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Transitioning from onsite to virtual tourism using metaverse: An EcoTech framework for sustainable tourism development

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Abstract: This study investigates how Virtual Reality (VR) tourism can help combat environmental degradation in Pakistan, including its potential to promote socio-economic growth in the country. Given the ever-increasing concerns governing the ecological degradation posed by physical tourism in a global landscape, VR tourism offers a sustainable alternative with much lesser impact on the environment and natural resources than on-site tourism. This study thus offers a conceptually-driven yet theoretically-supported and literature-backed EcoTech framework that integrates the external & internal factors affecting the adoption and effectiveness of virtual tourism activities & initiatives. To this end, the influence of external factors such as environmental concerns, environmental responsibility, pro-environmental behavior, eco-guilt and ecological impact on travel was theoretically evaluated to understand the individuals' attitudes toward embracing virtual tourism. Moreover, the influence of age, gender, income, educational background and household size of the individuals were also considered as key control factors that could potentially affect their visit intentions from socio-economic & demographic viewpoints. Accordingly, this study advocates 'Willingness-to-Forgo-Pleasure-of-In-situ-Tourism' as a key enabler for promoting eco-friendly tourism and environmental sustainability as a whole. By and large, the suggested EcoTech framework offers some policy insights and guiding mechanisms for tourism industry stakeholders such as tour operators, government tourism departments including the eco-conscious travellers & tourists looking for cost-effective, environment-friendly and resource-efficient alternatives to on-site tourism.

Keywords: perceived ease of use, perceived usefulness, technological innovativeness, telepresence, behavioral intention, attitude, personal norms, willingness to sacrifice, willingness to forgo pleasure of in-situ tourism, environmental concerns, eco-guilt, pro-environmental behavior, EcoTech tourism

1. Introduction

The role of tourism has always been instrumental in promoting employment and cross-cultural exchange, including the socio-economic growth of an economy [1,2]. Nevertheless, the tourism industry in Pakistan is still in its primitive form, relying on the conventional resource-intensive means of tourism and recreation [3]. As such, the country's potential to embrace contemporary trends in tourism with an aim to strengthen its socio-economic conditions while contributing to the environment at the same time remains untapped [1]. The tourism industry of Pakistan has long been facing issues such as inadequate infrastructure [4], security concerns [5], and the competitive nature of nearby destinations [6]. To meet these challenges and harness the potential of its indigenous tourism landscape, Pakistan must embrace technological advances if

its tourism industry is to leap toward economically viable and environmentally sustainable means of tourism [1,7]. Some of these technologies, such as Web 3.0, the Metaverse, and VR, serve as the game changers in creating immersive and innovative experiences that can attract local and foreign visitors alike [8].

The next evolution of the Internet and Web 3.0 involves a move toward decentralization, data ownership and the power of user, which will result in better, more interactive and fun-filled experiences for tourism [9]. By leveraging Web 3.0, users can interact digitally in a myriad of ways and experience a virtual world where travelers can visualize destinations, participate in communities, and work collectively to generate authentic user-generated narratives [10]. These personalized digital spaces pave the way for new innovations in the tourism industry of Pakistan [11]. Web 3.0 also aids tourism authorities and travel operators in gathering tourist information to better evaluate their experiences and accordingly review their offerings [12].

The Metaverse, a virtual environment that facilitates users to interact and explore 3D spaces, enriches Web 3.0, simulating future real-world tourism experiences [13,14]. The Metaverse can be used as a powerful marketing tool for Pakistan's tourism sector by helping to act as a preview of places like Hunza Valley, Mohenjo-Daro, and many other places [15]. Moreover, this technique draws possible tourists and offers people a secure and accessible opportunity to go to that country's destinations before committing to do so [16]. The Metaverse can solve infrastructure inflexibility in remote areas by creating a digital representation of the location that can be explored globally regardless of poor infrastructural location [17,18].

The impact of the Metaverse is magnified when it is experienced with virtual reality, an immersive, sensory-rich experience whereby users can explore destinations in a life-like experience [19]. Tourists with VR can virtually travel to Pakistan's destinations and participate in local festivals in the mountainous landscapes. They can visit the historic sites of Pakistan from their own homes [20]. VR technology can entice a tech-savvy crowd, stimulate interest in Pakistan's attractions among people who have never visited and assist in understanding Pakistani heritage among people who may have never been able to see [21]. Furthermore, VR can be used in local tourism strategies, and VR booths at international tourism fairs allow visitors to get an instant and immersive experience [22]. Adopting the Metaverse and virtual reality is where Pakistan's tourism industry can and must evolve and remain competitive in regional and global markets. If Pakistan were to adopt these technologies, it would not only overcome traditional barriers to tourism but also attract a new type of digital native tourist who can experience geography by creating such experiences and welcoming the world to explore the country's natural beauty and culture. As the travel industry changes rapidly, these technologies will allow Pakistan to be among the new countries in the tourism industry, thereby becoming a critical driving factor for its sustainable growth.

In the Pakistani market, incorporating technology into the tourism industry is considered a secondary priority, as environmental issues take precedence [23]. The use of tourism technology is still unexplored in Pakistan, which results in many significant challenges. Ecological sustainability has led organizations and stakeholders to work on these concerns [24]. Moreover, the rise in inflation has substantially reduced the discretionary income of domestic travellers, discouraged

recreational trips, and impeded the expansion and progress of the tourism sector [25]. Furthermore, societal norms and gender inequalities pose women with multiple obstacles, including travelling independently, as society does not allow them to do so [26]. These cultural restrictions further hamper the full utilization of Pakistan's tourism potential by preventing a considerable portion of the population from engaging in leisure travel [27]. Environmental concerns, economic difficulties, and cultural factors can promote sustainability, generating inclusiveness in Pakistan's tourism industry.

Considering the above gaps, the study proposes an EcoTech Tourism Framework based on an extensive review of literature and the underlying theoretical framework. The proposed framework has several theoretical, practical, and policy implications for various tourism industry stakeholders of Pakistan including other developing economies that are subject to similar socio-economic, political, and environmental conditions. Finally, the framework opens up new avenues for future empirical research, particularly in the context of VR tourism for emerging economies like Pakistan.

