitative techniques for a holistic analysis of attitudes toward environmental protection.
Study objectives	1. **Assess the impact of VR** experiences on participants' environmental awareness. 2. **Investigate changes** in attitudes toward responsible tourism.
Research group	527 participants from diverse demographic backgrounds, with no prior experience using VR for tourism-related purpose.
Study stages	1. **Immersive Virtual Tour**: Participants experienced a 360° VR tour of Jordan's Coral Reef, guided by an expert. 2. **Post-experience Evaluation**: Surveys and in-depth interviews were conducted to assess emotional, cognitive, and behavioural responses.
Data collection methods	1. **Surveys**: Pre- and post-experience questionnaires assessing participants' perceptions of VR, environmental awareness, and willingness to engage in sustainable tourism. 2. **In-depth Interviews**: Qualitative insights were gathered to explore emotional and reflective responses.
Data analysis techniques	1. **Quantitative Analysis**: Descriptive statistics, correlation analysis, regression models and Chi-square test applied to survey responses. 2. **Qualitative Analysis**: Thematic coding of interview data using Braun & Clarke's framework.
Triangulation of methods	Combination of **survey results, interview data, and statistical analyses** to enhance validity and reliability of findings.
Additional techniques	**Focus Group Discussions (FGI):** Conducted to capture group perspectives and shared opinions on VR's effectiveness in promoting responsible tourism.
Educational purpose of VR	VR was used as a **pedagogical tool** to enhance understanding of **coral reef conservation**, **ecological threats**, and the **role of responsible tourism**.
Study Limitations	1. Potential participant bias. 2. Limited budget and time constraints. 3. Challenges in ensuring a representative sample.
Mitigation strategies	1. Use of a **diverse participant sample**. 2. Implementation of **online surveys** to reach a broader audience. 3. Randomized or purposive sampling methods.
Survey results application	Findings contribute to understanding **VR's effectiveness as an educational tool** for **eco-tourism** and provide **recommendations for tourism industry stakeholders**.

It evaluates the impact of virtual reality (VR) experiences on participants' attitudes toward environmental protection and responsible tourism. The study involved an immersive 360° virtual tour of the Red Sea Coral Reef in Jordan, followed by pre- and post-experience surveys and in-depth interviews. The data analysis utilized statistical methods for quantitative results and thematic analysis Braun & Clarke, (2006) for qualitative responses. This mixed-methods approach allowed for a comprehensive examination of changes in environmental awareness and responsible tourism behavior among participants.

1.2 Case Study: The Unique Ecosystem in the Gulf of Aqaba, Jordan

As documented by UNESCO (2024), the Aqaba Marine Park (AMP) was established in 1977. The coral reefs located at the northern end of the Red Sea represent one of the most valuable marine ecosystems in Jordan. They play a pivotal role in the regional biodiversity. The high-water clarity and stable temperature facilitate the growth of climate-tolerant corals. The reef is home to more than 200 species of coral and approximately 1,200 species of fish, including a considerable number of endemic species. In addition to its invaluable ecological value, the reef provides a vital shoreline protection service. Furthermore, local communities derive income from tourism and fishing. As emphasised by Kleinhause et al. (2022), there is an urgent need for regional collaboration in marine coral research and conservation.

The sinking of artificial reefs serves to reinforce the importance of AMR. As stated by Jordan Travel (2024), the sinking of artificial reefs serves as an effective method for the protection of coral reefs in the Red Sea. The wreck of the Lockheed C-130 Hercules aircraft is situated at a depth of between 15 and 30 metres, while the M42 Duster tank is located at a depth of between 5 and 7 metres. The vessels (Figure 2) serve as habitats for marine fauna or as points of interest for visitors (Jordanian Royal Marine Conservation Society, 2020; ASEZA, 2022).

