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Examining the Effects of Metaverse Tourism on Environmental Sustainability*

Metaverse Turizminin Çevresel Sürdürülebilirlik Üzerindeki Etkilerinin İncelenmesi

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ÖZ

Metaverse yalnızca oldukça yeni bir teknolojik gelişme değil, aynı zamanda çok güncel bir araştırma konusudur. Metaverse, eğitim, sağlık sektörü, savunma sanayi, turizm, havacılık vb. gibi çeşitli alanlarda karşımıza çıkmaktadır. Bazı araştırmalar Metaverse'ün ekonomik boyutunu incelerken, bazıları Metaverse, sanal gerçeklik, artırılmış gerçeklik, karma gerçeklik, genişletilmiş gerçeklik, yapay zekâ gibi ilgili teknolojilerin misafir memnuniyeti veya ziyaretçi deneyimi üzerindeki etkilerini ele almıştır. Bu çalışma Metaverse turizminin çevresel sürdürülebilirliğe etkilerini belirlemek amacıyla yapılmıştır. Veri toplama yöntemi olarak derinlemesine görüşme tekniği kullanılmıştır. Yarı yapılandırılmış görüşme formları aracılığıyla alanında uzman ve bilgili kişilerin görüş, deneyim ve gelecek tahminlerini elde etmek amacıyla kartopu örnekleme yöntemi kullanılmıştır. Bulgular içerik analizi ile incelendiğinde, katılımcıların çoğunun Metaverse turizmini çevresel açıdan sürdürülebilir bulduğu görülmüştür, buna katılmayanlar ise ilgili platformları destekleyen blockchain, veri madenciliği ve bulut bilişim gibi teknolojilerin enerji tüketimine ve karbon ayak izine dikkat çekmektedir. Bu çalışma, katılımcıların en çarpıcı yorumlarını sunmakta ve gelecekteki araştırmacılara konuyu ekonomik, sosyal ve kültürel sürdürülebilirlik boyutlarıyla incelemelerini önermektedir.

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ABSTRACT

Metaverse is not only a fairly new technological development, but also a very current research topic. Metaverse appears in various fields such as education, health sector, defense industry, tourism, aviation etc. While some studies examine the economic dimension of the Metaverse, some researches have considered the effects of Metaverse and related technologies such as virtual reality, augmented reality, mixed reality, extended reality, artificial intelligence on guest satisfaction or visitor experience. This study was conducted to determine the effects of Metaverse tourism on environmental sustainability. In-depth interview technique was used as a data collection method. The snowball sampling method was used to obtain the opinions, experiences and future predictions of experts and knowledgeable people in the field through semi-structured interview forms. The findings were examined with content analysis, and most participants find Metaverse tourism environmentally sustainable, and those who disagree point out the energy consumption and carbon footprint of technologies such as blockchain, data mining and cloud computing that support these platforms. This study presents the most striking comments of the participants and suggests future researchers examine the subject with economic, social and cultural sustainability dimensions.

1. Introduction

The tourism industry is considered one of the most significant economic activities globally, with an estimated 1.8 billion international tourists by 2030 (UNWTO, 2020). Since most of these activities rely on the movement of millions of tourists through air transport, they require the use of fossil fuels and result in large amounts of greenhouse gas emissions (Dorta Antequera, 2021). Because 5% of global

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carbon emissions are of tourism origin, this sector is regarded as one of the responsible of climate change (UNWTO, 2013). In addition to the negative consequences of tourism related transportation, huge energy consumption of accommodation businesses, heating and maintenance requirement of touristic facilities, food waste and water consumption by the tourists are all affect the environment negatively (Özdemir and Güçer, 2018). While tourism-related environmental problems continued to be examined by the states and the academic community, the Covid 19 pandemic emerged and suddenly both citizens and tourists had to stay at home. As a result of the inability of tourists to relocate by air, road or sea transportation, the closure of hotels, motels and holiday villages and the suspension of service by food and beverage establishments, the negative effects of the sector on the environment have also decreased. Due to Covid 19, industrial waste emissions have decreased significantly, and as public and individual transportation density has declined, almost zero greenhouse gas and particle emissions have been achieved. Due to production restrictions in enterprises, less energy demand has occurred, the use of fossil fuels or traditional energy sources has been reduced, both the sky in megacities and forests, seas and beaches have become clean (Hayta and Öner, 2020). On 19 August 2021, it is also reported by the World Travel and Tourism Council (WTTC) that pandemic has raised the focus on sustainability which should be a collective responsibility at the front line of all other future policies to assure a revival that benefits both individuals and the planet (WTTC, 2021).