2. Literature background and review

2.1. Evolution of tourism

Although the concept of tourism has deep roots, there are thousands of studies regarding its history. Even though it is understood that the word "tourism" is the later adoption of the concepts of travel and journey, past studies have tailored that travel was only limited to specific purposes, but later on, the idea of tourism advanced with the creation of multiple modes of transportation [28]. The concept of leisure in tourism originated in the 16th century. Still, at that time, the understanding of leisure was quite different, and it was only restricted to wealthy and noble professionals (as affordability was not for everyone) [29]. By the 19th century, steamships and railways made tourism more feasible and broadened the audience. Not only this, but significant mountaineering associations also formed in the 19th century, including the Alpine Club, Swiss Alpine club and many more [30].

This was the true reforming advancement in the tourism industry. Bookings for such trips and vacations were restricted to paper print ads, physical offices, and newspapers. The accessibility is inconvenient, as digital media and the internet have yet to emerge. Later, in the late 20th century, television ads came into the competition, and this was the first digital reform in tourism [31]. This era brought more changes in travel practices, including adapting cars to replace trains [32]. Later, airways also entered and expanded the tourism industry [33].

2.2. Technology in tourism

Looking back in history, travel was primarily driven by the desire to explore unfamiliar places and learn about unique cultures [34]. Transportation and subsequent travel were initially difficult and extremely limited. However, with the advancement of transportation, people have started travelling for different reasons. Some went to

work; others ventured to new places and new people. Gradually, that motivation for travel altered, and more facilities and infrastructure were made available to make travel easier [35]. Recently, as technology-based solutions have emerged, tourism has become an experience beyond physical travel [36]. Digital innovations in tourism today make it possible for people to explore and interact with destinations in ways that jump beyond the established boundaries, raising the ball game for the industry [37].

Online Travel Agencies (OTAs) have made booking travel more user-friendly than ever with just a few clicks or taps from booking a flight, train ticket, or bus pass [38]. This further convenience is also brought about by integrating artificial intelligence (AI) more and more being involved in travel planning. Now, AI-powered applications create streamlined itineraries, offering tailored recommendations customized to travelers' preferences [39,40]. In addition, the travel video loggers' career has existed to provide aspirant travelers with an experiential review of what to expect just before they visit [41]. Together, these technological advancements have disrupted tourism, making it more organized and accessible, with new ways for people to engage with travel and destinations in the digital period [42].

Nevertheless, the transformation of the tourism industry goes far beyond these developments, as the tourism industry is changing very rapidly in unprecedented ways [43]. Tourism is now stepping into such phases as the industry stakeholders are looking for smart tourism where digital tools backed by Artificial Intelligence (AI) and Virtual Reality (VR) bring in a creative content that is immersive and interactive [44]. Also, promoting sustainability at the forefront of many developments has increased, and it is aligned with sustainable development goals for 2030, attracting responsible and ecological tourism [45]. Furthermore, the industry is also continuously advancing into novel concepts like Web 3.0 [46] and the Metaverse [47], and these concepts have promising opportunities for the industry to develop frameworks for interactions that may change the face of tourism as never before [45]. With Web 3.0 introducing decentralized, user-driven content and the Metaverse giving users completely immersive digital landscapes, people can not only experience places but also interact with the culture of those places in ways we have imagined [48]. This convergence of technology and sustainable goals positions the tourism industry to elevate visitor experiences and drive long-term growth and sustainability by building a world of digitally empowered travellers who are conscious of both the destination and the on-ground interaction [49].

2.3. Advent of smart and sustainable tourism

The advent of the Internet in the late 90s and early 2000s transformed the tourism industry, marking the most significant dynamics of the century industry [50]. The emergence of enhanced connectivity, streamlined services, and different social network applications has made travelers engage with other destinations [51]. A transformative change has occurred with the introduction of smart devices such as Virtual Reality Glasses, 3D Simulations, etc. It marks next-level immersive experiences for travelers [52]. To set a new standard of experiential tourism, these technologies have enabled travelers to engage with destinations in unprecedented ways, which enhances the pre-travel plans for travelers [53]. Different tools and

advanced applications significantly enhance sustainability as they allow the management of data in a better way, reduce environmental impacts, and allow visitors to visit eco-friendly practices [54].

It also creates new opportunities for industry stakeholders to work in a sustainable environment [55]. Many business concepts have been generated during this tenure, including Booking.com, Oyo rooms and Airbnb, which have enriched the industry's revenue [56]. These services allow travelers to plan and book their trip with a single click. Services like Uber, Livo, and Careem also added value to the industry by showcasing online and user-friendly bookings [57]. In the second decade of the 21st century, artificial intelligence (AI) has also been incorporated into the tourism industry [58]. The AI-powered applications, chatbots, virtual assistances, and applications of AR/VR provide a better understanding of trips and travel preferences [59,60]. The Internet of Things (IoT) allows tourists to access smart cities, the availability of transport services, the update of weather and much more [61]. Not only this, but it also helps travelers to pre-plan their trips as per their desirable needs. Ultimately, bright tourism balances both the tourism industry and the sustainable future of places.

2.4. Metaverse: The future of tourism

Technological advancements have always played a revolutionary role in each industry as these innovations focus more on sustainability [62]. Similar to other sectors, the role of technology in tourism always helps to generate new business ideas and models, also helps to sustain an eco-friendly environment [63], and modernizes the services offered in the tourism industry [45]. The technology of the Metaverse is beyond imagination, as it promises immersive experiences without any physical presence [17,64]. As described in **Figure 1** [65] and **Figure 2** [66] Generating a digital environment helps tourists enjoy hybrid experiences closer to reality, allowing the travelers to experience without any economic, physical, or social limitations [67,68].



Figure 1. Exploring the Metaverse [65].



Figure 2. Tourism and Metaverse [66].

It is essential to understand the importance of VR before looking into the details of a conceptual model. During the pandemic, the overall tourism industry collapsed in 2021, which was recorded as the worst year for the tourism industry [69]. This year highlighted the impact and noticed that extreme changes should be followed to ensure long-term sustainability. Later, the stakeholders identified the importance of new realities, and a few events took place during the pandemic, which realized the significance of the virtual tourism industry. Many online concerts during lockdown recorded exemplary revenue. The concerts arranged by LAHIFF sold 1.33 million online tickets and generated revenue of \$71 million [70]. Furthermore, the Metaverse's trend has seen more popularity during the lockdown in 2021, as shown by Google Trends (Figure 3).