Figure 2: Lockheed C-130 Hercules aircraft wreck and M42 Duster tank. Photos from virtual tour. Autor`s work

Tourism has been identified as a contributor to problematic issues. Diving, pollution and boat anchoring are damaging coral reefs. VR could be the solution. A reef ecosystem can be experienced without harming it. The case study used VR to show the beauty of the reef in video 360. The study allowed participants to experience the reef, Aqaba Marine Park (AMP), while learning about the threat of mass tourism. This was made possible by educational components and a real-time guide. It prompts consideration of the need for environmental protection, making virtual reality a potential tool for promoting sustainable tourism development.

3. Results

Table 4: Key Statistical Indicators. Autor`s work

Indicator	Description
Descriptive Statistics	Mean, median, and standard deviation were calculated for key variables. The mean scores were immersion **7.8/10**, realism **7.6/10**, and educational value **8.1/10**.
Correlation Analysis	Pearson correlation analysis revealed strong positive correlations: immersion & realism **($r = 0.72$, $p < 0.001$)**, realism & educational value **($r = 0.68$, $p < 0.001$)**, and immersion & educational value **($r = 0.74$, $p < 0.001$)**. These findings suggest that higher immersion and realism ratings are linked to greater perceived educational value.
Chi-Square Test for Independence	Examined the relationship between perceived environmental emotions and increased awareness. The test was significant **($x^2 = 18.5$, $p < 0.01$)**, indicating a strong association between emotional involvement and heightened awareness.
Regression Analysis	A linear regression model predicted consideration of sustainable tourism based on immersion, realism, and educational value. The model was significant **($F = 24.3$, $p < 0.001$)**, with **educational value as the strongest predictor ($\beta = 0.41$, $p < 0.001$)**.

3.1 Educational Value Distribution

The objective of this study is to assess the participants' perceptions of the virtual reality (VR) experience in terms of three key factors: immersion, realism and educational value.

1. Educational value: The responses were predominantly in the "High" (39%) and "Medium" (32%) categories, while the "Very High" (19.0%) category also demonstrated a notable presence. The responses classified as "Low" (8%) and "Very Low" (2%) were relatively infrequent (Table 4).

2. Immersion: Many participants rated the level of immersion as either "high" (39%), "medium" (23%), or "very high" (21%). A smaller proportion indicated that the level of immersion was low (12%) or very low (5%) (Table, 5)

2. Realism: Most participants rated realism as either "High" (40%) or "Medium" (29%), with a smaller proportion indicating "Very High" (20%). "Low" (7%) and "Very Low" (4%) ratings were rare (Table, 5).

The high ratings of immersion and realism influenced the perception of VR's educational value. The results confirm that VR is an effective tool to support environmental education and awareness building.

Table 5: Educational Value Distribution. Source: Autor`s work

Variable	n (%)
Very high	100 (19)
Medium	169 (32)
High	206 (39)
Very low	11(2)
Low	42 (8)

Table 6: Immersion Rating Distribution and Realism Rating Distribution. Source: Autor`s work

Variable	Immersion n (%)	Realism n (%)
Very high	111(21)	105 (20)
Medium	121(23)	153 (29)
High	206 (39)	211(40)
Very low	63 (12)	21(4)
Low	26 (5)	37(7)

3.2 Increased Awareness Distribution

Assessing emotional engagement and increased environmental awareness through the VR experience. **1 Awareness has increased**. A similar pattern of responses was seen: 41% "rather yes", 28% "definitely yes". The neutral response was as follows: 19% said yes, 8% said no and 4% said not. The VR experience engaged participants emotionally and raised awareness of environmental issues (Table 6).

2. Emotional Reactions: Most participants reported positive emotional responses, with 40% indicating a "Rather yes" and 23% a "Definitely yes" response. Neutral responses, including "Difficult to say," accounted for 21%, while «Rather not"(11%) and "Definitely not"(5%) were infrequent (Table 6).