While these issues were on the global agenda and alternative solutions were being sought to reduce the negative environmental effects of tourism, the concept of "Metaverse" came into our lives with the help of various technological developments. Adopted by various fields such as education, health sector, defense industry, tourism, aviation etc., Metaverse is not only a new technological development but also a current research topic. Due to the nature of Metaverse technology, which enables users to work, to join activities, to travel or to visit museums from the comfort of their home by using specific equipment without physical movement, its similarity to the conditions brought by Covid 19 has been noticed. Therefore, whether Metaverse tourism is more environmentally sustainable has become an important research question. This study was conducted to determine the effects of Metaverse tourism on environmental sustainability. It is aimed to contribute to literature in addition to studies examining the subject of Metaverse and tourism from different perspectives. Some studies have examined the economic dimension of the Metaverse or the adoption process of Metaverse by individuals or companies. Some researchers have underlined the effects of Metaverse and related technologies on guest satisfaction or visitor experience. However, studies investigating environmental sustainability within the scope of Metaverse, and tourism are in the minority.

2. Literature Review

The World Economic Forum (2022) recognizes tourism as one of the most essential sectors that could gain advantage from the Metaverse. Despite these positive expectations, it is stated that the subject of Metaverse is still in its infancy in the tourism literature (Go and Kang, 2023; Loureiro et al., 2020) and tourism applications in the field of Metaverse have not yet been explored (Yang and Wang, 2023). The concept of Metaverse and related technologies such as virtual reality (VR), augmented reality (AR), mixed reality (MR), extended reality (XR) and artificial intelligence (AI) can be better understood after examining the definitions. Metaverse is a cyberspace in which various virtual, augmented reality worlds could interact and create a mass environment where multiple users are able to interact from all over the world focusing on social connection through the internet (Dionisio et al., 2013). VR is defined as an artificial experience where people could interact in a 3-D space through a VR headset or helmet and perceive the environment created artificially by use of images, objects and sounds (Lee et al., 2021). AR is described as a realized virtual world by adding virtual information to the real world and using some augmentation techniques for the transformation of computer-based data into real images (Kounavis et al., 2012). Combining AR and VR to create a virtual experience over the physical world, MR could be defined as a hybrid technology where users do not need to remove from real surroundings and can interact with physical and 3 dimensional objects coexisting in real-time (Aloqaily et al., 2023). XR is seen as an umbrella category where all the real-virtual environments are combined and human–machine interaction becomes possible with the help of wearables and computer technology (Alizadehsalehi et al., 2020). AI could be explained as the capacity of a machine to mimic the cognitive abilities of a human like learning, recognizing patterns, problem solving, and task performing that normally depend upon human intelligence (UNF, 2023). Metaverse could be generated by the integration of AI with AR, VR, blockchain technology, and networking which provides secure, and realistic virtual environments (Aydın and Nalbant, 2023). After having all these terms explained, it should be noted that when Metaverse is mentioned in this research, it also includes related technologies of XR and AI.

2.1. Advantages of Metaverse Tourism Considering Environmental Sustainability

When people choose to participate in touristic activities in Metaverse platforms or take advantage of these technologies, the term Metaverse tourism emerges. Metaverse tourism is interpreted as a tourism type that converges the physical and virtual environments and cultivating them via multi-sensory information processing and providing products or experiences to tourists spatially (Go and Kang, 2023). Tourism activities that tourists participate in Metaverse platforms or in other virtual