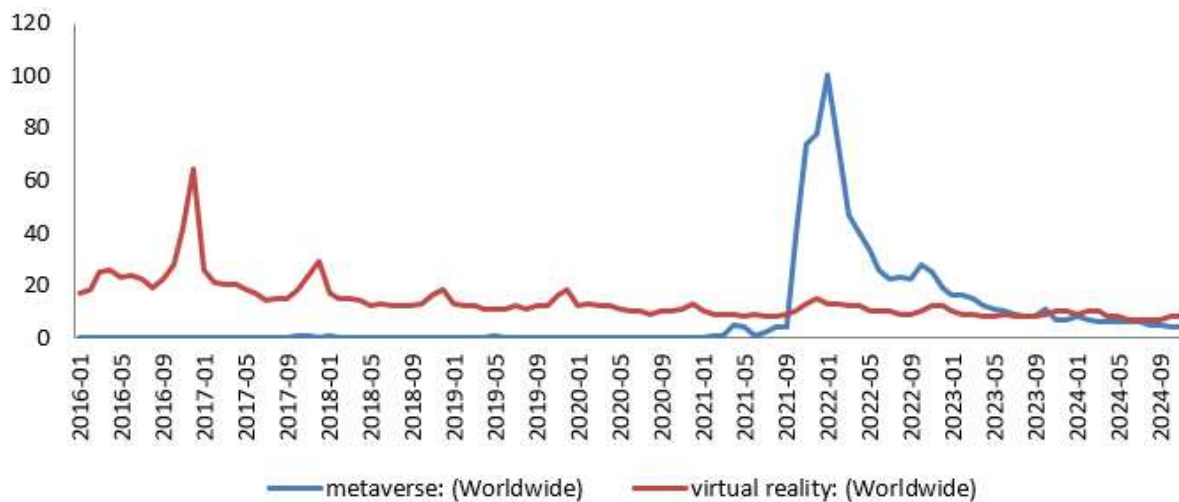


Figure 3. Google trends of metaverse and virtual reality worldwide.

Besides this, if we look into the terms “metaverse tourism” and “virtual tourism”, the statistics are quite different, indicating that the term “metaverse” tourism still needs more exploration (Figure 4).

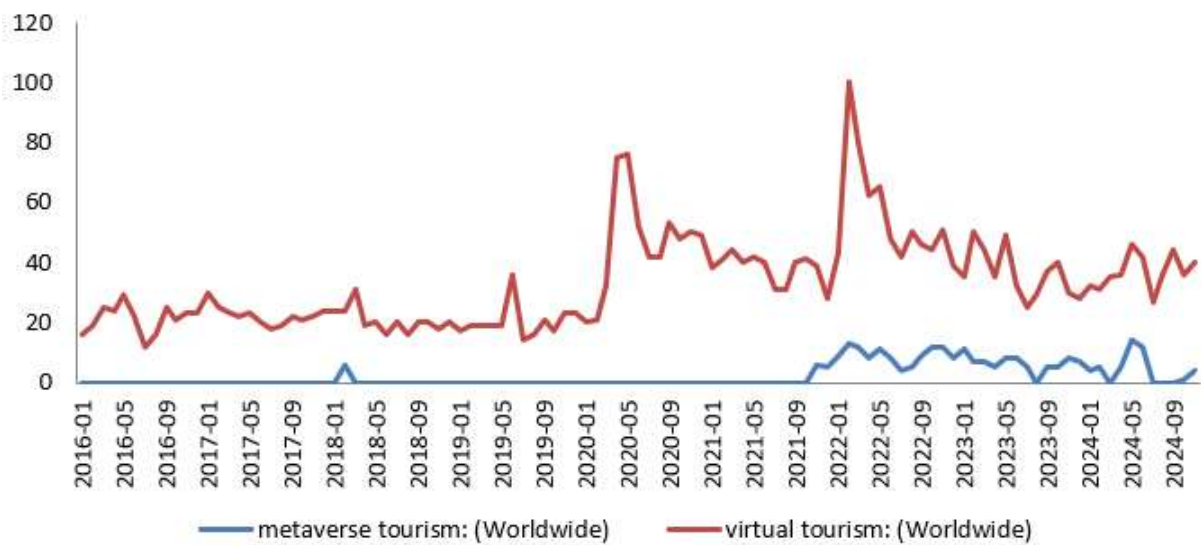


Figure 4. Google trends of metaverse tourism and virtual tourism.

3. The underlying guiding theoretical framework

This conceptual paper is grounded on two established theories: the S-O-R model and the TAM. The SOR model is based on the relationship between external stimuli and subsequent responses and breaks it into organism levels (i.e., internal cognitive and emotional processes) and organism behavior levels for understanding the relationship between external technological factors (i.e., VR metaverse and consumer behavior). However, in the tourism context, the factors that influence acceptance of these technologies are explained by the TAM, which identifies the factors explaining acceptance of technology. Combining these frameworks offers a comprehensive analysis of the external stimuli (technological advancements) and their impact on psychological and emotional states (organism) of consumers (modes of being) and further on behavioral responses (e.g., engagement, willingness etc., to participate in virtual tourism).

To understand the limitations of environmental consciousness and technological advancements, the dual-process approach of SOR and TAM is applied, which may influence pro-environmental tourism choices for travelers. This research enhances theoretical understanding by combining the Stimulus-Organism-Response (SOR) framework and the Technology Acceptance Model (TAM) to provide a comprehensive, two-pronged explanation for sustainable behaviour within metaverse tourism. Specifically, TAM elucidates rational, technology-driven assessments like perceived usefulness, while SOR accounts for the influence of emotional and sensory elements such as telepresence and eco-guilt. This integrated perspective offers a novel explanation of how immersive technologies provide information that influences behaviour and fosters emotional engagement, thereby motivating users to make environmentally responsible tourism decisions—a subtle dynamic missed by TAM or SOR when considered individually. The TAM and SOR models have been widely used in a range of previous tourism studies, including Zhang et al. [71] and Huang et al. [72], which offer a powerful lens to capture the ‘affective’ and ‘cognitive’ enablers towards adopting VR tourism. The proposed model is based on technology adoption,

and this aspect is supported by TAM, whereas the cognitive aspect is supported by the SOR model. These two models holistically guide us in proposing the EcoTech framework.