Table 7: Increased Awareness and Emotional Reactions (Environmental distribution). Source: Autor`s work

Variable	Increased Awareness n (%)	Emotional Reactions n (%)
Somewhat Agree	216 (41)	211(40)
Strongly Agree	148 (28)	121(23)
Neutral Response	100 (19)	111(21)
Somewhat Disagree	42(8)	58(11)
Strongly Disagree	21(4)	26(5)

3.3 Sustainable Tourism Consideration and VR as an Alternative to Physical Travel

Table 8: Sustainable Tourism Consideration and VR as an Alternative to Physical Travel. Source: Autor`s work

Variable	Sustainable Tourism Consideration n (%)	VR as an Alternative to Physical Travel n (%)
Somewhat Agree	227 (43)	232 (44)
Strongly Agree	158 (30)	153(229)
Neutral Response	79 (15)	79(15)
Somewhat Disagree	42 (8)	42(8)
Strongly Disagree	21(4)	21(4)

This study examines how virtual reality (VR) affects support for sustainable tourism and perceptions of VR as an alternative to physical travel.

1.Regarding sustainable tourism, the majority (43%) of respondents indicated support, while 30% expressed a definite support. Additionally, 15% of respondents were undecided, while only 8% and 4% indicated opposition. These findings are illustrated in Table, 7.

2. VR is the preferred alternative, with 44% saying 'Rather yes and 29% saying 'Definitely yes'. The neutral responses accounted for 15%, while 'Rather not' (8%) and 'Definitely not' (4%) were less common. The VR experience resulted in participants supporting sustainable tourism and considering VR as a viable alternative to physical travel (Table, 7).

4. Discussion

The study provides a detailed overview of the groundbreaking potential of virtual reality (VR) as an effective tool for the development of sustainable tourism. The findings indicated that participants formed powerful emotional associations with the issues presented in the virtual reality environment. Furthermore, respondents indicated an enhanced awareness of environmentally conscious practices. The educational benefits of immersive realism were highly valued. This serves to validate its capacity to positively influence attitudes towards environmental conservation, including those pertaining to coral reefs. It is also noteworthy that the use of VR does not result in any physical impact on the sites in question. Furthermore, it fosters a sense of responsibility and encourages sustainable tourist behaviour.

4.1 Challenges and Potential Limits of Virtual Reality

VR technology offers many advantages for sustainable tourism, though it also presents challenges.

1.Technological constraints: The creation of high-quality VR experiences necessitates the utilisation of sophisticated hardware and software, which often comes at a considerable financial expense.

2. Financial constraints: The creation of realistic and interactive VR content for selected ecosystems necessitates a substantial financial, operational and logistical investment.

3. User accessibility: There is a paucity of access to VR technology in many regions. This has an impact on the global adaptability of the technology.

4.2 Tourism Industry and Policy Implications

1.Industry applications: Tourism organizations should implement VR to increase tourist interest and reduce environmental impact.

2.Policy recommendations: Policy makers should promote VR in tourism strategies, especially in sensitive areas, and support small operators implementing the technology.

3.Educational campaigns: VR can increase the effectiveness of environmental campaigns by educating travellers about environmentally friendly behaviour and heritage preservation.

By using VR, the tourism sector can promote sustainable development and conservation of natural and cultural resources for future generations.

5. Conclusion

The findings of this study indicate that virtual reality has the potential to revolutionise the way in which sustainable tourism is promoted. The ability of VR to offer immersive and emotionally engaging experiences has the potential to educate participants about environmental issues in a way that influences their attitudes towards adopting responsible tourism practices. The results of the research demonstrate that the use of VR can effectively minimise the physical impact of tourism on vulnerable ecosystems such as coral reefs, while promoting higher levels of awareness and behavioural changes that support sustainability. These findings highlight the potential of VR as a key tool for the tourism industry in navigating the challenges posed by mass tourism. Despite the promising results, this research acknowledges several limitations. The accessibility and cost of VR technology remain substantial barriers, particularly in underdeveloped regions. Furthermore, while the study effectively examined the emotional impact and attitudes, further investigation is necessary to ascertain the long-term impact of VR experiences on actual behaviour. Future research could examine the scalability of VR solutions, the integration of advanced interactivity, and the development of VR content tailored to different cultural and environmental contexts.

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