environments remind us of the environmental advantages brought by the Covid-19 pandemic, as elements such as relocation, use of transportation vehicles and accommodation facilities that are unique to traditional tourism are eliminated. Mobilities not only involve the movement of travelers but also the movement of numerous materials and objects which could raise sustainability problems based on the large number of people in the movement. VR could contribute to defeating some of the movements providing customers virtual experiences without physical presence (Loureiro et al., 2020). Without the physical presence of tourists, mass tourism can be more sustainable and heritage preservation can become more tangible (Dewailly, 1999). Various research clarifies that Metaverse tourism is more environmentally sustainable than traditional tourism with the help of alternative solutions and profitable resources (Caulfield 2022; Chen, 2020; Go and Kang, 2023; Schiopu et al., 2021; Talwar et al., 2023). In addition to reducing real-world travel, Metaverse can support remote working and deter pollution problems (Caulfield, 2022). VR and AR technologies can facilitate the life of both tourists and the citizens in smart cities where tourists could download specific applications on their mobile phones to gather information about touristic places and tours, cultural monuments, restaurants, accommodation facilities etc. (Garcia-Crespo, 2016; Zelenka, 2009). Waste management, energy consumption and water supply can be more effectively controlled in these smart cities (Diaz-Diaz et al., 2017) in addition to the protection of cultural heritage through AR and VR technology.

Considering that there are a huge number of personnel working in the tourism sector, the positive impact of this technology on the environment can be justified with the help of remote working. Metaverse can help to improve air quality by reducing carbon emissions result from transportation (Xie, 2017) and from the maintenance of the office buildings (Vlădutescu, 2023). Numerous studies suggest that AI can be used to help achieve 79% of sustainable development goals (SDGs) (Vinuesa et al., 2020). Keeping in mind that excess number of tourists causes water waste while they take part in touristic activities, there has been need for technology for the sustainability of fresh and clean water. AI can be effective for managing wastewater as well as detecting toxic particulates in the water (Kar et al., 2022). Another concrete example underlines the AI's support for reducing carbon emissions stating that Lufthansa Group saved nearly 8,700 tons of CO2 in 2022 after the optimization of airline operations via AI (Economist Impact, 2023).

In a study examining the comments of experts on the subject about the effects of Metaverse tourism on the environment, participants who thought that it would be more environmentally sustainable associated it with reducing the destructive effects of mass tourism, protecting sensitive touristic regions and contributing to tourism education (Özdemir Uçgun and Şahin, 2023). Encompassing all the environmental advantages of the Metaverse mentioned so far, a research has addressed the impact of metaverse within the scope of the Sustainable Development Goals SDG's and underlined that the Metaverse will be beneficial in most of the 17 goals expected to be achieved by 2030; to educate people and create environmental awareness, to support sustainable practices in agriculture, to identify the best sources of energy for more sustainable cities, to help the conservation of the oceans, seas, marine life and forests (De Giovanni, 2023).

2.2. Criticisms of Metaverse in Terms of Environmental Sustainability

The negative impact of Metaverse on the environment can be eliminated by adopting effective regulations and sustainable actions at the global level (Vlădutescu and Stănescu, 2023). Companies should be able to digitalize in a responsible manner by achieving corporate social responsibility purposes with the adoption of digital technologies after a careful evaluation of their environmental effects (De Giovanni, 2023). In this context it is important to comprehend the criticisms on the sustainability of Metaverse. Various studies point out that Metaverse causes more energy consumption by adopting high technology (Davies-Filleur, 2022; Lovell, 2018; Townsend, 2022; Tozzi, 2022) object to the studies listing the positive effects of the Metaverse on the environment and claim that these universes consume more energy due to the use of high technology.

Özdemir Uçgun and Şahin, (2023) explains that if Metaverse tourism is preferred over physical tourism activities, transportation-based carbon emissions as well as food waste and water waste will decline. However, if Metaverse functions as a marketing tool to increase real tourism figures then it will not be environmentally friendly not to mention the energy consumption of crypto mining (servers and coolers). It is claimed that blockchain technology which forms the base of Metaverse increases carbon emissions since coal mining requires energy and causes air pollution and global warming (Koch, 2021). The use of big data causes the consumption of 200 terawatt hours by data centers in a year which is higher than the energy consumed by countries like Thailand, Argentina or Ukraine (Lovell, 2018) Similarly, Cambridge Centre for Alternative Finance, (2020) explains that cryptocurrencies requisite as much energy as needed to sustain Finland (University of Cambridge, 2023).