3.1. S-O-R Model

To examine how external stimuli (S) influence internal states (O), which lead to specific behavioral responses (R), researchers adopt the Stimulus–Organism–Response (SOR) framework proposed by Mehrabian and Russell in the year 1974, which is a robust theoretical lens [73]. This model is integrated into the EcoTech Tourism Framework to examine the entanglement between peers (Technology), peoples (Human Cognition), and planets (Environmental Sustainability) in influencing tourism behaviors. Technological and environmental factors trigger the stimulus phase of this model and evoke cognitive and emotional responses. Technological Innovativeness [74], Telepresence [75], Elaboration of Mental Imagery [76], Perceived Ease of Use [77], and Perceived Usefulness [78] are key stimuli. The organism phase is equivalent to internal psychological states produced by stimuli [79]. The stimuli are mediated by constructs such as attitudes [80] and personal norms. For example, telepresence leverages the power of immersion to cultivate a positive attitude toward eco-conscious travel, while personal norms enhance the moral and emotional cash flow of travel decisions. These are actionable behaviors during the response phase, such as behavioral intention and the willingness to sacrifice traditional tourism. In response, tourists value virtual options concertedly with their environmental values, decreasing tourists' ecological footprints without diminishing experiential satisfaction [81].

3.2. Technology Acceptance Model (TAM)

The TAM, proposed by Davis (1989), is a well-accepted theoretical framework to explain how an individual adopts and uses a new technology [3]. TAM focuses on two key determinants of technology acceptance: two variables were used, namely Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) [82,83]. In the case of the EcoTech Tourism Framework, TAM is beneficial as these key factors help explain why users accept or reject a technology. TAM is integrated within the EcoTech Tourism Framework and the SOR framework to explain how tourists use virtual and sustainable tourism technologies. On the other hand, PEOU, PU, telepresence, and technological innovativeness impact cognition and affect. Such stimuli trigger individual responses, which are mediated through factors such as attitude and behavioral intention. Many tourists will resort to eco-friendly virtual tourism to replace traditional travel [84].

4. Methodology

This study suggests a conceptual EcoTech Tourism Framework that assists in understanding the factors affecting VR tourism adoption in Pakistan. Being a conceptual study, the methodology relies on a structured theoretical approach involving a comprehensive literature review & synthesis for the careful identification and subsequent selection of the relevant factors in the context of the tourism landscape

of Pakistan [85]. As previously discussed, the framework was further guided and supported by the underlying theories such as SOR and TAM to ensure the logical connectivity of the specific psychological and technological factors in addition to the potential influence of some socio-economic control factors that collectively promote the acceptance of VR tourism in Pakistan.

4.1. Literature review & synthesis: Identification of key factors for the conceptual framework

As mentioned earlier, an extensive literature review was conducted using Scopus and Web of Science databases. The review focused on the following key areas:

- Technology Adoption Models (e.g., TAM)
- Behavioral and Emotional Theories (e.g., SOR)
- VR and Metaverse Tourism
- Sustainable and Ethical Tourism
- Pakistan-specific Travel Behavior and Barriers

Search terms included a combination of “virtual reality tourism,” “SOR model,” “TAM,” “eco-guilt,” “telepresence,” “metaverse,” “Pakistan tourism,” “gender mobility,” “digital divide,” and “sustainable travel behavior.” Approximately 80 peer-reviewed journal articles were analyzed, and initial factors were extracted. Priority was given to the factors that were:

- Previously validated in a tourism or technology context.
- Able to demonstrate conceptual relevance to VR-enabled experiences.
- Aligned with environmental sustainability and technological innovativeness in the socio-cultural and economic context of Pakistan.

4.2. Mapping and alignment of the key factors with the underlying theories

The selected factors were then classified according to the SOR model:

- Stimulus (S): External factors influencing internal states (e.g., telepresence, environmental concern).
- Organism (O): Affective and cognitive mediators (e.g., eco-guilt, personal norms, perceived usefulness).
- Response (R): Behavioral outcomes (e.g., willingness to adopt VR tourism and sacrifice traditional travel).

Simultaneously, TAM factors (constructs) such as perceived usefulness, perceived ease of use, and behavioral intention were mapped onto the Organism and Response components of the SOR model. This integration enabled the framework to combine technological cognition and emotional response mechanisms. An iterative mapping process was followed to streamline the model and ensure conceptual coherence. The factors with similar functions (e.g., “attitude toward use” and “personal norms”) were consolidated while preserving their theoretical nuances.

4.3. Factor inclusion & exclusion criteria

Three criteria guided the selection of the key factors:

- Theoretical relevance to immersive tourism behavior.

- Empirical robustness, favoring variables with prior validation in published tourism or technology adoption research.
- Contextual fit, ensuring the ability to reflect Pakistan's unique socio-cultural and infrastructural factors.

For example:

- Telepresence was included as a core stimulus due to its vital role in VR experience design and emotional immersion.
- Eco-guilt was included as an effective mediator relevant to climate-conscious travel behavior.
- Household size was selected as a control variable for its influence on collective travel decisions in Pakistani families.

4.4. Contextualization of the chosen factors for Pakistan

Pakistan-related moderators and control variables were included to enhance the model's relevance to the context. These include:

- Gender-based mobility restrictions (control factor) reflect cultural constraints on female travel.
- Infrastructure readiness to represent the digital divide between urban and rural areas in terms of broadband and VR accessibility.
- Cultural values and collective norms influence the formation of personal norms within a collectivist society.

These contextual dimensions influence or moderate relationships within the framework, particularly those involving perceived usefulness, eco-guilt, and willingness to sacrifice.

5. Proposed EcoTech Tourism Framework

This proposed EcoTech Tourism Framework, as shown in **Figure 5** provides a structured approach to understanding how individuals can be motivated to adopt technology-driven alternatives to traditional and environmentally harmful tourism activities. The proposed framework integrates environmental consciousness with technological acceptance to achieve sustainable tourism. Environmental consciousness, perceived ease of use, perceived usefulness and emotional responses to technology contribute to technology acceptance and shape tourist behavior.