It is vital to clarify the accuracy of these claims by investigating them with concrete measures via some projects or simulations. For example, based on the hypothesis that Metaverse requisites high energy in the future, Middle East Technical University (METU) analyzed the sustainability of Metaverse with a project called 'sustainverse' by modeling the daily energy consumed by supercomputers, networking devices or storage and found that there will be less energy consumption in the coming years (Eviren et al., 2022).

3. Methodology

This research is part of a project carried out within the scope of 2219 International Postdoctoral Research Fellowship Program of the Scientific and Technological Research Council of Turkey – TUBITAK. Ethics committee permission was given for the survey application of this study by Istanbul Aydın University Ethical Principles and Ethics Committee on 15.02.2024.

Table 1. Study Participants and Type of Involvement

Participant	Type of Involvement
P1	Academician / has publications on Metaverse & Tourism
P2	Founder of a Blockchain & Metaverse Academy / Digital Currency Trainer
P3	Academician / has publications on Metaverse & Tourism
P4	Independent AR Developer / Teaches machine learning in high school degree
P5	Academician / has publications & projects on AI and smart tourism
P6	Academician / has publications on Metaverse & Tourism
P7	Academician / Teaches courses in Metaverse platform
P8	Owner of an IT Company & AI Entrepreneurship
P9	General Manager of a F&B Business
P10	Academician / Lectures in VR environment since 2020
P11	Finance Director of an International Chain Hotel which launched NFT's for customers
P12	Owner & Chef of a popular US restaurant
P13	CEO of an XR Company / Executive Board Member of Open AR Cloud Association & Metaverse Standards Forum
P14	Procurement & Contract Manager of an International Chain Hotel
P15	Movie Producer & master student / Employed in the field of art adopting technology
P16	Owner of a software company serving AR-VR–XR content
P17	Founder of an XR Entrepreneurship
P18	Researcher on Smart Cities & Digital Twins / Strategic Partner of a high-tech company in London
P19	Space Architect & Engineer – Project architect of a Space Tourism Project
P20	Tourism & Financial Investment Consultant / Services include Blockchain, XR & AI technologies
P21	Designer & Instructor in VR spaces in a US university
P22	Banker & Stock market investor / Blockchain follower
P23	R&D Natural Language Processing Engineer / AI Expert
P24	Founder of a software company that combines Metaverse & XR with Gamification & Blockchain technologies
P25	F&B Director of an International Chain Hotel which adopts NFT's / involved in project creation

To examine the effects of Metaverse tourism on environmental sustainability, qualitative research techniques were used in the study. After a detailed literature review, semi-structured interview form was created and used as a data collection tool. In phenomenological studies that try to derive a universal explanation from the individual experiences of people regarding a concept, data should be collected through in-depth interviews with individuals who have experience on the subject and whose numbers vary between 5 and 25 people (Polkinghorne, 1989). The data were gathered from 25 participants with the help of in-depth interview method which is a technique that can obtain detailed and multi-dimensional data used to reveal the experiences, thoughts and perceptions of the interviewer and to discover the unknowns of the subject (Uslu and Demir, 2023). Snowball sampling technique which relies on the referrals of previous interviewees was adopted. Interview forms were sent to the participants listed in Table 1 by e-mail, they were given time to review the questions, and then the interviews were conducted face to face or in recorded meetings via Zoom between November 2023 - January 2024. The knowledge and experience of the first two participants was facilitated to shape the research questions to revise the interview form accordingly. The interviews lasting at least 40 minutes were examined using the content analysis method and the repeated answers of the participants were summarized. The research results were stated by using an exploratory and qualitative method known as ethnographic summary technique that conveys the meanings of individuals' and organizations' behaviors and ideas in a narrative style (Hannabuss, 2000). A nomenclature of study participants P1–P25 is used to present the most striking expressions of them in quotation marks.