Given the increased environmental challenges caused by the climate change and rapid depletion of natural resources, the tourism industry is under significant pressure to reduce its ecological footprint. By integrating the S-O-R and TAM as guiding theories, the framework highlights how environmental factors such as eco-guilt, ecological concern, and moral obligation can be aroused to make people change their behavior and embrace sustainable tourism. In this regard, technology plays an enabling role through perceived ease of use, perceived usefulness and telepresence in providing a platform for virtual tourism that allows people to experience authentic travel virtually through all their five senses and emotional feelings. The framework also emphasizes how behavioral intention bridges technology adoption and sustainable tourism behaviors. In this case, innovative tools, including VR can involve exposure to destinations without travel behaviors harming the planet through carbon emissions

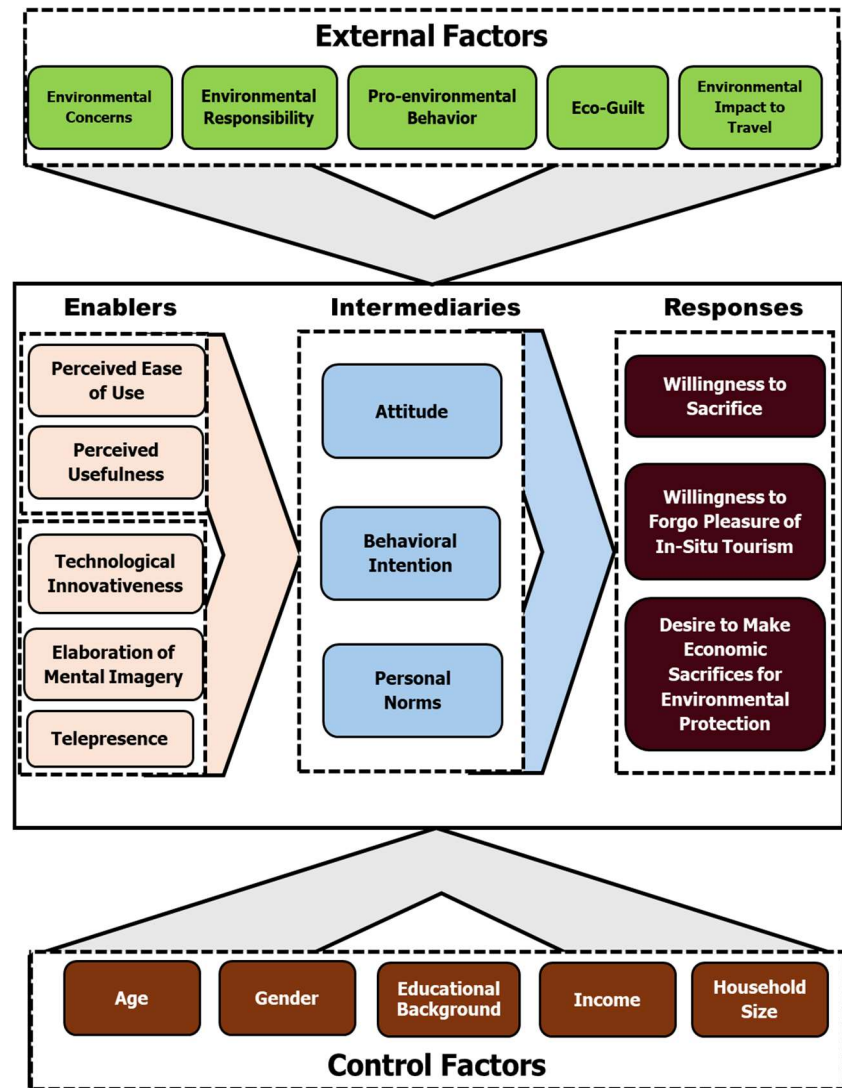


Figure 5. EcoTech Tourism Framework.

or damaging fragile ecosystems. Personal norms are shaped by the influence of environmental responsibility and moral obligation to motivate people to relinquish the Pleasure-of-In-situ-tourism and replace it with a more eco-conscious alternative.

Control factors such as age, income, and household size affect how people respond to this model's stimuli, making it versatile across different demographic contexts. Ultimately, the EcoTech Tourism Framework represents one in which technology is a potent lever to balance human desires to explore against the urgent call for environmental sustainability. This shows a way forward for how policymakers, businesses, and consumers can adopt innovation while protecting the planet's health.

5.1. Components of EcoTech framework (enablers, intermediaries, control factors, external factors & responses)

5.1.1. Enablers

Perceived Ease of Use: It is a key component in TAM, referring to the use of technology or any tool associated with technology being efficiently used by an individual without any extraordinary effort. The instructions are clear: minimal

learning and intuitive interfaces [86]. Under the EcoTech Tourism Framework, the contribution of PEU determines whether an adaptation to technologies like virtual reality and the Metaverse can replace physical tourism. If each technological device or facility effortlessly works in the field, sustainability could become widespread shortly.

Perceived Usefulness: The ease of use is not only practical for sustainability; its importance, influence, fruitful outcomes, and problem-solving capabilities are also crucial. Perceived Usefulness refers to the degree to which people believe using a particular technology is beneficial and valuable in accomplishing specific goals [87]. Within the EcoTech Tourism Framework context, PU determines whether adopting technological devices or facilities can be a viable alternative to physical travel. For instance, using VR for tourism can replicate the sensory and emotional benefits of physical tourism. Additionally, VR or other technological devices can be cost-effective and environmentally sustainable.

Technological Innovativeness: Technological innovativeness refers to a person's openness to technological advancements and willingness to explore and adapt to new technologies in any field [88,89]. The EcoTech Tourism Framework signifies how people perceive and engage with technology in the tourism sector. TI explores technological ideas that could help travelers try and integrate facilities that may contribute to the industry's sustainable growth [90]. Physical tourism will remain the same, no matter how straightforward its usage or productive its outcomes might be, if individuals need to be more technologically innovative and curious about emerging technologies [91].

Elaboration of Mental Imagery: It is the cognitive process of creating, enhancing, and analyzing mental images based on the information one receives [92]. It involves using imagination to simulate experiences, allowing people to mentally visualize and "experience" situations without physically engaging in them. In smart tourism, EMI significantly shapes perceptions, intentions, and behaviors by enabling individuals to project themselves mentally into a virtual or immersive world [93].

Telepresence: The psychological state or perception where the person feels physically present in a remote or virtual environment is telepresence [75]. Immersiveness is a core concept in technology-mediated experiences, especially in the case of Virtual Reality (VR), Augmented Reality (AR), and other types of immersive platforms. Telepresence is the illusion of interaction with a place other than where you are, even when you are not there [94]. In Pakistan, telepresence transcends being merely a technological novelty; it serves as a vital means of accessibility and inclusion, particularly for women facing cultural limitations on their physical movement and for individuals in remote rural areas. By enabling virtual participation in social, religious, and environmental tourism, telepresence democratizes access to these experiences.

5.1.2. Intermediaries

Attitude: It refers to consumers perceiving the technology substitute in tourism, including virtual reality or augmented reality experiences [95]. It is perceived through a positive or negative lens regarding the value, benefit, and impact of technology usage in the tourism experience, particularly with the environmental and experiential elements [96].