4. Findings

After covering various studies on the environmental sustainability of Metaverse and related technologies, this part of the study includes the findings about environmental sustainability specifically for Metaverse tourism by compiling the own experiences, observations and comments of the participants who are knowledgeable on the subject. Presented in Table 1, the study participants come from different backgrounds, from software company founders to academics, from AR – VR company managers to hoteliers or F&B directors who use relevant technologies. 24 of the 25 participants are men, which can be interpreted as those who work in relevant occupations or are early entrepreneurs in new technologies are mostly men. 92 percent of the participants, whose average age is 37, have experience with Metaverse, AR or VR technologies. When the location of the participants' workplaces is examined, it is found that they are distributed in many countries, 10 participants are from US, 9 of them are from Turkey, 2 are experts from England, 1 is from France, 1 is from Sweden, 1 is from Estonia and 1 is from Greece. This could be effective in terms of reflecting different perspectives on the subject regardless of geography.

To examine the sustainability of Metaverse tourism some questions were posed to the participants such as, "Can

Metaverse tourism prevent the negative environmental impacts of real-world tourism and promote sustainability? Would Metaverse tourism be more sustainable to carry out touristic activities in a virtual environment in terms of water waste, food waste, pollution or energy consumption?". When interviews with an average duration of 47 minutes are examined, it was determined that 60 percent of the participants found Metaverse tourism more sustainable. In addition, the second group of people constituting 12 percent of the respondents were of the opinion that Metaverse tourism is not environmentally sustainable, and the third group, remaining 24 percent stated that it is contradictory because it has both positive and negative effects on the environment.

Participants who find Metaverse tourism more sustainable generally think that tourists participating in touristic activities in a virtual environment will reduce tourism-related energy consumption and prevent carbon footprint by not using transportation vehicles especially. This finding is parallel to the studies of Diaz-Diaz et al. (2017) and Loureiro et al. (2020). An owner of a software company that produces XR content (P24) explains that 'Metaverse tourism not only reduces energy consumption and carbon footprint, but also consumes less water and natural resources than traditional tourism. While water consumption in hotels, restaurants and tourist facilities is considerably higher than the water we consume at home, in the Metaverse environment, it is almost zero'. 6 other participants supported this judgment regarding water consumption with similar statements which also coincide with existing research (Kar et al., 2022; Xie, 2017). According to an AI expert 'in events, like festivals, concerts or exhibitions that take place in a virtual environment, physical waste and environmental pollution are less likely to occur'. Another participant (P16) argues that Metaverse tourism supports the fight against climate change and adds 'in Metaverse tourism, the destination carrying capacity is not exceeded by visitors. Today, the biggest problem of many destinations is the influx of visitors, but with these technologies, tourists do not leave their homes and do not produce carbon emissions by using vehicles. Having similar ideas about carrying capacity, 8 participants also support this view. The founder of a blockchain and Metaverse academy (P2) explains the sustainability of Metaverse tourism by dividing the issue into time periods 'there may not be a decrease in physical tourism activities in the short term, as generations X and Y learned this technology later and will approach tourism in the traditional way they are used to. But Alpha and Beta generations will definitely be more inclined to digital environments and will prefer Metaverse tourism, so there will be a decrease in tourism movements in the long term and the environmental problems it brings will disappear'.

A quarter of the participants think that Metaverse will be more sustainable by using it as a tool to educate tourism stakeholders and tourists. The founder of an XR company (P17) has this to say, 'if enjoyable games and digital content can be produced about environmental issues, people can learn and implement these without getting bored'. Among the people who support this view, there are even people in the second group who state that they are abstaining. Another participant draws attention to agricultural sustainability 'Metaverse tourism will be very beneficial, especially for countries whose economies are based on agriculture, because the issue of consuming limited resources is alarming. Carbon emissions and excess consumption of food or other scarce resources by incoming tourists are prevented and remain for the benefit of the local citizens'. A space tourism architect (P19) suggests the following with a different perspective on the issue of Metaverse tourism's sustainability, 'we use various large plotters in architecture and a lot of paper waste occurs, but if we adapt these technologies to our projects, we will prevent both serious paper waste and material consumption. Likewise, this applies to all buildings and facilities serving the tourism industry'. Most of the participants in this first group were also aware of the criticisms regarding the environmental sustainability of Metaverse tourism. In response to those who think that technologies supporting the Metaverse, such as cloud computing, data mining and high tech, cause more harm to the environment, a participant (P8) explains that 'even assembling a Boeing passenger plane still requires energy, and thus carbon emissions will increase. The same goes for all touristic vehicles, rail systems or buses, etc., which are also used by local people. Also, if we evaluate holistically such as reproducing after the wear and tear of the transportation vehicles, the use of natural resources in physical tourism, the pollution of oceans and seas, etc., Metaverse tourism is absolutely more sustainable'. Another respondent (P20) justifies as 'the servers to be installed for the Metaverse tourism service may increase energy consumption at first, but this can be prevented by using blockchain-based computers, phones or other internet-connected devices or items as resources. In the long run, as this technology develops, decision makers will surely make it more environmentally friendly'.

People in the second group, which constitutes 17 percent of the participants and who think that Metaverse tourism is not environmentally sustainable generally base this on the assumptions that it will boost traditional tourism activities. An academician lecturing in Metaverse platform (P7) clarifies that 'Metaverse tourism will not reduce real tourism activities but will increase total tourism figures with the help of marketing activities and promotions. As a result, our ecological footprint will increase'. Tourists can choose the destinations, accommodation establishments, museums, etc. they want to go to in this virtual environment with "try before buy" concept. They will try these touristic products and services virtually and then desire to experience them in reality by travelling distant routes with transportation vehicles, staying in accommodation facilities and consuming resources etc. This technology will not replace physical tourism activities but will complement it. As a result, there will be a rise in the total number of visitors which is environmentally harmful. Five participants have a

common opinion stating that 'Metaverse tourism is not so innocent from an environmental point of view, because the related technologies behind the scenes, such as blockchain, data mining and cloud computing etc. also consume a significant amount of energy and become harmful to the environment with their carbon footprint'. This judgment concurs with the study findings made by Davies-Filleur, (2022); Lovell, (2018); Townsend, (2022) and Tozzi, (2022). The general manager of a restaurant (P9) suggests that 'there is not much difference considering food waste or water waste of F&B facilities or gastronomy tourism destinations, because the most difficult area for Metaverse technology to imitate or reach in the tourism sector is our business field'. An opposing view to this comment comes from another restaurant owner and chef (P12) who suggests that 'by benefiting from artificial intelligence, VR and AR technologies, standardization can be achieved in industrial kitchens that produce a large number of meals, employees can be trained about food waste, and human made waste can be prevented. For example, there is a significant difference between preparing a time-consuming dish such as homemade ravioli in a boutique restaurant and rolling out the same ravioli dough to tourists in big hotels. Artificial intelligence can be very helpful in such touristic facilities'.

Those in the third group who are conflicted about the effects of Metaverse tourism on the environment and cannot make a clear judgment generally think that this type of virtual tourism will prevent the energy consumption of accommodation establishments and touristic facilities, such as lighting – heating - maintenance etc. However, since the same respondents also claim that the infrastructure required by these technologies will have a negative impact on the environment since they require very serious energy, they cannot predict which of the benefits or harms will outweigh. A researcher on smart cities and digital twins (P18) makes an interesting analogy 'I liken the answer to the question of whether the Metaverse tourism is environmentally friendly to the debate that has been going on for years about electric cars. It has both positive effects and unsustainable aspects which will be better understood in the future'. The CEO of an XR company (P13) underlines that 'I think there is some confusion about the carbon footprint of Metaverse tourism. Maybe tourists will not travel anywhere by plane, but with this technology, serious technological waste occurs as the electronics become obsolete and are thrown away in time. If we look at the waste of hardware in data centers and the energy consumption required, it becomes clear that this is a serious environmental problem. For example, I bought Quest2 VR glasses, but the new model Quest3 has been released now, the old one will now go to waste'. A hotelier (P14) asserts that 'when disadvantaged groups such as disabled, elderly or low-income people, who normally cannot participate in physical tourism and do not harm the environment, participate in virtual tourism from their homes with Metaverse tourism, they become partners in the energy waste of these technologies. In addition, since Metaverse tourism will not completely eliminate real tourism activities, environmental damage will continue exponentially'.

Although the participants had positive, negative or abstaining opinions about the environmental sustainability of Metaverse tourism, most of them stated that this issue should also be examined in terms of economic, social and cultural sustainability and warned to identify the problems that this type of digital tourism may cause in the future.