Behavioral Intention: Behavioral Intention can be the individual's willingness or probability to act on a particular behavior, which in many cases will be the strongest predictor of the actual behavior [97]. This represents a degree of cognitive and affective readiness of individuals to engage with technological innovations for sustainable tourism, significantly influenced by environmental and technological factors [98]. In addition, those with strong behavioral intentions are more likely to replace physical travel with virtual experiences, leading to ecological degradation [99]. Behavioral Intention intermediates technological and environmental factors and sustainable tourism outcomes in the EcoTech Tourism Framework. Encouraging openness to eco-friendly, technologically driven tourism alternatives advances environmental goals and aligns people with low-impact travel.

Personal Norms: Personal norms are an internalized moral obligation to do things that benefit society or the environment, e.g., engage in virtual tourism rather than physical travel. Individual morals, knowledge of environmental issues, and empathy influence them [100]. In the EcoTech Tourism Framework, personal norms are one of the most critical internal motivations for manifesting sustainable behavior by visitors. In this regard, they foster technological solutions toward environment preservation rather than consuming immediate benefits of sports consumer behavior [101]. In Pakistan, religious beliefs, family traditions, and communal values significantly influence personal and moral standards. Counter to the individualistic tendencies seen in the Western societies, environmental responsibility in Pakistan is primarily motivated by religious doctrines about the natural world, Islamic ethical principles, and shared social norms.

5.1.3. External factors

Environmental Concerns: Environmental concerns are the extent of an individual's knowledge and fear of environmental degradation and its possible effects [102]. It's mostly with climate change, deforestation, pollution, and biodiversity loss in mind. People with strong ecological concerns about tourism worry they are damaging the environment [103]. Consequently, green behaviors like virtual tourism are encouraged, given the above concerns, to reduce environmental footprints [104].

Environmental Responsibility: Environmental responsibility recognizes and embraces the need to defend the natural environment from adverse human activity. This means that an individual, as a personal recognition of their action, reduces damage to ecosystems and lives sustainably [105]. Responsibility can be defined as responsible decision-making so the traveller can decide to support sustainable transportation choices, ecotourism initiatives, or conservation [106]. Individuals with a strong sense of responsibility towards the environment tend to seek technological alternatives to travelling based on virtual reality to honor their responsibility in protecting the environment [107].

Pro-Environmental Behavior: Pro-environmental behavior is pressure on society or ethics to behave in such a way as to be good to the environment. Such as the obligation because of laws, policies, or cultural norms favoring sustainable practices [108]. Concerning tourism, pro-environmental behavior can refer to eco-friendly practices such as reducing waste generated while travelling or by staying away from

over-touristic destinations [109]. Such behavior reflects individual and collective efforts to avoid individual and societal impacts of tourism on nature.

Eco-Guilt: Eco-guilt, or environmental guilt, is regret or shame of one's actions that negatively affect the environment, such as excessive air travel, using excess natural resources, or contributing to pollution [110]. This is a normal emotional reaction for environmentally aware individuals already aware of the harmful repercussions of their behaviors and still incapable of relinquishing certain enjoyments (such as traditional tourism) [111,112]. Eco-guilt can move people towards behavioral shifts towards virtual tourism or other Eco-friendly practices to relieve some of the perceived gain from ecological damage [113].

Environmental Impact of Travel: The environmental impact of travel refers to tourism's positive and negative environmental outcomes. These negative detrimental effects include the release of greenhouse gases, the exhaustion of natural resources, the production of waste, excessive tourism, and the ecological and societal pressures resulting from unsustainable travel methods. Besides this, the positive environmental impacts can generate revenue for wildlife. This situation underscores the critical necessity for more environmentally responsible travel alternatives [104].

5.1.4. Control factors

Age: Different age groups adopt quite different technology. Younger people are more technologically savvy than older folks and are more ready than they are to take on new technology and innovations [115]. In contrast, elderly individuals tend to accommodate the familiar tourism experiences because of the need to be acquainted with modern technology. However, suppose senior citizens are correctly introduced to technology. In that case, they will be willing to embrace virtual tourism due to a change in environmental awareness and difficulty accessing physically strenuous places [116].

Gender: Gender is important in the tourism industry concerning views, mindsets, and actions towards technological acceptance and eco-friendly practices. Although male and female utilizers of virtual tourism experiences may not exhibit differences in their willingness to undertake virtual tourism experiences, they might differ regarding concern over ecological issues and involvement in sustainable activities [117].

Income: An individual's financial status is an extremely great determinant of an individual's capability and readiness to participate in virtual tourism. Those with lower incomes may not be able to afford to visit many different locations and instead enjoy using cost-effective substitutes such as travel videos or vlogs [118]. In contrast, individuals with higher incomes may enjoy the best of both worlds by visiting destinations via both in-person and virtual experiences. For those with limited financial means, virtual options and virtual optional options may be because their ritual tourism services have the potential to offer inclusive solutions that cater to all income brackets [119].

Educational Background: Awareness and comprehension of both related technological advances and environmental challenges depend upon the level of education. Those with a higher education are more likely to know and be knowledgeable on environmental issues and be able to understand and put

technological solutions into practice [120]. Individuals with higher levels of education tend to be more aware of environmental issues and are better prepared to comprehend and implement technological solutions. Furthermore, a background in education enforces the relationship between having an idea of ecological problems and being willing to do what is needed for their solution [121].

Household Size: Travel preferences and receptiveness to virtual alternatives are strongly influenced by household composition. Virtual tourism options might appeal more to families with larger numbers since these will usually cost less, be more environmentally friendly, and be more convenient logistically. However, smaller households or individual travelers might favor traditional, physical sightseeing experiences since such travelers usually encounter fewer organizational challenges in initiating and conducting trips [122].

5.1.5. Responses

Willingness to Sacrifice: Achieving a greater goal or any benefits, including social, environmental, and economic benefits, if an individual is willing to sacrifice, is termed Willingness to Sacrifice (WTS) [123]. WTS has a greater cause in sustainability and works for the betterment of the environment to minimize the harm to the planet. It mainly focused on implementing three main SDGs, including sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12), and climate action (SDG 13). Understanding the WTS concept helps various industries design effective policies and awareness campaigns, including tourism [124]. Understanding the concept of WTS in the EcoTech Tourism Model focuses on travelers' moral and social responsibility to achieve long-term and sustainable goals. It can be achieved through tourists' behavioral intentions, personal norms, and attitudes towards travel.