5. Discussion and Conclusion

In this study examining the sustainability of Metaverse tourism, in depth interviews were conducted by taking expert opinions and findings become more effective to make additional determinations and to open new horizons with the help of open-ended questions posed to the participants.

A majority of 16 out of 25 participants are of the opinion that Metaverse tourism is environmentally sustainable, which confirms past studies by Chen, 2020; Schiopu et al., 2021; Caulfield 2022; Go and Kang, 2023 and Talwar et al., 2023. These experts find this new type of tourism environmentally friendly in terms of energy consumption, carbon emissions of transportation vehicles, water and food waste caused by physical tourism activities. 12 percent of the remaining participants argue that these technologies will harm nature due to the energy required by high tech such as blockchain, data mining, cloud computing and digital twins. These arguments stated by participants who think that Metaverse is not environmentally sustainable coincide with the findings stated in past research (Davies-Filleur, 2022; Koch, 2021; Lovell, 2018; Townsend, 2022; Tozzi, 2022). Moreover, they claim that these technologies will serve as a tourism marketing tool and increase traditional tourism activities. This argument is similar to the judgment that the environmental impact of Metaverse depends on whether it will be preferred over traditional tourism or will serve as a marketing tool, as stated in the research of Özdemir Uçgun and Şahin, 2023. Participants who are not in either of these groups pointed out that Metaverse tourism has both advantages and disadvantages. The participants, who's most striking statements were included throughout the study, generally drew attention to the increase in fuel consumption, carbon footprint and related climate change due to tourists' travels. Based on this opinion, it could be deduced that local consumption is environmentally friendly and that people shopping and purchasing food from the closest place to their hometown will protect the environment regardless of the tourism type they participate.

The majority of the participants emphasized the advantage of Metaverse, XR and AI technologies in educating tourism stakeholders on environmental sustainability. The views of these participants are parallel to those of De Giovanni (2023), who evaluates the effects of Metaverse within the scope of SDG's to be achieved by 2030 and talks about the function of Metaverse to raise environmental awareness by educating people. It should not be disregarded that people are only willing to protect things that have meaning to them. To protect nature, individuals must first feel the forest and

trees, experience the benefits of falling rain on the soil, and care about the sounds of seas, lakes and streams starting from the childhood years as humans before becoming avatar tourists. It is therefore very important how Metaverse tourism is adapted by tourism stakeholders regarding the purpose, duration and form of use. As stated by the participants, the reflections of Metaverse tourism should be considered on social, cultural and economic sustainability issues. If this technology causes digital addiction, disrupts the concept of family, raises economic problems due to the unemployment of those working in physical tourism facilities, and increases the crime rates of individuals due to inequality of access to technology, at that point, an ideal balance will need to be sought between environmental benefits and the costs of these technologies.

The study results could extend the findings of previous studies by directly compiling the opinions of current Metaverse tourists and people who have knowledge of the subject. In this context, its theoretical contribution to literature is very important and serves as a basis for future researchers. The profound practical implication of this paper is to present the possible advantages of Metaverse in terms of environmental sustainability for all the tourism stakeholders which are currently adopting these technologies or will facilitate in the future. Moreover, by underlying the environmental threats result from Metaverse and related technologies, this study could trigger those who develop relevant technologies or digital decision makers to raise awareness, produce more environmentally friendly alternatives to possible problems, and find solutions to minimize energy consumption.

Even if each of the participants is absolutely knowledgeable and experienced about the subject, the difficulty of arranging appointments with the participants for long lasting in-depth interviews is one of the limitations of the study. This research examined Metaverse and tourism on the axis of environmental sustainability. However, the aim of sustainability is to advance the resources in accordance with human needs while considering the social and economic aspects as well as the environmental pillars (Karakutuk et al., 2021). Therefore, future researchers are suggested to examine economic, cultural and social sustainability of Metaverse tourism and evaluate both the possible advantages such as inclusion of minority groups (disabled – low income and old people) in tourism, education possibilities, risk reduction aspects and probable disadvantages like technology addiction, health problems resulting from exposure to related equipment (obesity, headache, eye problems etc.), isolation from the society, ethical violations, cyber-crimes, cyber bullying, and social inequality.

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