Willingness to Forgo Pleasure of In-Situ Tourism: The willingness to forgo the pleasure of in-situ tourism pertains to the voluntary avoidance of physical travel to sensitive ecological and touristic areas [101]. This willingly neglects one's pleasure of taking part in in-person tourism, thus defending SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 14 (Life Below Water) [125]. This shift towards avoidance explains the popularity of virtual tourism. Shifting personal gratification pursuits toward ecological tourism preservation aids in long-term ecological guardianship. Individuals take on such a viewpoint out of concern for environmental degradation, carbon emissions, cultural preservation, and, most notably, the maintenance of local infrastructures strained by tourists. This suggests that more people are encouraged to adopt eco-friendly policies and change unsustainable travel behaviors, especially during these relaxed times [114]. Studies conducted in this area demonstrate various public values that can motivate changes in models for sustainable tourism and its associated conservation initiatives.

Desire to Make Economic Sacrifice: The intention to incur economic losses to protect the environment signifies the economic self-sacrifice an individual makes by paying higher prices, accepting green taxes, or changing their expenditure away from traditional options toward sustainable ones [126]. This connects with SDGs 8, 12, and 13 on Decent Work and Economic Growth, Responsible Production, Consumption,

and Climate Action. Several people, at both individual and societal levels, have started to acknowledge that sustainable development requires an economic toll and that investment needs to be sacrificed. This group of people makes aesthetic choices in the name of the long-term environmental good, choosing to save trees, fund renewable energy, buy from green brands, and generally support eco-friendly businesses [127]. The achievement of market-based ecological protection policies and consumer-driven green change policies entirely depends on this economic burden. There is active participation in global green strategies to meet the set environmental goals of citizens guided by ethical consumption [128].

5.1.6. Contextual moderators: The Pakistani tourism landscape

The EcoTech Tourism Framework recognizes that the adoption of VR tourism and related behavioral responses are influenced not only by psychological and technological factors but also by unique sociocultural and infrastructural elements within a specific country, such as Pakistan. In Pakistan, particularly in rural and more conservative regions, gender-related limitations on mobility can significantly restrict women's physical travel opportunities, making telepresence and VR tourism particularly valuable by providing inclusive and socially acceptable alternatives. Furthermore, inadequate digital infrastructure, characterized by factors like low broadband penetration and limited access to VR equipment, acts as a key moderating factor impacting the correlation between perceived usefulness and the intention to use VR tourism. In addition, digital literacy levels influence how individuals understand and engage with immersive tourism technologies, thereby affecting their perception of ease of use and, ultimately, their adoption of the technology. These contextual moderators specific to Pakistan are integrated into the framework to accurately represent the actual challenges and potential benefits for VR tourism adoption within emerging tourism markets.

6. Implications & contribution

6.1. Theoretical implications

The EcoTech Tourism Framework presents several critical theoretical implications. First, it improves the Technology Acceptance Model (TAM). It shows that factors such as Perceived Ease of Use and Perceived Usefulness are important antecedent factors in adopting virtual tourism technology. Moreover, the framework extends the existing Stimulus–Organism–Response (SOR) model by including telepresence and elaboration of mental imagery as key stimuli that promote the eco-conscious behavior of travelers.

Additionally, this framework is compatible with environmental and behavioral theories on the Norm-Activation Theory (NAT) and the Theory of Planned Behavior (TPB). The psychological and moral drivers of environmentally responsible travel decisions are highlighted by integrating factors such as personal norms, eco-guilt and willingness to sacrifice.

6.2. Implications for research

Integrating technology, environmental sustainability, and behavioral science within the EcoTech Tourism Framework has significant implications for researchers from different disciplines. Additionally, it allows examining how techno factors, like telepresence and perceived usefulness, influence eco-conscious behaviors (e.g., willingness to sacrifice for the environment). Mediating effects (e.g., eco-guilt), as well as moderating factors (e.g., gender and age), can be examined to understand various outcomes (e.g., adoption of virtual tourism, reductions made to carbon footprint and evolution of tourist behavior). In addition, the framework can be used for comparative analysis between traditional and virtual tourism, making allowance for cultural variation and accommodating longitudinal studies of behavioral change.

6.3. Implications for tourists & tourism operators

- Global challenges

The implications are increased resilience of the tourism industry to global challenges like economic inflation, pandemics, and environmental degradation.

- Technological innovations

All this implies a collaboration between technology companies and the tourism sector to launch innovative and advanced solutions.

- Urban and regional planning

This further implies that urban planners can integrate sustainable tourism into urban developmental strategies, and the virtual platform facilitates the showcase of the attraction in rural and marginalized areas.

- Business growth

This has implications for businesses in that the benefits to the environment of virtual tourism could be viewed as a selling point for companies and the growth of new business models based on sustainable tourism business models that are technology-driven.

6.4. Implications for government departments & ministries

- Tourism development departments, ministries & corporations

The findings suggest that tourism departments, ministries, and corporations should make known advances in the sustainable tourism spaces by leveraging virtual tourism technologies to avoid the issue of over-tourism. Consequently, it can assist in protecting and preserving cultural and natural heritage without adversely impacting fragile ecosystems and heritage sites. Moreover, tourism and accessibility should collaborate to make accessibility available for underserved populations who cannot physically travel.

- Ministry of climate change and environmental coordination

A strong framework to assess and reduce the ecological impact of its tourism industry, especially in air and road transport, must be put in place by the Ministry. Decreasing reliance on traditional travel methods and promoting green alternatives, like virtual tourism, is essential. People must be educated regarding unsustainable travel behaviors and how eco-friendly decisions can improve the environment.

- Ministry of IT & Telecom

The findings of this research indicate that the IT & Telecom ministry should promote a culture of investment in and development of VR and AR including other telepresence technologies, aimed at promoting sustainable tourism. If the country adopts this initiative, it will emerge as a key player in EcoTech tourism for the other developing economies, giving rise to regional trade and partnerships especially in the areas of VR tourism products, services and technologies.

- Use eco-guilt through sensory campaigns

Eco-guilt is an essential emotional driver within the structure of the Ministry of Tourism, and environmental groups can initiate a targeted campaign that emphasizes the environmental impact of traditional tourism (such as CO₂ emissions, etc.) of conventional tourism. These campaigns can promote VR tourism as a more durable and responsible option.

- Subscribe to VR tourism infrastructure through carbon tax sales

Carbon offset or eco-tourism tax can be introduced in domestic air or vehicle travel to reduce traditional tourism. This revenue can subsidize high-quality VR materials and broadband infrastructure development, especially in areas with limited physical tourism.

6.5. Implications for educational institutions

- Expansion of academic offerings

Education can be allied with the latest industry trends by institutions providing fields like Virtual Reality in tourism, Environmental Behavioral Psychology and Sustainable Tourism Management.

- Interdisciplinary learning

Institutions that foster interdisciplinary approaches to discipline learning facilitate the linking of sustainability and technology, allowing students to move beyond focusing on the individual technological function to explore the interplay of technology and sustainability for a given application.

- Skill development

Students will learn how to deal with problems of sustainable tourism and technology as used to solve global challenges by incorporating telepresence, virtual tourism, and environmental responsibility concepts.

- Research initiatives

The factors suggested in the conceptual model serve as a foundation for future research projects, encouraging students and faculty to investigate and tackle intriguing questions about how tourism and environmental protection can be balanced in innovative ways.

- Experiential learning

Workshops, VR-based simulations, and case studies showing the practical implications of eco-conscious behavior will also help institutions support experiential learning.

- Contributions to sustainable development goals

Initiating VR experiences will help educational institutions achieve the United Nations' Sustainable Development Goals in quality education, sustainable consumption, and climate action.

6.6. Implications for Sustainable Development Goals (SDGs)

- **SDG 12 (Responsible Consumption and Production)**

Promoting virtual tourism is an implication for responsible consumption and production by effectively addressing over-tourism, reducing waste production, and conserving resources, ultimately fostering sustainable travel practices.

- **SDG 13 (Climate Action)**

Reduction of carbon footprints will diminish high-emission transportation methods. VR tourism practices can foster the climate, minimize wastage, and provide future alternatives.

- **SDG 9 (Industry, Innovation, and Infrastructure)**

Technological advancements like VR, AR, and the Metaverse can transform the tourism sector by introducing sustainable, innovative ideas and developing modern, sustainable structures.

- **SDG 14 (Life below Water)**

The reduction in coastal tourist places can also positively impact the marine environment, which will contribute to preserving biodiversity and sustainable marine tourism.

- **SDG 15 (Life on Land)**

Understanding the importance of VR tourism can shift tourists to VR tourism, which will reduce mass destruction and help to secure land habitat and other lives on land.

- **SDG 11 (Sustainable Cities and Communities)**

The implications also extend to urban areas, with virtual tourism easing the strain on city infrastructure in popular tourist destinations by decreasing overcrowding, waste accumulation, and pollution levels.

- **SDG 4 (Quality Education)**

The implication of VR-based tourism is to raise awareness of technology, environmental controls, and knowledge of global sustainability plans. This will educate the upcoming generation about international standards by acknowledging sustainable practices.

- **SDG 5 (Gender Equality)**

In a configuration with SDG5: Gender equality, VR tourism can play a transformative role in promoting equal access for women traveling in Pakistan, especially in a rural and conservative region where cultural standards restrict physical dynamics. Politicians should support the development of VR tourism among women near their access points (e.g., schools, women's skills centers, and safe public spaces) that enable them to participate in cultural, religious, and ecological tourism.

- **SDG 8 (Decent Work and Economic Growth)**

The VR increases innovation and job creation within the digital tourism sector, supporting economic growth through sustainable travel services and controlling inflation at the state level.

7. Study limitations

This paper offers a novel conceptual model for TAM and SOR. It proposes several implications through which the future dynamics of the VR tourism industry can be reshaped, though many limitations can be addressed and worked on in future research.

This paper presents a conceptual EcoTech Tourism Framework without any empirical validation. Future researchers may validate the proposed framework by examining the relationships between the key factors.

The paper proposes the selected factors for VR-based sustainable tourism as these focus on the environment and technology. Several other factors can also be considered to enhance the effectiveness of this model, including some contextually relevant mediators and moderators that can further enhance the VR tourism intentions of the individuals.

Though the suggested policies in this study are grounded on literature, the empirical findings and various real-world case studies must be incorporated in the future to support and validate this framework.

The evolving nature of VR tourism and Metaverse needs to be addressed more in the future, both conceptually and empirically.

As already mentioned above, while the conceptual EcoTech Tourism Framework is yet to be empirically validated, the following limitations are acknowledged:

The causal pathways are theoretically derived and not tested through statistical analyses.

The proposed framework assumes rational and affective consistency in user behavior, which may not hold across all demographic or regional groups.

The contextual moderators (e.g., infrastructure, gender norms, etc.) are modeled as influencing factors but are not empirically measured.

While logically derived, policy implications remain speculative and require real-world pilot programs for validation.

We however aim to empirically test the framework using quantitative and qualitative methods involving Pakistani travelers and tourists as the sample population.

8. Conclusion

The objective of this study was to theoretically evaluate the adoption potential of VR tourism as a transformative technology for the tourism industry of Pakistan. By integrating TAM and SOR as the guiding theoretical frameworks, we propose a conceptual EcoTech Tourism Framework that provides a holistic approach for elaborating how innovative technologies like telepresence and mental imagery, when externally moderated by some psychological & moral factors (such as eco-guilt, personal norms, environmental concerns, and willingness to sacrifice) and influenced by some control factors (like gender, age, income, and education), collectively guide the adoption of VR tourism as a sustainable alternative to on-site tourism.

As a whole, the suggested framework provides a comprehensive understanding of how technological advances could promote sustainable tourism practices in the wake of the current socio-economic and environmental challenges faced by Pakistan.

The framework particularly suggests some actionable insights for tourism industry stakeholders such as researchers, tour operators, tourists, government policymakers, etc., in addition to assisting these stakeholders in contributing to the relevant SDGs. From a future research perspective, this study opens up new doors for devising socially, economically & environmentally responsible strategies and actions aimed at driving Pakistan's economic growth in general and the development of its tourism industry in particular.

Characterized by gender-specific mobility limitations, inadequate technological infrastructure, and little environmental consciousness, Pakistan's tourism landscape necessitates localization of the globally trending sustainable tourism models and best practices. Overall, by meaningfully incorporating the contextually relevant socio-economic and psychological factors including the infrastructural limitations, the suggested EcoTech framework offers a theoretically relevant and practically effective roadmap for adopting VR tourism in Pakistan in the days to come.

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